

STM32 Nucleo pack for USB Type-C™ and Power Delivery with the Nucleo-F072RB board

Introduction

The USB Type-C™ and Power Delivery Nucleo pack (P-NUCLEO-USB001) is a development kit composed of a NUCLEO-F072RB board, the MB1257 expansion board and a full-featured Type-C cable. These components along with the certified STM32F0 USB Type-C™ PD middleware stack X-CUBE-USB-PD are needed for demonstrating the functionalities of the USB Type-C™ and USB Power Delivery technologies, facilitating the users to develop their solutions.

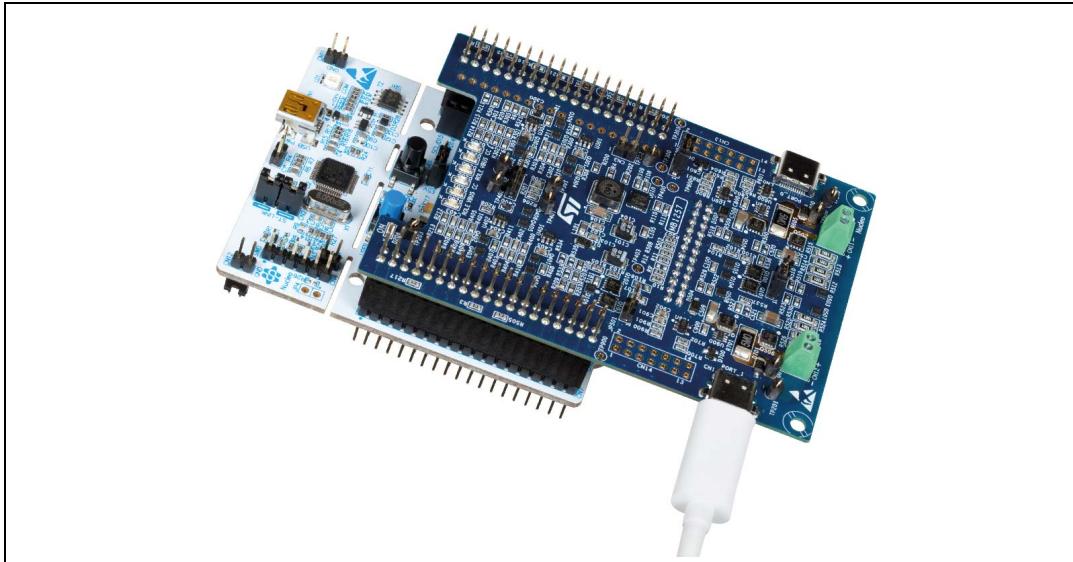
The USB PD is a brand-new protocol designed to enlarge the USB capabilities; it enables the power delivery from 15 W to 100 W over the same cable used for the data communication. The devices supporting the PD protocol are able to negotiate voltage and current over the USB power pins and to define their roles as Provider or Consumer according to the requirements.

After briefly introducing the USB Power Delivery main characteristics and operations, this document describes the P-NUCLEO-USB001.

Once that the boards are configured, the embedded demonstration firmware allows the user to see some basic information such as the attach and detach of the cable, the cable's orientation and the role of each port.

The *Figure 1* shows the assembled USB Type-C™ and Power Delivery Nucleo pack.

Figure 1. USB Type-C™ and Power Delivery Nucleo pack



1. Picture is not contractual.

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1 Brief overview on USB Type-C and Power Delivery technology

The USB Type-C and the Power Delivery are promising technologies to simplify development and to enhance the consumer and mobile user experience. The new reversible USB Type-C connector makes the plug insertion more user friendly.

These technologies offer a smart connector to carry all the necessary data (including other communication protocols for video) and by using the Power Delivery protocol they allow to negotiate up to 100 W to supply or charge the equipment connected to this USB port. Less cables, less connectors and universal chargers are among the final objectives.

Natively the USB Type-C connector supports up to 15 W (5 V at 3 A), extended to 100 W (up to 20 V at 5 A) with the optional USB Power Delivery feature. 15 W is far enough for most of the hundreds of millions of legacy USB powered devices actually on the market.

This first section introduces the two new standards: USB Type-C and USB Power Delivery.

1.1 USB Type-C in a nutshell

The USB Implementer Forum (USB-IF) introduces two complementary specifications:

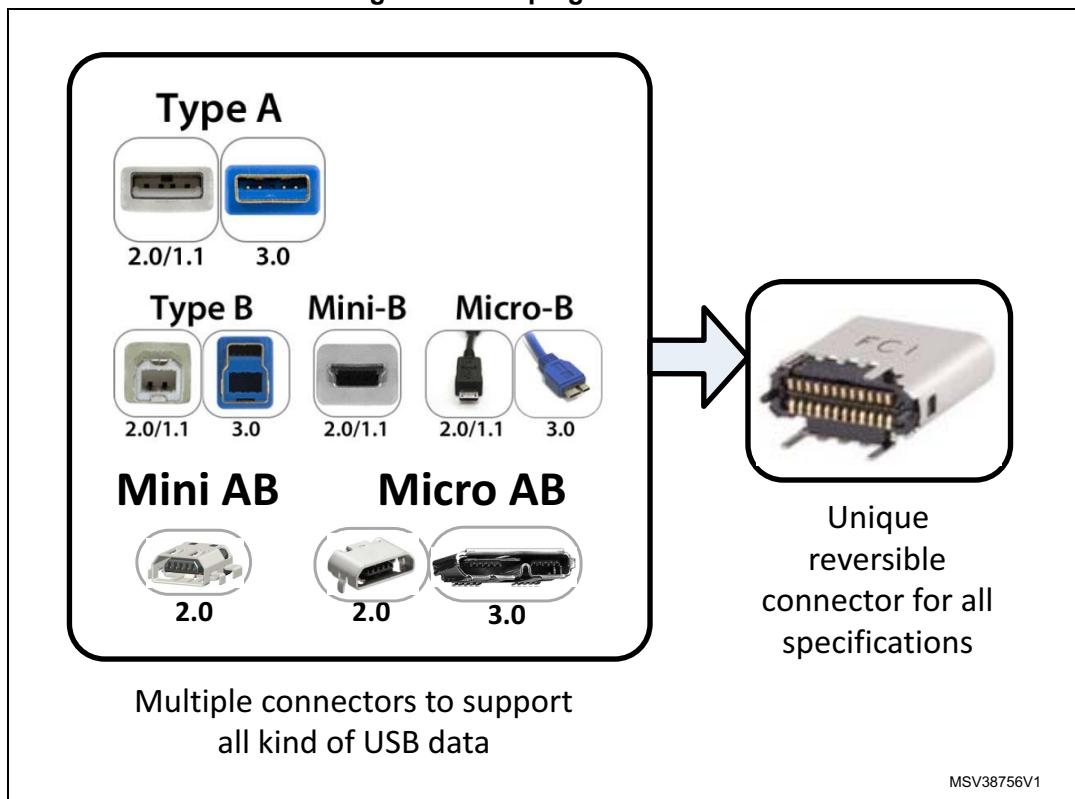
- The USB Power Delivery (PD) specification rev 2.0 (refer to [Section 7: References](#)) details how a link can be transformed from a 4.5 W power source (900 mA at 5 V on V_{BUS}) to a 100 W power or consumer source (up to 5 A at 20 V).
- The USB Type-C receptacle, plug and cable specification rev 1.2.

The new connector is designed to be non-polarized and fully reversible, no matter which way it is inserted.

As such, this new reversible 24-pin USB Type-C plug aims to be an universal connector with all the advanced features proposed by PD:

- Negotiating power roles
- Negotiating power sourcing and consumption levels
- Performing active cable identification
- Exchanging vendor specific messages
- Performing Alternate-Mode negotiation, allowing different communication protocols to be routed onto the reconfigurable pins of the USB Type-C connectors.

Figure 2. USB plug form factors



The USB Type-C cables use the same male connector on both ends.

The USB Type-C supports all prior protocols from USB2.0 onward, including power capability.

The new connector is quite small as it is only 8.4 mm wide by 2.6 mm high.

As depicted in [Figure 2](#), the new USB Type-C plug allows having a single connector to cover all features provided by the previous plugs. This functionality makes the USB usage easier for all customer due to its flexibility in data and power role.

The USB Type-C connection allows ports to be in host-mode only, device-mode only or dual-role. Both data and power roles can be independently and dynamically swapped using the USB PD protocol.

1.2 USB Type-C vocabulary

The terminology commonly used for the USB Type-C system is:

- **Downstream Facing Port (DFP):** associated with the flow of data in a USB connection, typically the ports on a host or on a hub to which devices are connected. In its initial state, the DFP has to operate as USB Host (when the USB communication is supported) and Source.
- **Upstream Facing Port (UFP):** associated with the flow of data in a USB connection. The port on a device or a hub that connects to a host or the DFP of a hub. In its initial state, the UFP has to operate as a USB Device (when USB communication is supported) and Sink.
- **Dual-Role Power (DRP):** refers to a USB port that can operate either as a source or as a sink. The role of the port may be fixed to either source or sink or may alternate between the two port states. Initially when operating as a source, the port also takes the role of a DFP and when operating as a sink, the port takes a role of a UFP. The port role may be dynamically changed to reverse either power or data roles.
- **Source:** port asserting Rp (pull up resistor) on CC (Configuration Channels) pins provides power over V_{BUS} (5 V to 20 V and up to 5 A). It is most commonly a DFP host or hub. See [Figure 5](#) for Rp and [Section 1.6](#) for CC pins).
- **Sink:** port asserting Rd (pull down resistor). See [Figure 5](#) on CC pins and consuming power from V_{BUS} (5 V to 20 V and up to 5 A), most commonly a device. A USB Type-C PD port with Rd asserted on its CC wire and capable to sink power over V_{BUS} is called Consumer.

1.3 Mapping of the USB Type-C connector pin

The 24-pin USB Type-C includes:

- Symmetric connections:
 - USB2.0 differential pairs (D+/D-)
 - Power pins: V_{BUS} /GND
- Asymmetric connections:
 - Two sets of Tx/Rx signal paths which support USB 3.1 data-speed
 - Configuration channels (CC lines) which handle discovery, configuration and management of USB Type-C power delivery features
 - Two Sideband Use (SBU lines) signals are present for analog audio modes and may be used by alternate mode

[Figure 3](#) and [Figure 4](#) show the receptacle and the plug pinouts and [Table 1](#) shows the pinout description.

Figure 3. USB Type-C receptacle pinout

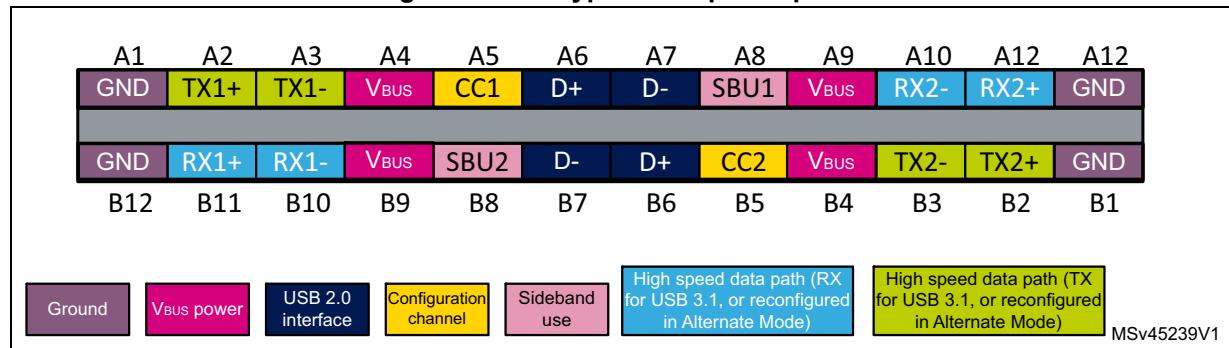


Figure 4. USB Type-C plug pinout

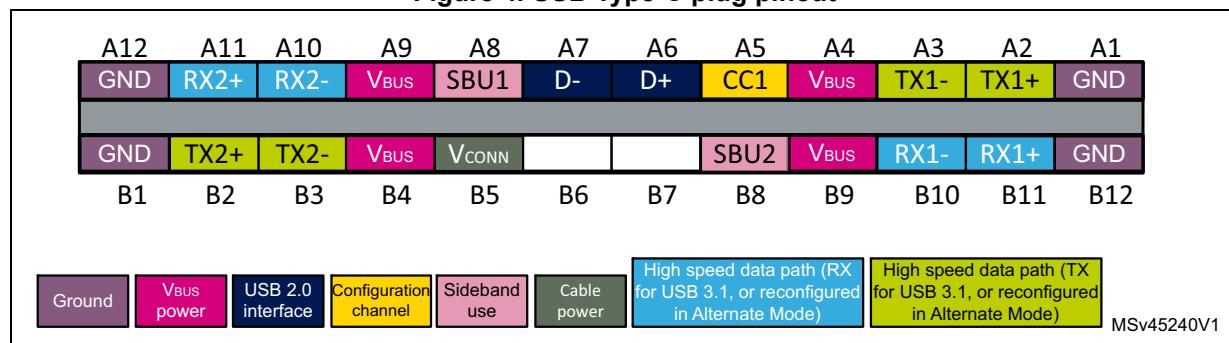


Table 1. USB Type-C pinout description

Pin	Receptacle signal	Plug signal	Description	Comment
A1	GND	GND	Ground return	Can be up to 5 A split into four pins
A2	TX1+	TX1+	USB3.1 data lines or Alternate	10-Gbyte TX differential pair in USB 3.1
A3	TX1-	TX1-		
A4	V _{BUS}	V _{BUS}	Bus power	Max power is 100 W (20 V - 5 A) split into four pins
A5	CC1 or V _{CONN}	CC	Configuration channel or power for active or electronically marked cable	In V _{CONN} configuration, min power is 1 W
A6	D+	D+	USB2.0 datalines	-
A7	D-	D-		-
A8	SBU1	SBU1	Sideband use (SBU)	Alternate mode only
A9	V _{BUS}	V _{BUS}	Bus power	Max power is 100 W split into four pins
A10	RX2-	RX2-	USB3.1 datalines or Alternate	10-Gbyte RX differential pair in USB 3.1
A11	RX2+	RX2+		
A12	GND	GND	Ground return	Can be up to 5 A split into four pins

Table 1. USB Type-C pinout description (continued)

Pin	Receptacle signal	Plug signal	Description	Comment
B1	GND	GND	Ground return	Can be up to 5 A split into four pins
B2	TX2+	TX2+	USB3.1datalines or Alternate	10-Gbyte RX differential pair in USB 3.1
B3	TX2-	TX2-		
B4	V _{BUS}	V _{BUS}	Bus power	Max power is 100 W split into four pins
B5	CC2 or V _{CONN}	V _{CONN}	Configuration channel or power for active or electronically marked cable	In V _{CONN} configuration, min power is 1 W
B6	D+	-	USB2.0datalines	-
B7	D-	-		-
B8	SBU2	SBU2	Sideband use (SBU)	Alternate mode only
B9	V _{BUS}	V _{BUS}	Bus power	Max power is 100 W split into four pins
B10	RX1-	RX1-	USB3.1datalines or Alternate	10-Gbyte RX differential pair in USB 3.1
B11	RX1+	RX1+		
B12	GND	GND	Ground return	Can be up to 5 A split into four pins

1.4 Full-featured Type-C cable

Full-featured Type-C cables are Type-C to Type-C cables that support USB2.0 and USB 3.1 data operation, and include SBU wires. They are Electronically Marked Cable and use USB PD to provide the cable characteristics. Up to 1 W drawn from V_{CONN} is requested to supply the electronics inside these cables.

1.5 V_{BUS} power options

V_{BUS} provides a path to deliver power between a host and a device and between a charger and a host/device. Power options available from a perspective of a device with a USB Type-C connector are listed in [Table 2](#).

Table 2. Power supply options

Mode of operation	Nominal voltage	Maximum current	Note
USB 2.0	5 V	500 mA	Default current based on specification
USB 3.1	5 V	900 mA	
USB BC1.2	5 V	up to 1.5 A	Legacy charging

Table 2. Power supply options (continued)

Mode of operation	Nominal voltage	Maximum current	Note
USB Type-C current at 1.5 A	5 V	1.5 A	Support high power devices
USB Type-C current at 3 A	5 V	3 A	
USB PD	up to 20 V	up to 5 A	Directional control and power level management

1.6 CC pins

There are two CC pins in receptacle but only one CC pin is connected through the cable to establish signal orientation and the other CC pin is reused as V_{CONN} for powering electronics inside USB Type-C cables.

On both CC1 and CC2, DFP must have Rp pull-up resistors, whereas UFP must have Rd pull-down resistors.

The full-featured cables have to provide impedance Ra to ground on V_{CONN} pin.

1.7 Plug orientation and cable twist detection

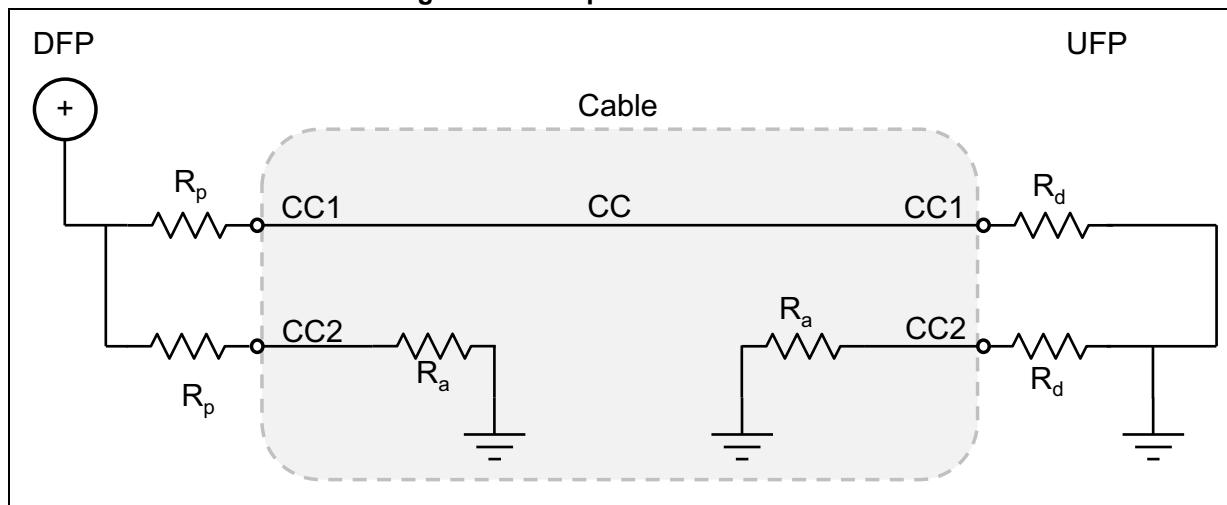
As USB Type-C plug can be inserted in the receptacle in either orientation, it is mandatory to first detect the orientation.

The detection is done through CC lines using Rp/Rd resistors.

Initially a DFP exposes Rp terminations on its CC pins and a UFP exposes Rd terminations on its CC pins.

To detect the connection, the DFP monitors both CC pins: when the cable is inserted it connects one CC line of the DFP to one CC line of the UFP.

If a full-featured cable is used, it exposes an Ra resistor on the UFP and DFP CC lines that are not directly connected together (see [Figure 5](#)).

Figure 5. Pull-up/down CC detection

1.8 Power capability detection and usage

The current supply capability of the port to the device depends on the R_p pull-up resistor value on DFP. A 5 A capability can be negotiated using the USB PD protocol.

Table 3 below shows the different possible values.

Table 3. DFP CC termination (R_p) requirements

V_{BUS} power	Current source to 1.7 V - 5.5 V	R_p pull-up to 4.75 V - 5.5 V	R_p pull-up to 3.3 V +/- 5%
Default USB power	80 μ A +/- 20%	56 k Ω +/- 20%(1)	36 k Ω +/- 20%
1.5 A at 5 V	180 μ A +/- 8%	22 k Ω +/- 5%	12 k Ω +/- 5%
3.0 A at 5 V	330 μ A +/- 8%	10 k Ω +/- 5%	4.7 k Ω +/- 5%

1.9 USB Power Delivery 2.0

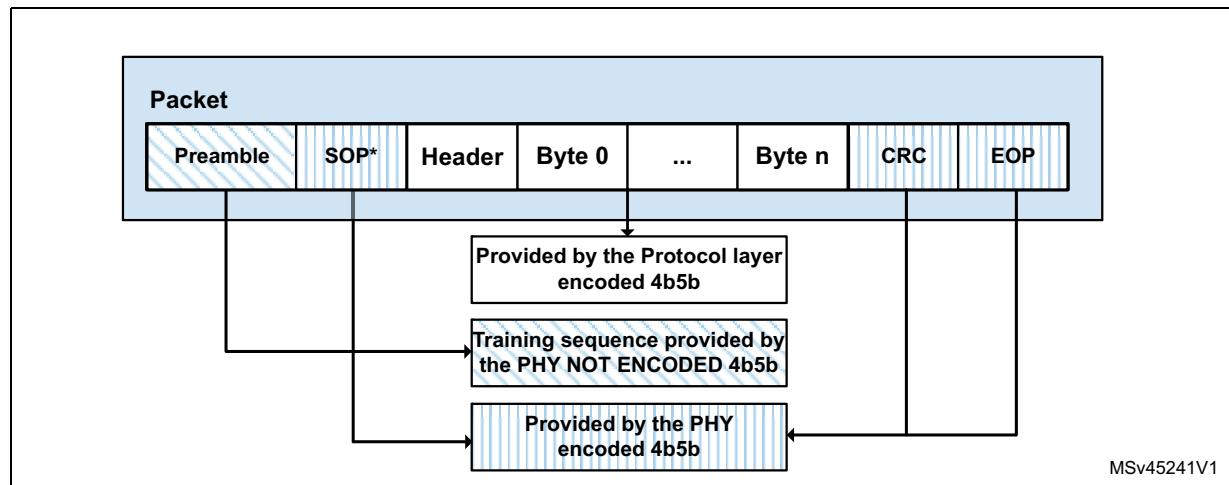
In USB PD 2.0, pairs of directly attached ports negotiate voltage, current and/or direction of power and data flow over the USB Type-C cable. The directly attached ports adopt the CC wire as the communication channel using the Biphase Mark Coding (BMC).

This mechanism operates independently of other USB methods used to negotiate power.

1.10 Packet structure

The USB PD packet format is shown in *Figure 6*.

Figure 6. USB PD packet format



The main parts of the packet are:

- Preamble: 64-bit sequence of alternating 0s and 1s to sync up with transmitter.
- SOP* is the start of the packet. It can be SOP, SOP' (start of packet sequence prime) or SOP" (start of packet sequence double prime):
 - SOP packets shall be limited to PD capable DFP and UFP only
 - SOP' packets are used for communication with cable plug attached to the DFP
 - SOP" packets are used for communication with cable plug attached to the UFP
- Message data including message header which identifies the type of packet and the amount of data
- CRC: error checking
- EOP (end of packet): unique identifier

A cable plug capable of SOP' or SOP" communication shall only detect and communicate with packets starting with SOP' or SOP", as reported in [Figure 7](#).

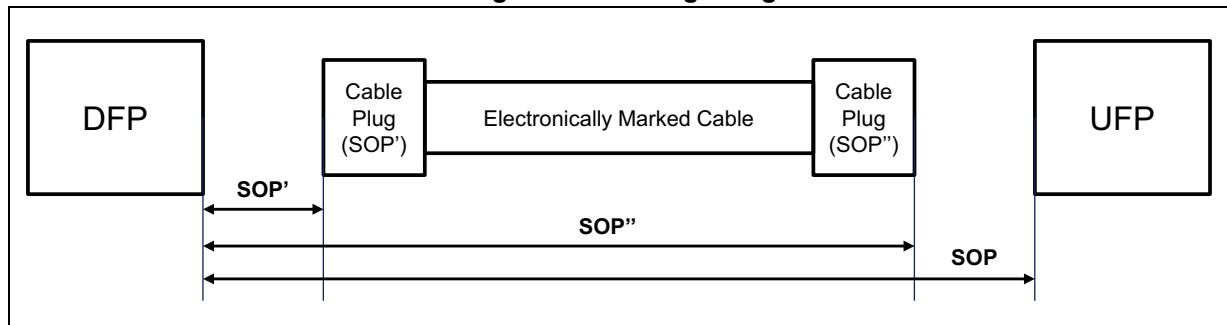
The protocol uses start-of-packet (SOP) communications, each of which begins with a set of encoded symbol called K-code.

The SOP communication allows control or data messages.

The control message has a fixed size and is used to manage the data flow.

The data message size varies depending on its contents. It provides information on data objects.

Figure 7. SOP* signaling



1.11 Negotiating power

DFP is initially considered as a bus master.

The default voltage on V_{BUS} is always 5 V and can be reconfigured, through USB PD messaging, up to 20 V.

The default current capability is initially defined by R_p value and can be reconfigured up to 5 A. A current of more than 3 A requires an electronically marked USB PD Type-C cable.

The protocol allows the power configuration to be dynamically modified.

It is also possible to perform a Power Role swap to exchange the power supply roles such that the DFP receives power and the UFP supplies power. For a Type-C connector it is possible to perform a Data Role swap such that the DFP becomes the UFP and vice-versa and to perform a V_{CONN} swap to change the partner supplying V_{CONN} to the cable.

1.12 Alternate Modes

All the hosts and devices (except chargers) using a USB Type-C receptacle shall expose a USB interface.

If the host or device optionally supports Alternate Modes:

- The host and device shall use USB PD Structured Vendor Defined Messages (Structured VDMs) to discover, configure and enter/exit modes to enable Alternate Modes.
- Where no equivalent USB functionality is implemented, the device shall provide a USB interface exposing a USB Billboard Device Class used to provide information needed to identify the device. A device is not required to provide a USB interface exposing a USB Billboard Device Class for non-user facing modes (for example diagnostic modes).

As Alternate Modes do not traverse the USB hub topology, they shall only be used between directly connected host and device.

1.12.1 Alternate pins reassignment

In the [Figure 8](#), pins highlighted in yellow are the only pins that shall be reconfigured in a full-featured cable.

Figure 8. Pins available for reconfiguration over the full-featured cable

A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
GND	RX2+	RX2-	V _{BUS}	SBU1	D-	D+	CC1	V _{BUS}	TX1-	TX1+	GND
GND	TX2+	TX2-	V _{BUS}	V _{CONN}			SBU2	V _{BUS}	RX1-	RX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
Pins available for reconfiguration											

MSv45242V1

[Figure 9](#) shows pins available for reconfiguration for direct connect applications. There are three pins more than in previous figure because this configuration is not limited by the cable wiring.

Figure 9. Pins available for reconfiguration for direct connect applications

A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1
GND	RX2+	RX2-	V _{BUS}	SBU1	D-	D+	CC1	V _{BUS}	TX1-	TX1+	GND
GND	TX2+	TX2-	V _{BUS}	V _{CONN}			SBU2	V _{BUS}	RX1-	RX1+	GND
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
Pins available for reconfiguration											

MSv45243V1

1.12.2 Billboard

The USB Billboard Device Class definition describes the methods used to communicate the Alternate Modes supported by a Device Container to a host system.

This includes string descriptors that can be used to provide support details in a human-readable format.

For more details, refer to *USB Device Class Definition for Billboard Devices rev1.0a April 15, 2015*.

2 System architecture

The P-NUCLEO-USB001 is a development pack that permits to implement solutions based on the USB Type-C and the USB PD technologies. It is fully configurable for implementing and supporting several configurations like Provider, Consumer or Dual Role Power (DRP).

The P-NUCLEO-USB001, together with the USB-IF certified STM32F0 USB PD middleware stack (X-CUBE-USB-PD), permits to control two USB Type-C ports using a single STM32F0 32-bit ARM® Cortex®-M0 microcontroller. A simple Analog-Front-End PHY is used to interface the STM32F072RBT6 MCU with the Configuration Channels (CC lines) of the Type-C™ receptacles and allows communicating over those lines using the PD communication protocol.

STM32 USB PD middleware stack is compliant with the USB Type-C 1.2 and PD 2.0 specifications (refer to [Section 7](#)).

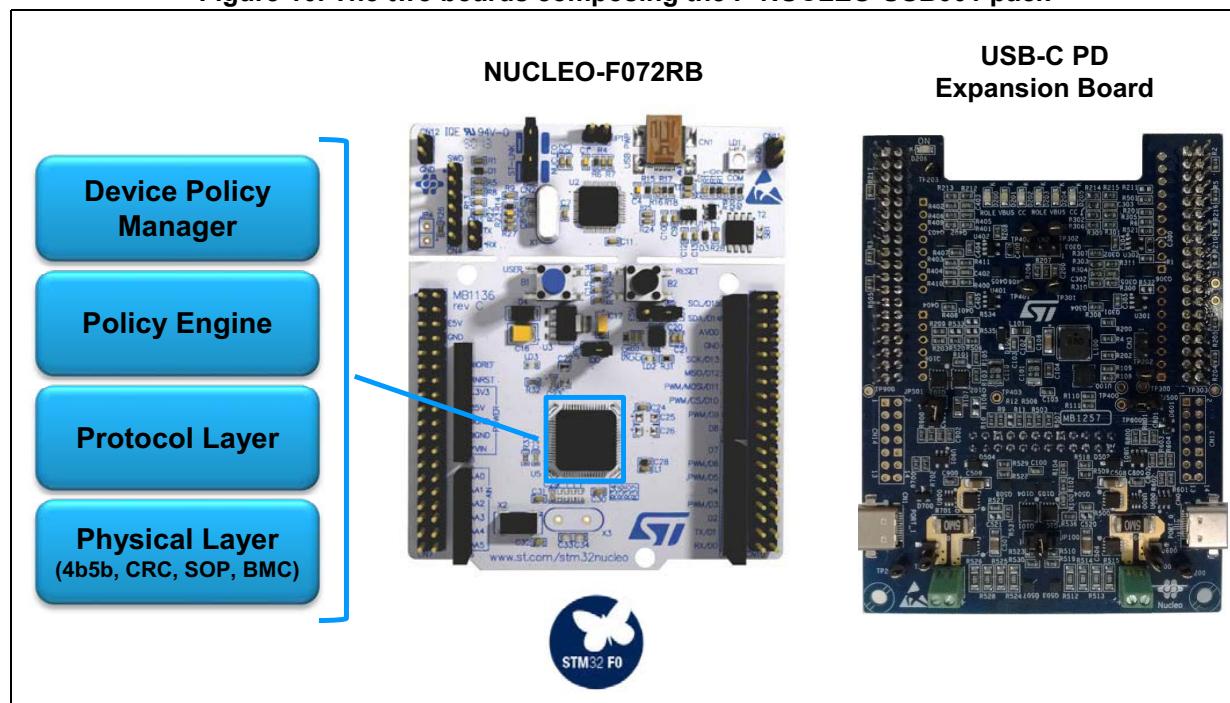
2.1 Hardware description

This section describes the hardware components of the pack (see [Figure 10](#)):

- A NUCLEO-F072RB Nucleo board specifically customized to exploit all the peripherals needed to serve the PD application. This board represents the control block where the stack is running.
 - The MB1257 expansion board implementing the USB Type-C interface.
 - A USB Type-C full-featured cable.

The following sub-sections describe the individual components.

Figure 10. The two boards composing the P-NUCLEO-USB001 pack

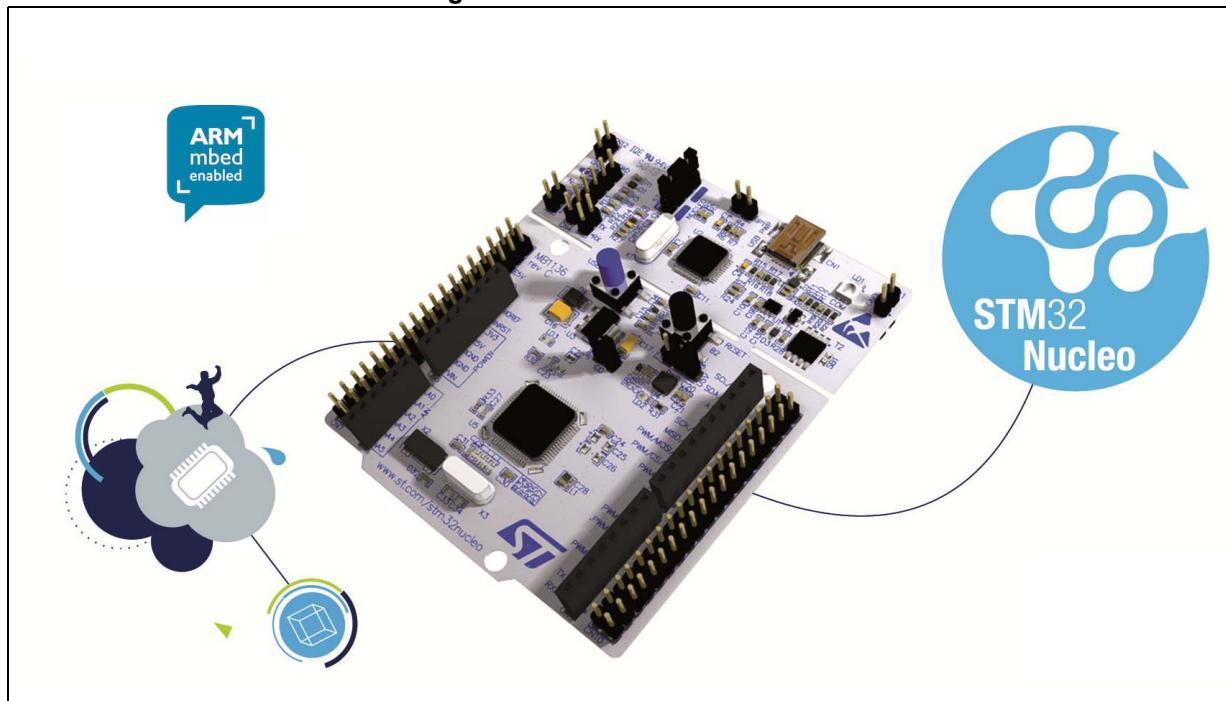


2.2 NUCLEO-F072RB board

The STM32 Nucleo board (see [Figure 11](#)) provides an affordable and flexible way for users to try out new ideas and build prototypes with any STM32 microcontroller. The Arduino™ connectivity support and the ST morpho headers expand the functionality of the STM32 Nucleo open development platform with a wide choice of specialized expansion boards. The STM32 Nucleo board does not require any separate probes as it integrates the ST-LINK/V2-1 debugger/programmer. The STM32 Nucleo board comes with the STM32 comprehensive software HAL library together with various packaged software examples.

Information about the STM32 Nucleo boards is available on st.com at the <http://www.st.com/stm32nucleo> webpage.

Figure 11. STM32 Nucleo board



The NUCLEO-F072RB Nucleo board embeds an STM32F072RBT6 MCU, a 32-bit microcontroller based on ARM® Cortex®-M0 with 128-Kbyte Flash memory and 16-Kbyte SRAM. These characteristics, together with its peripheral set, makes it eligible to run the appropriately designed STM32 USB-C PD middleware stack (X-CUBE-USB-PD).

The STM32F072RBT6 is equipped with a USB2.0 full-speed data interface as peripheral.

The NUCLEO-F072RB board embeds the ST morpho extension pin headers for full access to all STM32 I/Os, and an on-board ST-LINK/V2-1 debugger/programmer with SWD connector able to manage the serial communication with the application MCU (STM32F072RBT6).

Specifically for the USB PD application, the NUCLEO-F072RB Nucleo board contained in the P-NUCLEO-USB001 pack has been customized, modifying the solder bridges configuration characterizing the standard STM32 Nucleo board. So that the STM32F072RBT6 microcontroller embedded in the board, is eligible to run the USB PD

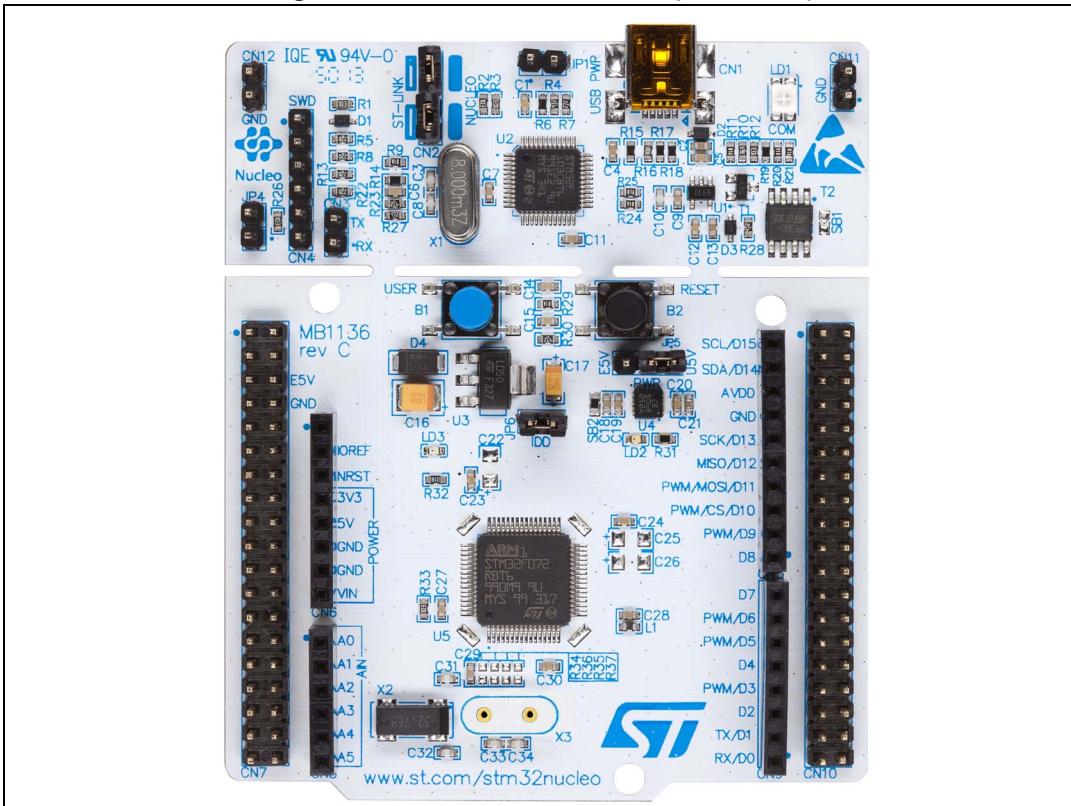
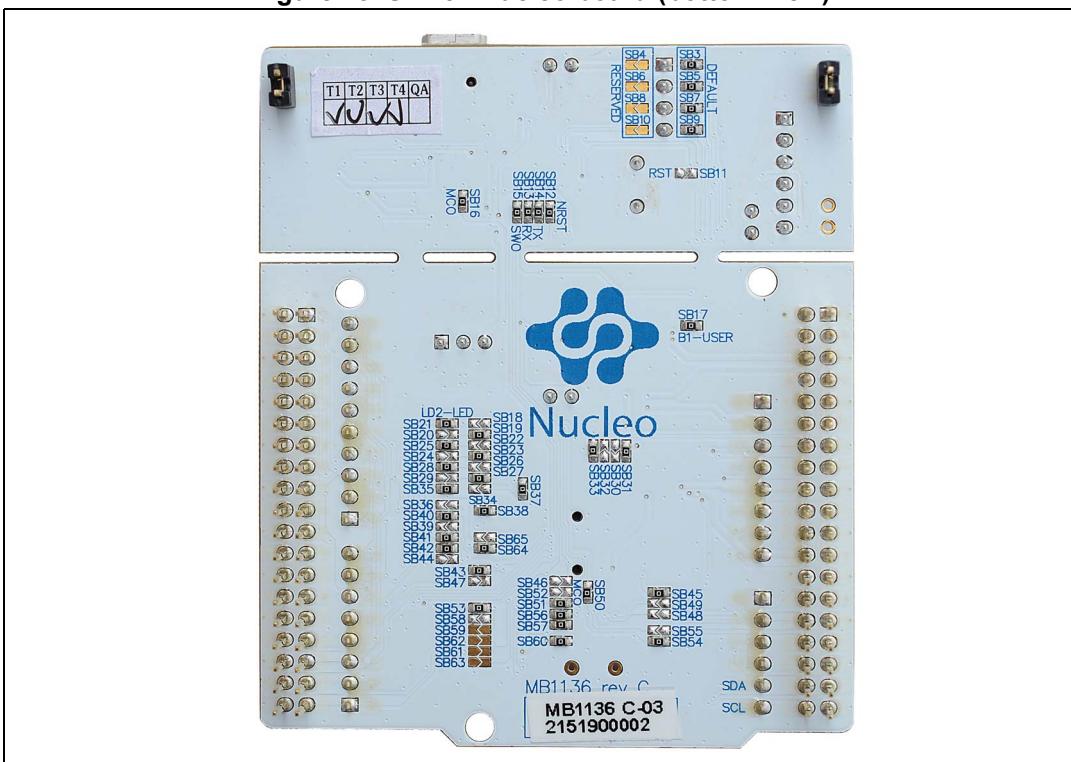
middleware stack X-CUBE-USB-PD in association with the USB-C PD expansion board MB1257.

The following *Table 4* reports the complete list of the solder bridges and resistances to be modified on the front side and on the back side of the NUCLEO-F072RB Nucleo board (see *Figure 12* and *Figure 13*).

For further information refer to *STM32 Nucleo-64 boards user manual (UM1724)* available at the www.st.com website.

Table 4. Solder bridges and resistors to be modified

Bridge Reference	State	Description
SB13	OFF	PA2 and PA3 on STM32F103CBT6 (ST-LINK MCU) are disconnected from PA3 and PA2 of the STM32F072RBT6 MCU.
SB14		
SB15	OFF	The SWO signal is not connected to PB3 on STM32F072RBT6 MCU.
SB21	OFF	Green user LED LD2 is not connected to PA5 on STM32F072RBT6 MCU.
R34	OFF	LSE not used: PC14 and PC15 used as GPIOs instead of low speed clock.
R36		
SB48	ON	To connect another USART (not the default USART2) to ST-LINK MCU, using flying wires between ST morpho connector and CN3. SB13 and SB14 should be OFF.
SB49		
SB62	ON	To connect another USART (not the default USART2) to ST-LINK MCU, using flying wires between ST morpho connector and CN3. SB13 and SB14 should be OFF.
SB63		

Figure 12. STM32 Nucleo board (front view)**Figure 13. STM32 Nucleo board (bottom view)**

2.3 MB1257 expansion board

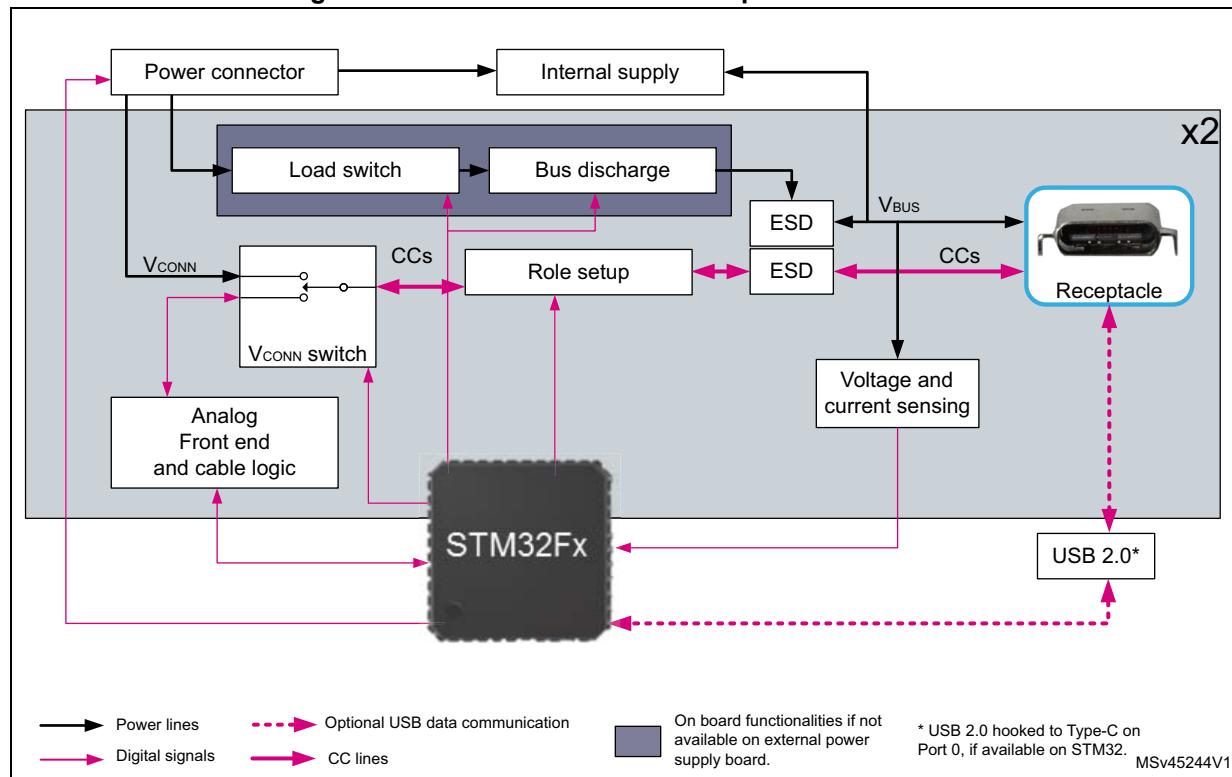
The MB1257 expansion board embeds two Dual-Role Power USB Type-C ports with their relative discrete Analog-Front-End Physical Layer (PHY). This board permits to exploit the robustness of the digital receiver obtained by a discrete design and, at the same time, to guarantee the low-power operation.

To support the USB PD protocol and preserve the completeness, MB1257 board needs to exploit high flexibility. Thus in the MB1257 board, a USB Type -C port is a subsystem composed by different stages, each one accomplishing a specific feature of PD protocol. The most peculiar blocks implementing a port are:

- The USB Type-C receptacles
- V_{BUS} current and voltage sensing stages
- The Analog-Front-End stage
- CC signal management
- The V_{CONN} switch blocks
- The V_{BUS} Port switch
- The V_{BUS} discharge mechanism

The [Figure 14](#) depicts the block scheme of the complete architecture, including all the main interactions between the STM32F072RBT6 MCU and the main functional blocks outlined so far.

Figure 14. Block scheme of the complete architecture



The MB1257 expansion board is today available in two revisions named:

- MB1257 Revision B or MB1257B (shown in the [Figure 15](#) and [Figure 17](#))
- MB1257 Revision C or MB1257C (shown in the [Figure 16](#))

The differences between the MB1257 Revision B and the MB1257 Revision C are discussed in [Section 5](#) and are mainly related to minor BOM and HW changes done to improve performances and compliances to the last certification rules of following building blocks:

- CC Analog-Front-End and CC management (see [Section 2.5](#))
- V_{CONN} switches (see [Section 2.5](#))
- V_{BUS} management and discharge mechanism (see [Section 2.7](#))

User may encounter some differences when running one of available version of X-CUBE-USB-PD middleware stack on these platforms.

The following subsections briefly describe the main functional blocks that characterize the USB C PC application, including their connectors and jumpers. The description of the block refers to PORT_0 as example, but all the assumptions are the same for the other port.

Figure 15. MB1257B main connectors and jumpers for setting

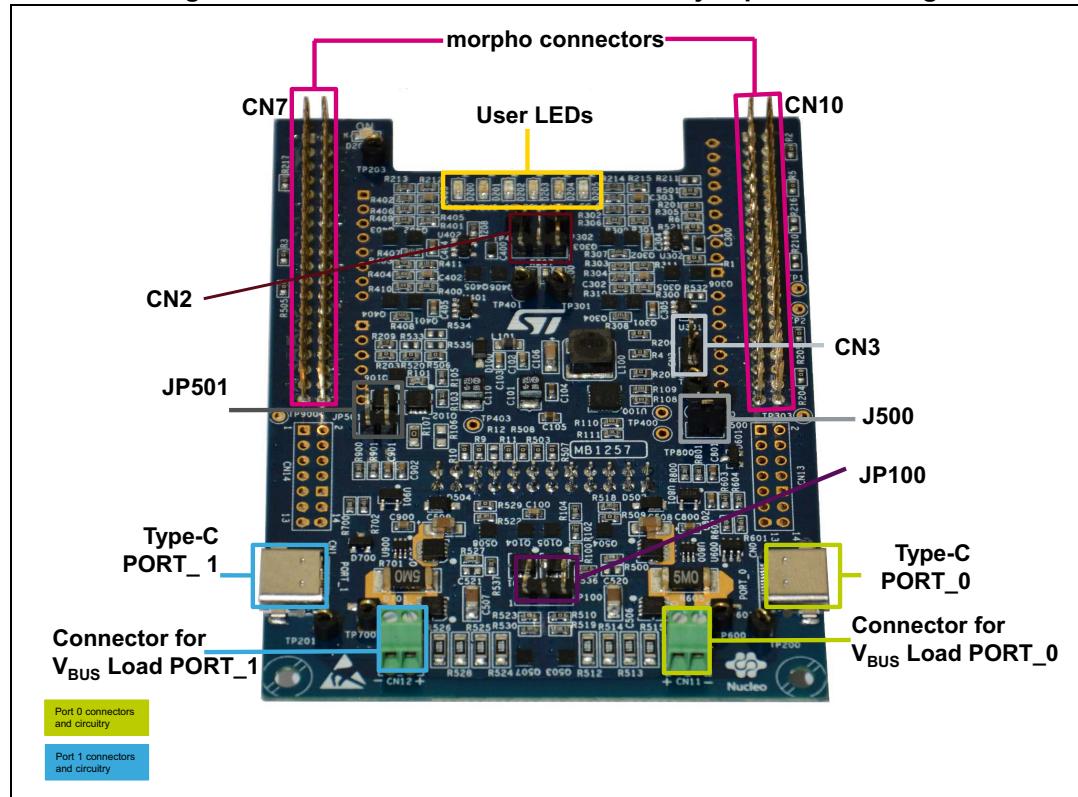


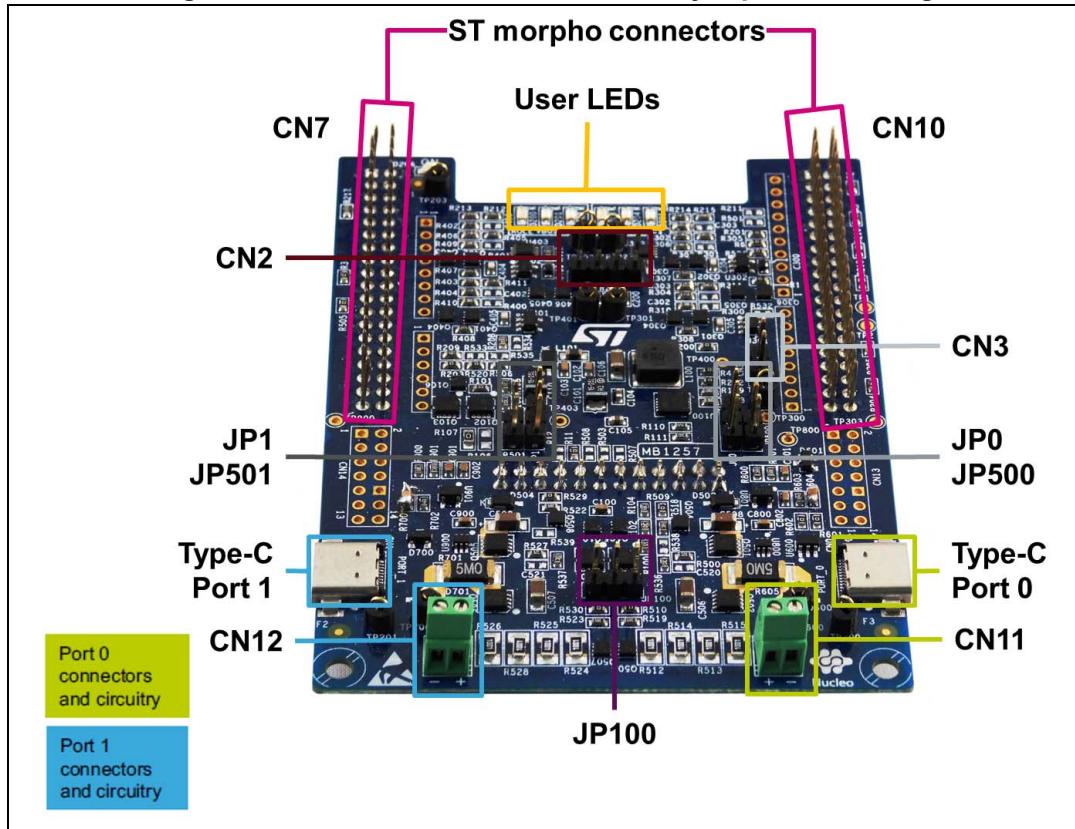
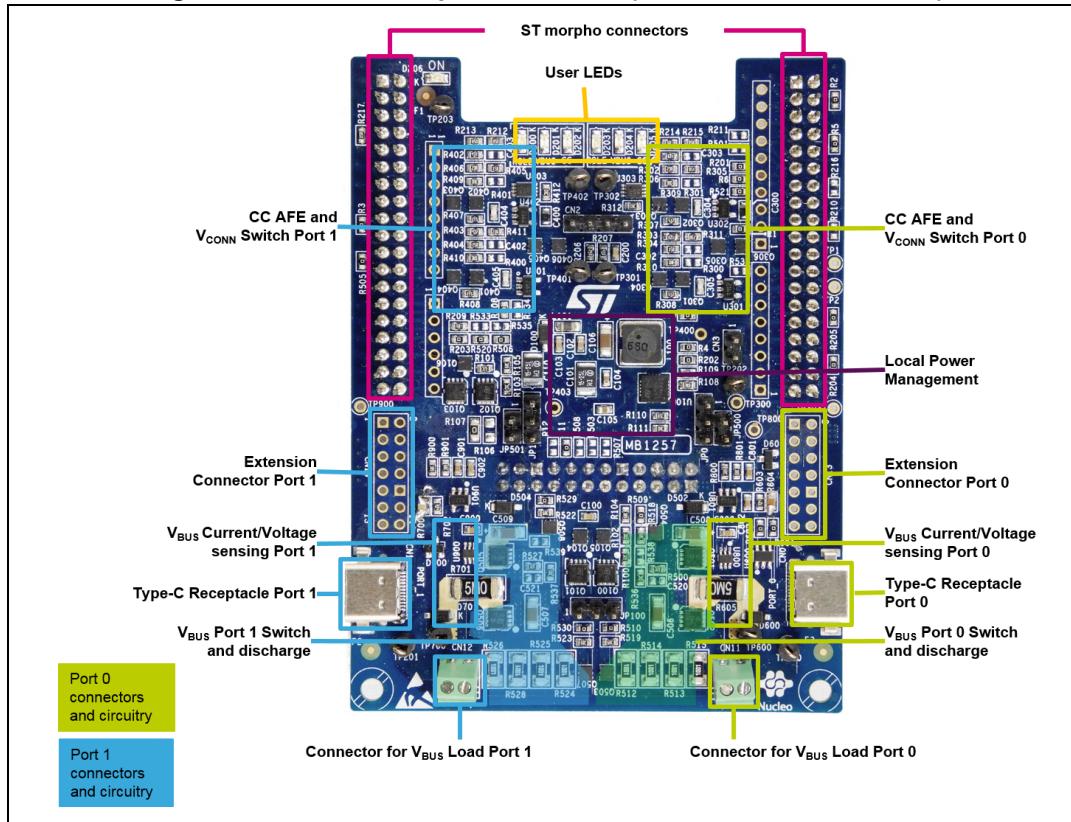
Figure 16. MB1257C main connectors and jumpers for setting

Figure 17. MB1257B expansion board (view of the main blocks)



The MB1257B expansion board and its silkscreen layout are shown in [Figure 18](#), [Figure 20](#), [Figure 21](#) and [Figure 23](#). For the MB1257C board and silkscreen layout refer to [Figure 19](#), [Figure 20](#), [Figure 22](#) and [Figure 23](#).

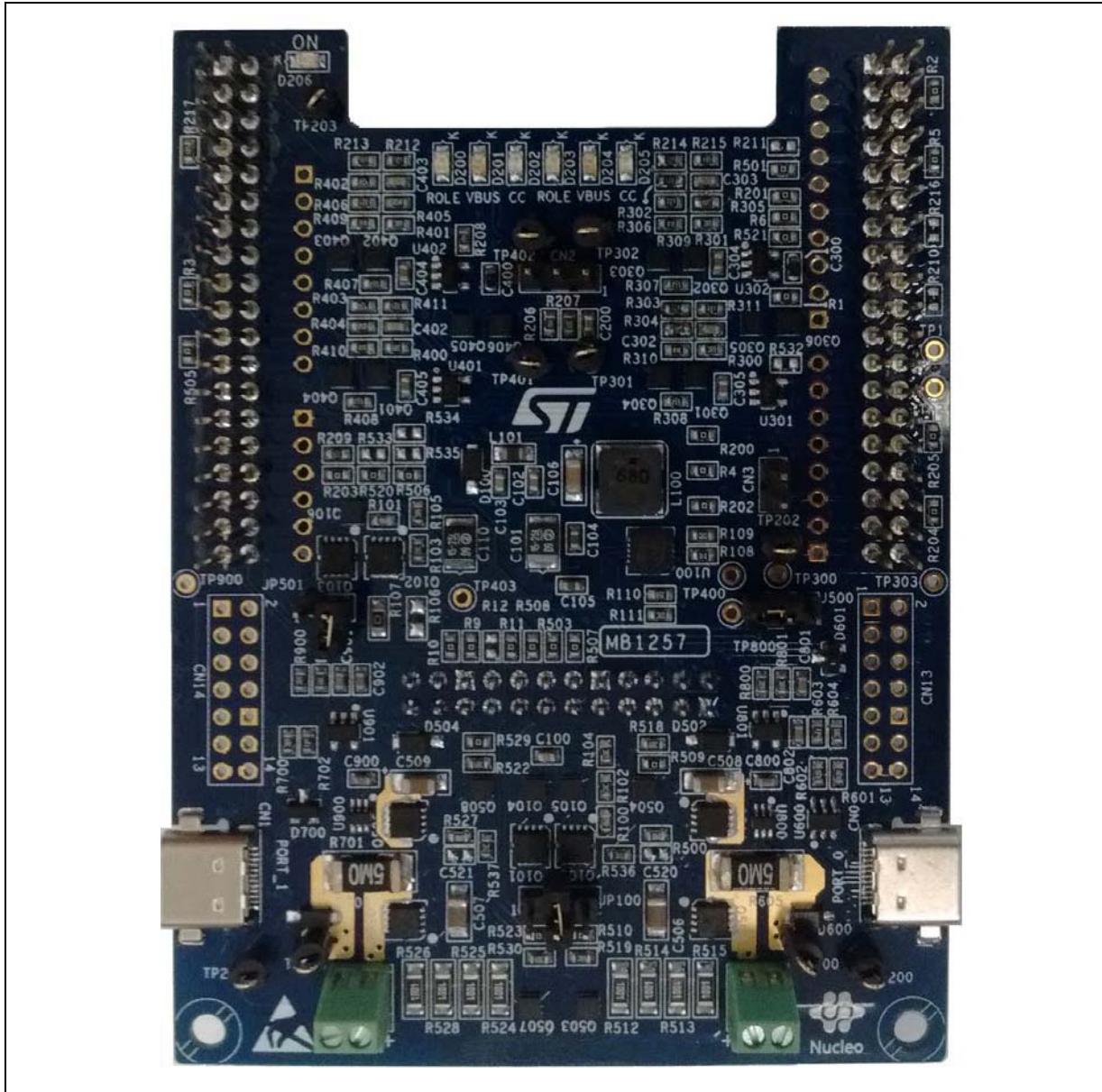
Figure 18. MB1257B expansion board (top view)

Figure 19. MB1257C expansion board (top view)

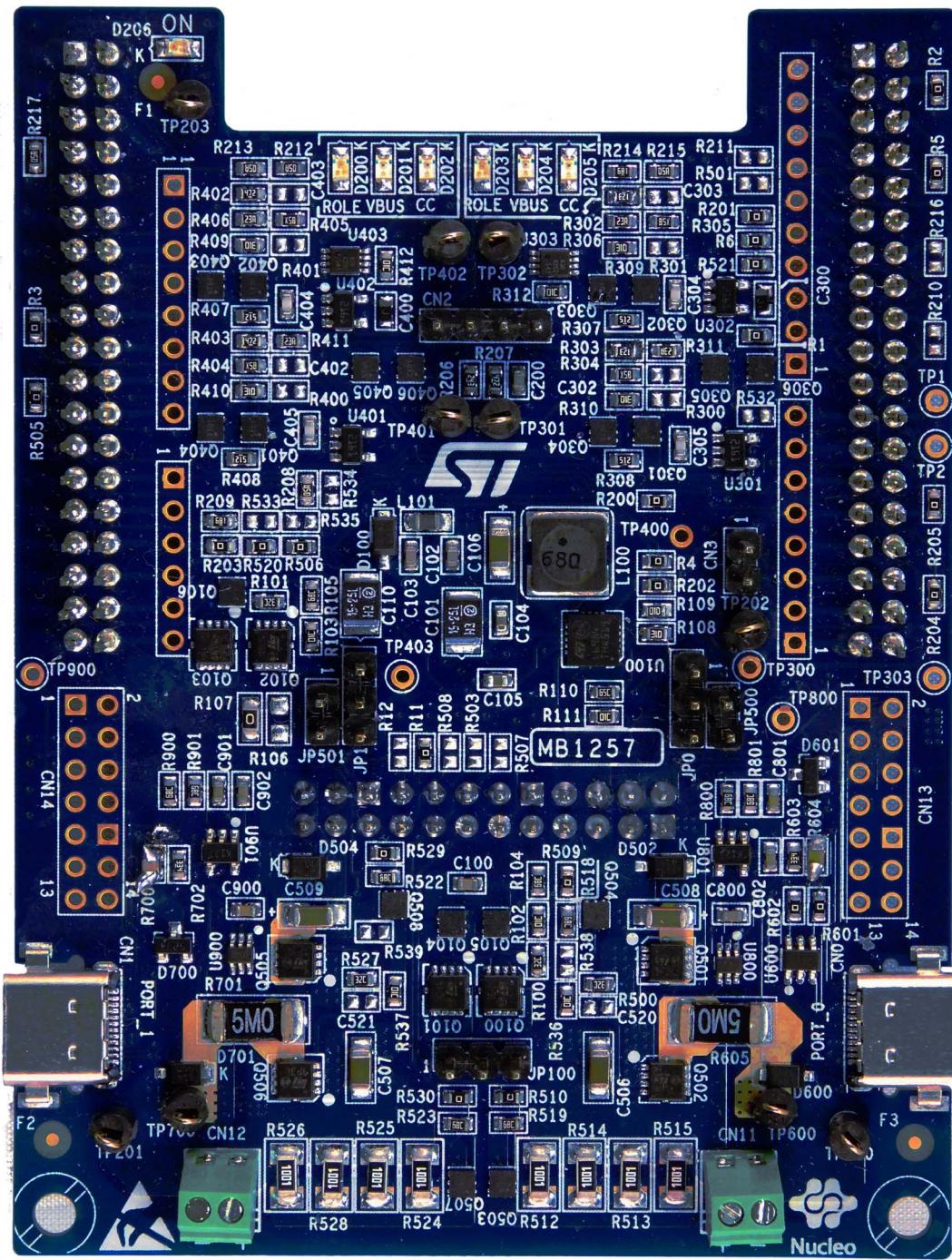


Figure 20. Bottom view of the MB1257B and MB1257C the expansion boards

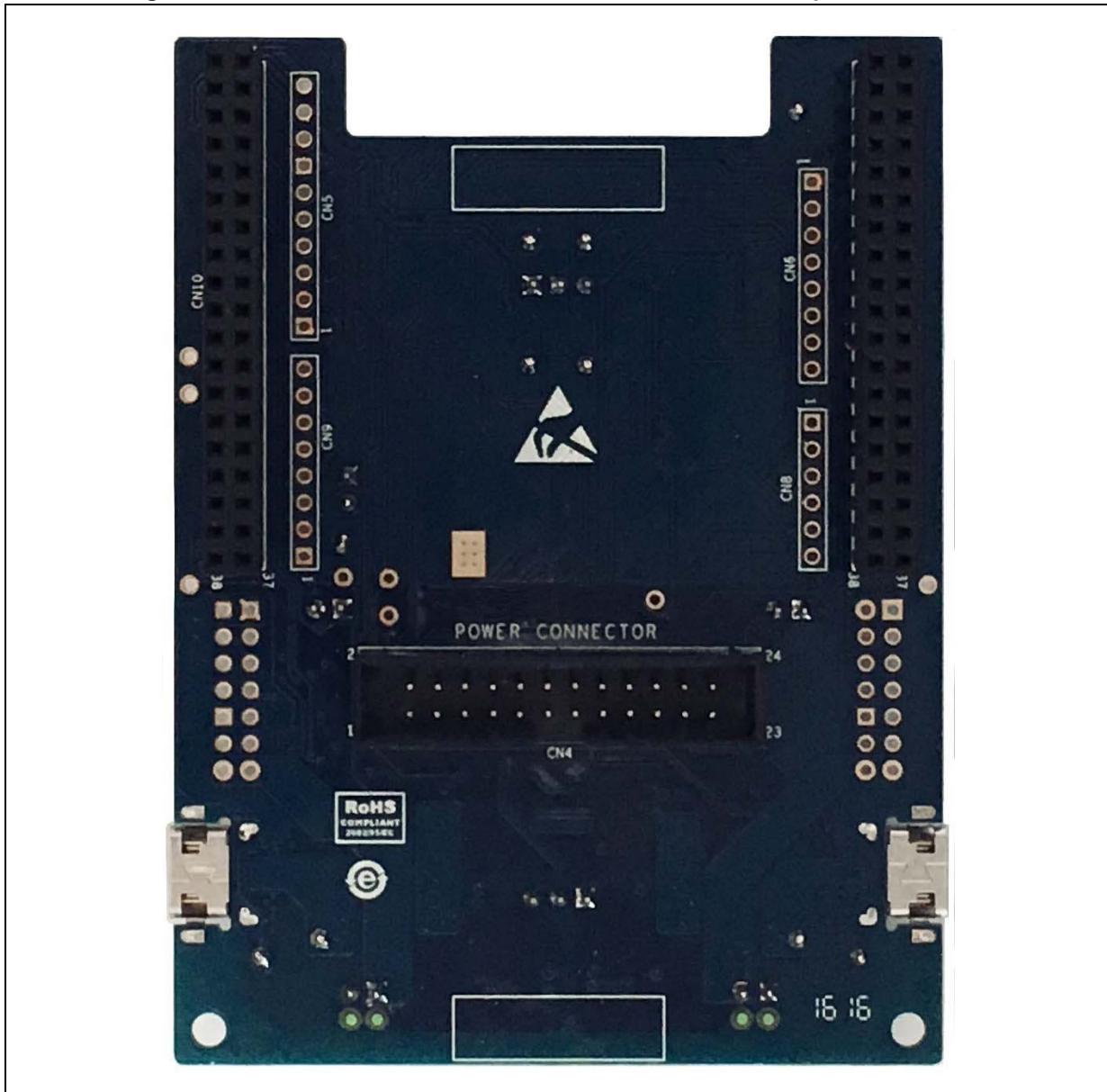


Figure 21. MB1257B expansion board, silkscreen layout (top view)

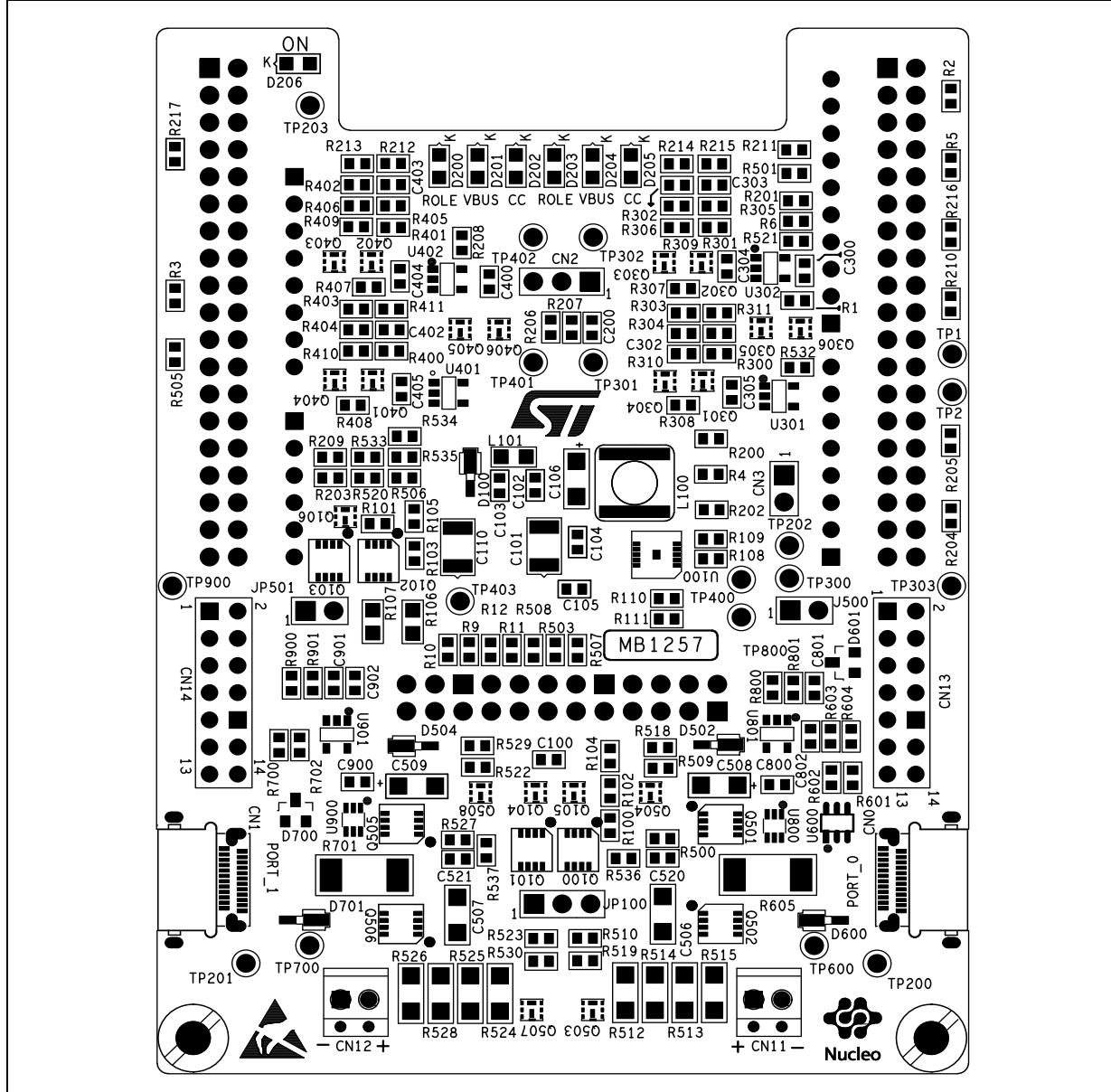


Figure 22. MB1257C expansion board, silkscreen layout (top view)

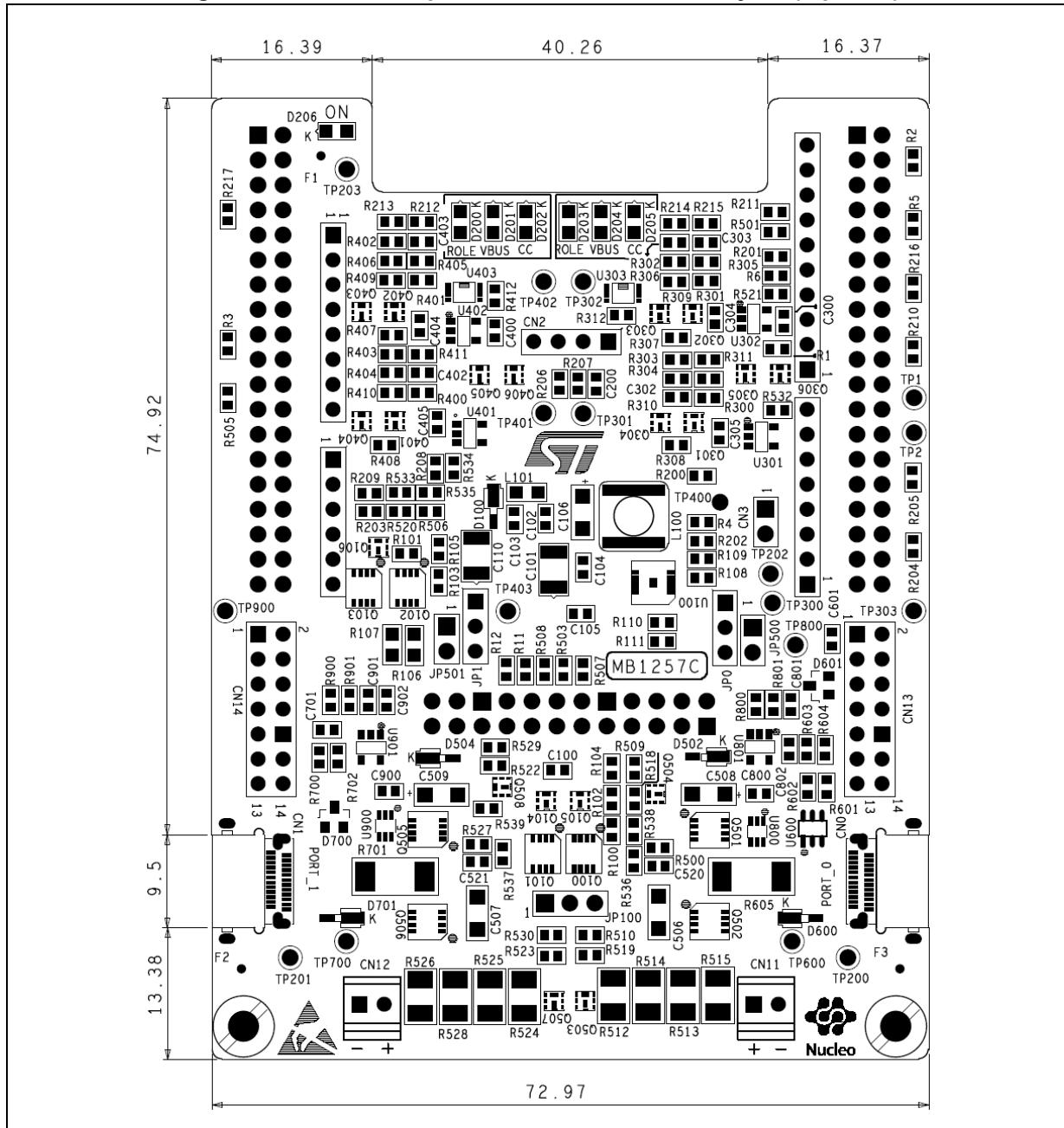
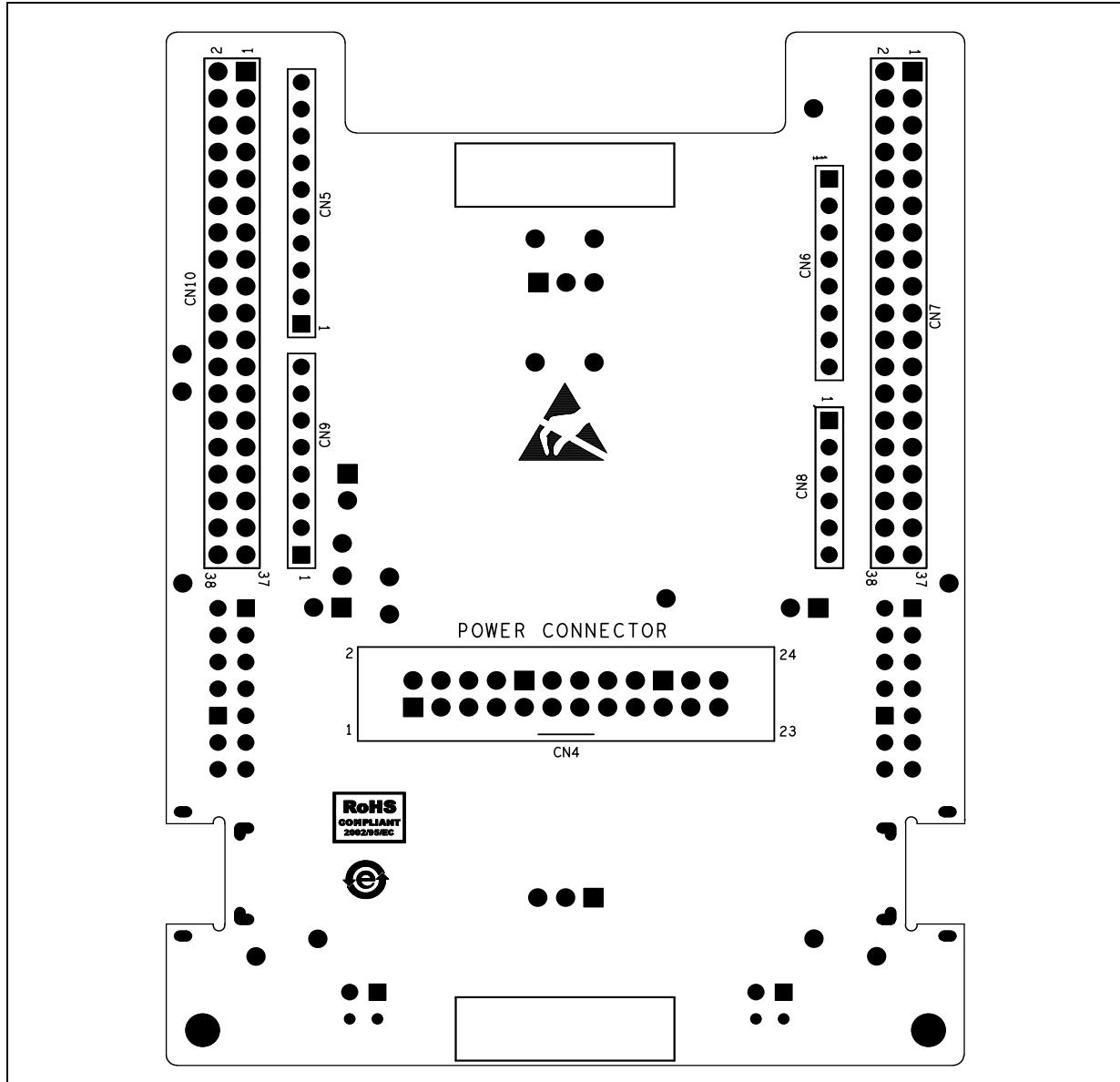


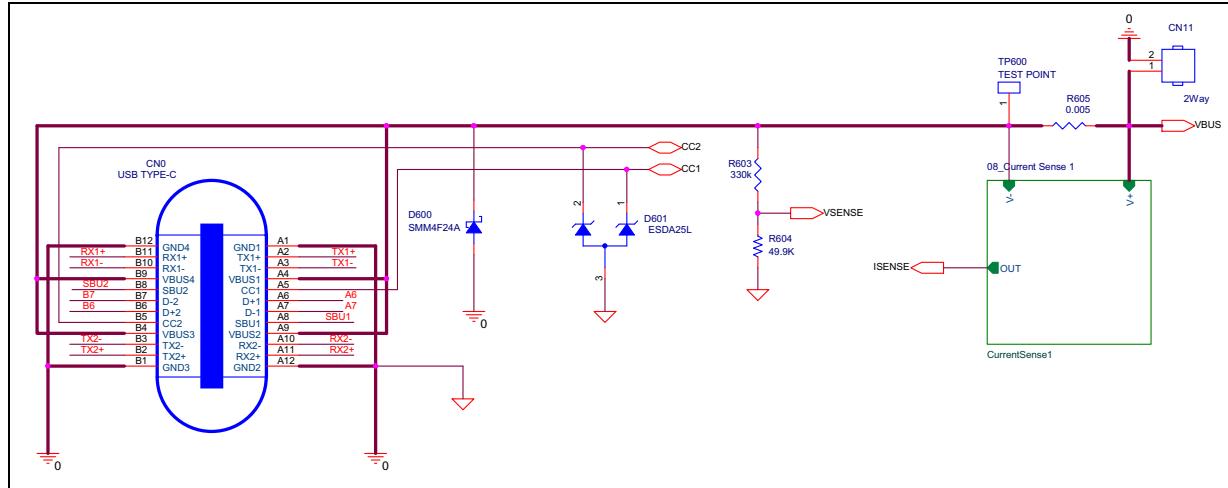
Figure 23. Bottom view of the silkscreen layout for MB1257B and MB1257C expansion boards



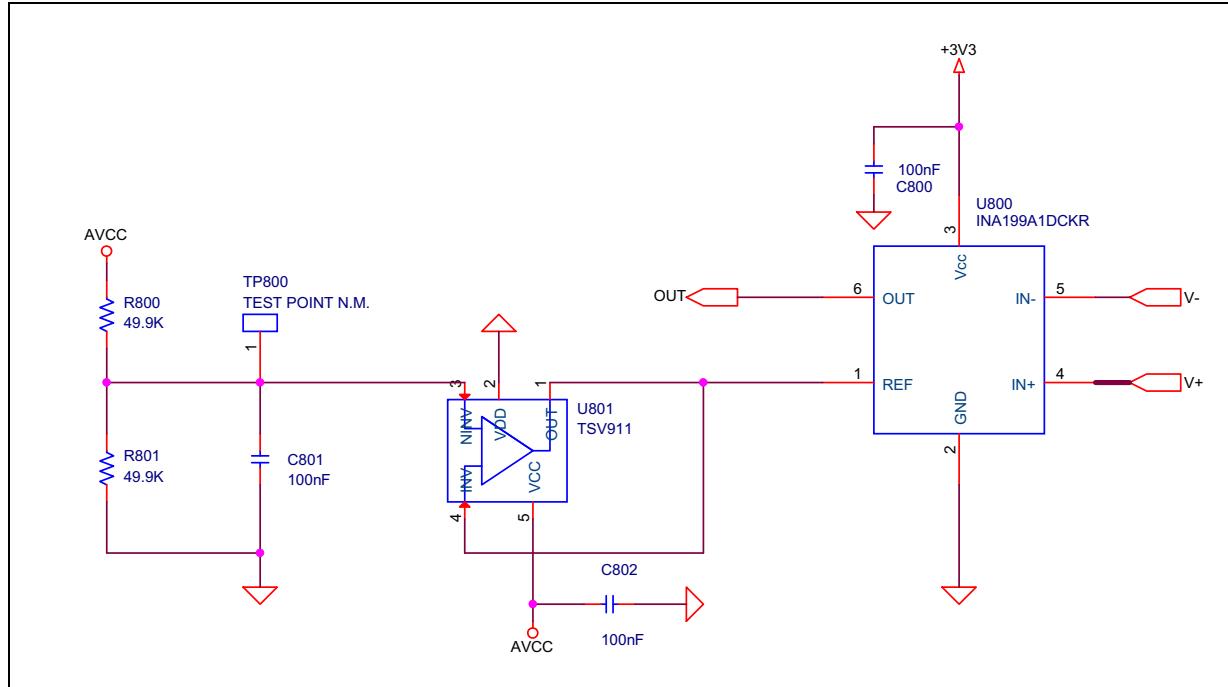
2.4 MB1257: USB Type-C receptacle and current-sense stage

Two USB Type-C certified receptacles, CN0 and CN1, are present on the MB1257 board, representing respectively the PORT_0 and PORT_1. Both ports are eligible to supply another platform plugged by a USB Type-C cable when they are configured as Provider or, otherwise, to be supplied in case of Consumer configuration.

Figure 24 shows the USB Type-C receptacle pinout on the MB1257x schematic (also see [Section 1.3](#)).

Figure 24. MB1257B (PORT_0): schematic view of the receptacle and voltage-sensing stage

As represented in [Figure 24](#) and [Figure 25](#) each port is equipped with voltage and current-sensing stages managed by the ADC peripheral. These allow to monitor the power level applied on each port.

Figure 25. MB1257 (PORT_0): schematic view of the current-sensing stage

The MB1257C V_{BUS} sensing has been improved by changing values of the resistors composing the voltage divider R603/R604; furthermore a filtering capacitance has been added in parallel of R604 (see [Section 5.2](#)).

2.5 CC Analog Front-End and CC management

As described by the USB-C PD specification, the power role of a port (either Provider or Consumer) depends, at hardware level, on a resistance value exposed to the other partner connected by the USB Type-C cable. Therefore, the STM32F072RBT6 MCU is eligible to manage the configuration of the Analog Front-End block, to select the assigned role see [Figure 26](#), [Figure 27](#) and [Figure 28](#) that show the main stages that this function carries out.

Figure 26. MB1257B (PORT_0): schematic view of the Analog Front-End

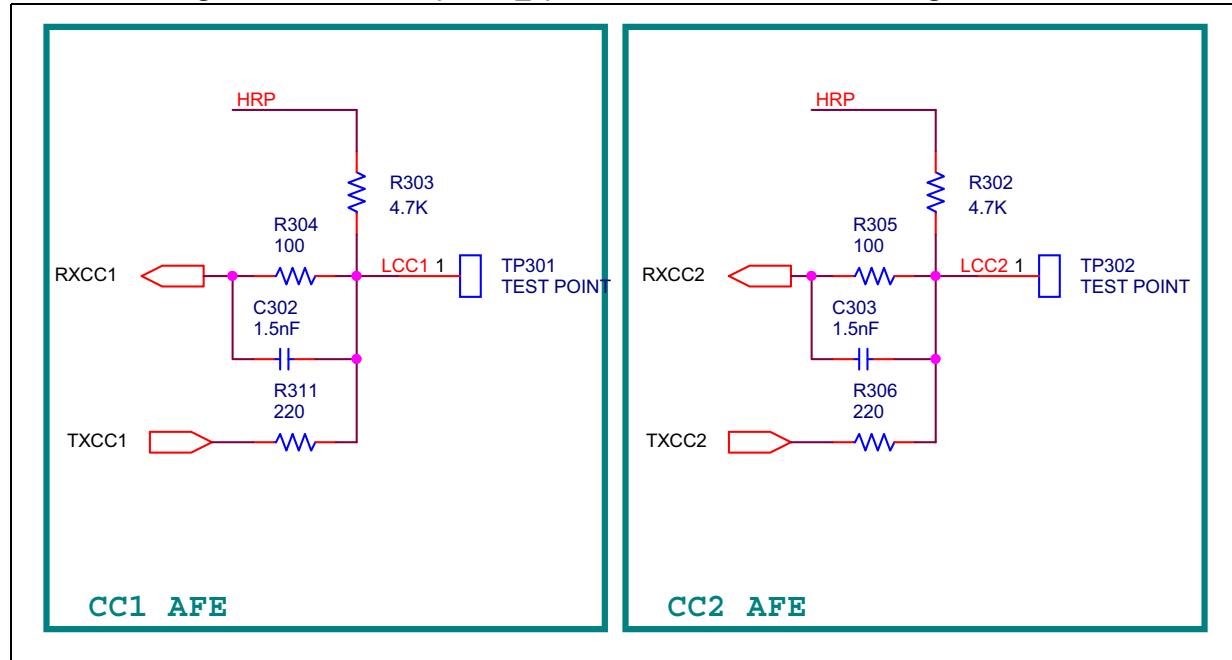


Figure 27. MB1257C (PORT_0): schematic view of the Analog Front-End

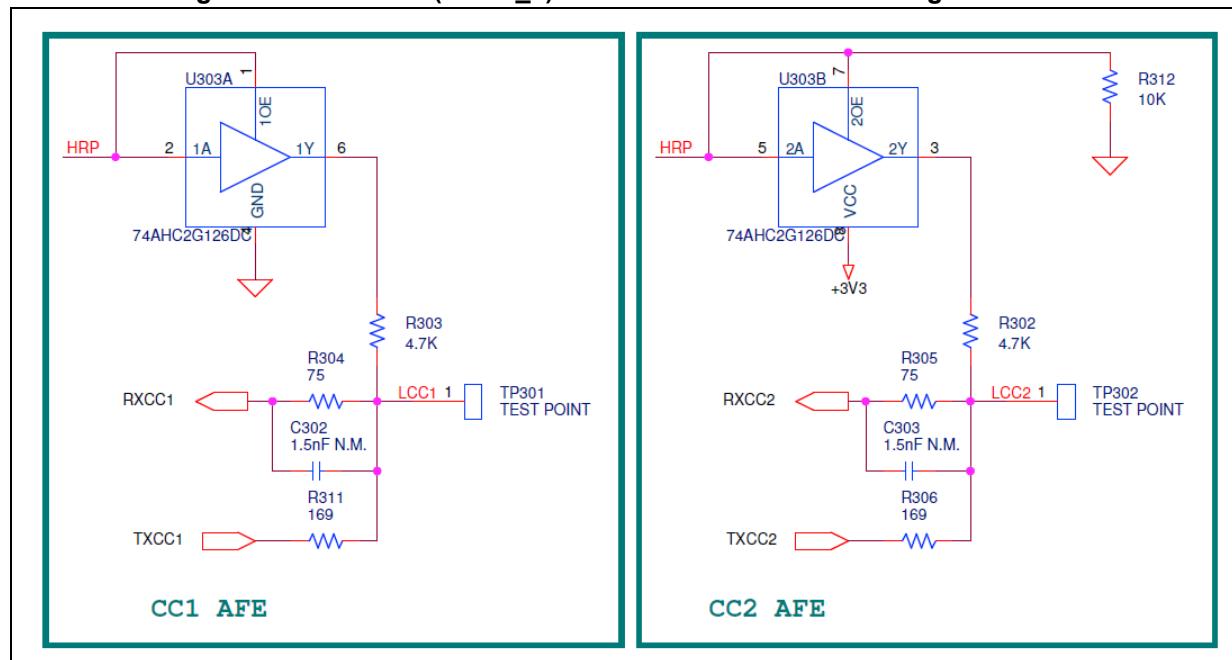
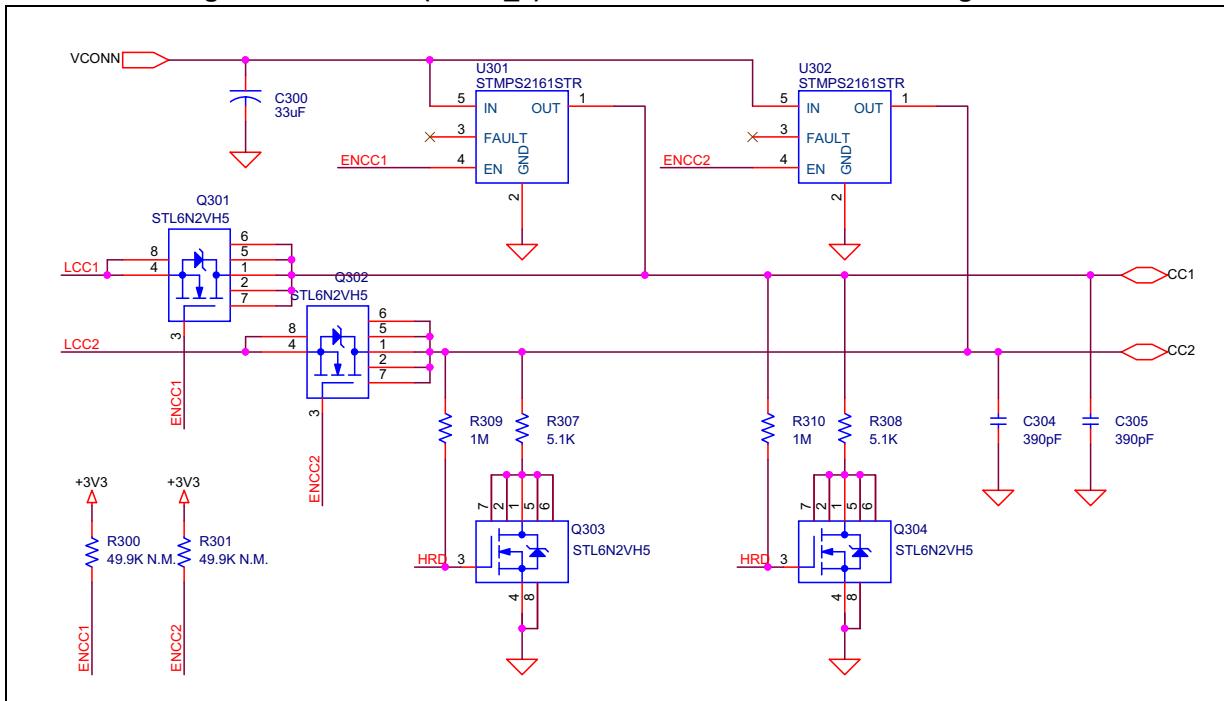


Figure 28. MB1257 (PORT_0): schematic view of the CC management



The HRP and HRD signals are used for the role assignment:

- When the designated port must be configured as Provider, the STM32F072RBT6 MCU sets high the HRP ([Figure 26](#) for MB1257B or [Figure 27](#) for MB1257C) and sets low the HRD ([Figure 28](#)). In this way, a pull-up with 4.7 k Ω Rp resistance (R303 for the CC1 line or R302 for the CC2 line) is exposed on the CC lines.
- If the designated port must be configured as Consumer, the STM32F072RBT6 MCU sets HRP low ([Figure 26](#) for MB1257B or [Figure 27](#) for MB1257C) for releasing the Rp resistance in the CC line Analog Front-End stage, and sets high the HRD pin (related to the Q303 and Q304 MOSFETs in [Figure 28](#)). This operation exposes the 5.1 k Ω Rd resistance on CC lines (R308 for the CC1 line or R307 for the CC2 line).

In both cases the CC enable command (labelled as ENCC1 or ENCC2 in [Figure 28](#)) are set high to allow CC lines to be connected to the MCU.

Buffers U303 and U403 on MB1257C are used to avoid unwanted cross-communication and offsets on CC lines through Rp. When HRP is set high ([Figure 27](#)), the Rp are connected to the CC lines while when it is low buffers set their output in high impedance so that Rp are not seen on CC lines anymore.

The CC line selection is first mechanically-driven by the cable insertion in the receptacle and then managed by the STM32F072RBT6 MCU, through the Cable Attach/Detach mechanism.

In fact, the STM32F072RBT6 MCU sets high the ENCC1 e ENCC2 pins on Q301 and Q302 ([Figure 28](#)), and then it checks the voltage on LCC1 and LCC2 ([Figure 26](#) for MB1257B or [Figure 27](#) for MB1257C) by its ADC peripherals, identifying the CC line selected for the communication.

About the communication aspect, the STM32F072RBT6 MCU enables the transmission on the CC lines managing the resistor divider on R311/R304 (CC1) or R306/R305 (CC2), and the ENCC1 or ENCC2 pins for selecting CC lines.

Values of passives in the MB1257C AFEs have been tuned to improve performances of the PHY.

2.6 MB1257 V_{CONN} switches

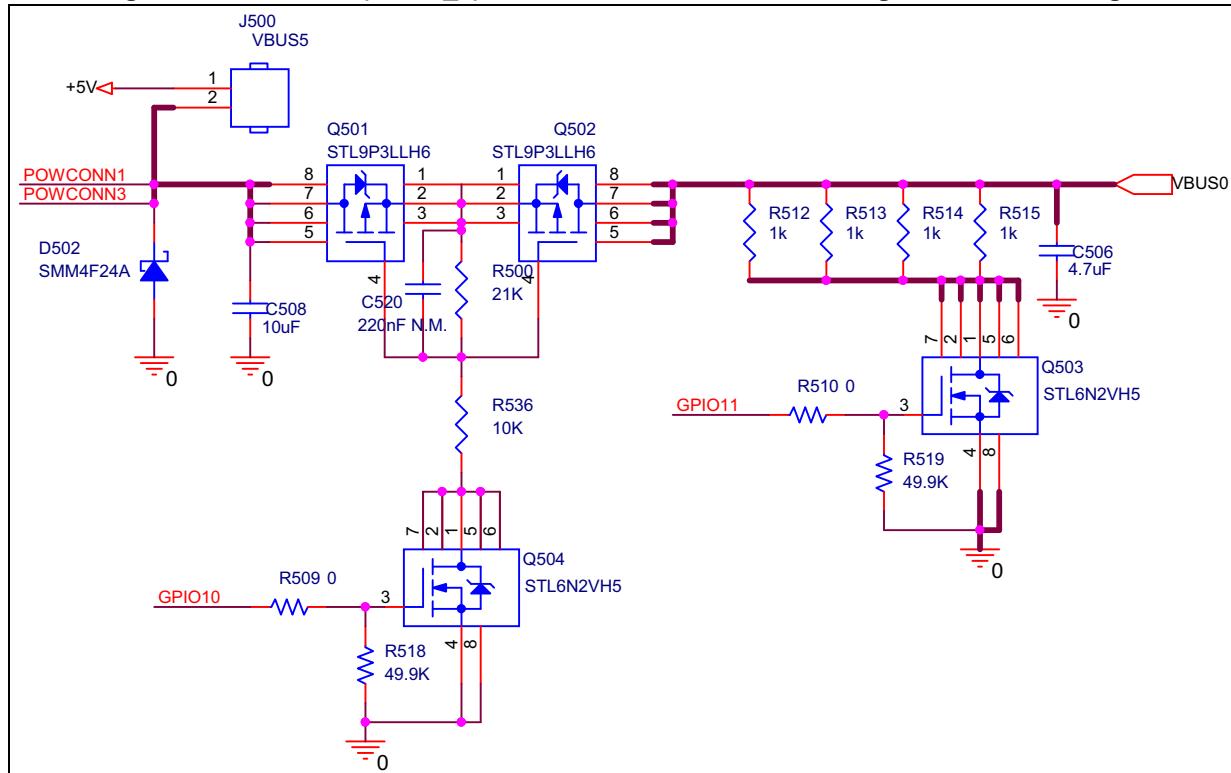
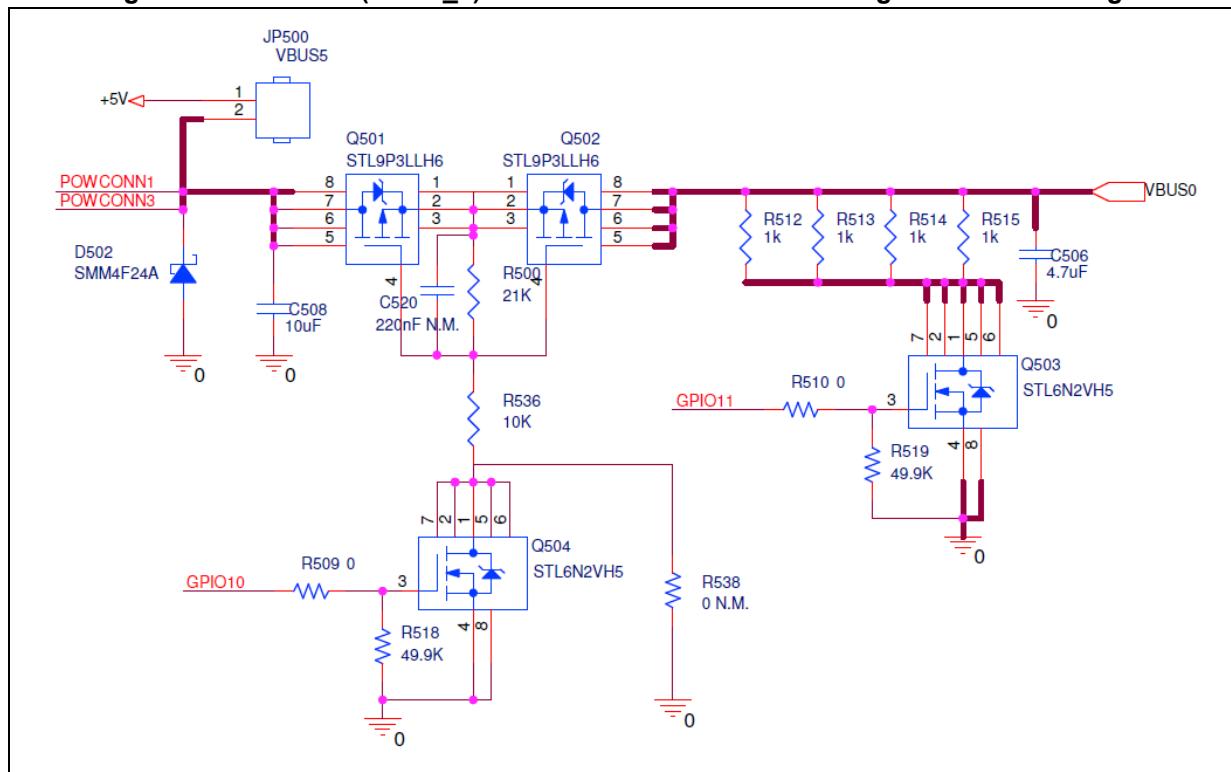
When the full-featured cable is connected to one of the ports, the V_{CONN} is directly managed by the STM32F072RBT6 MCU by the ENCC1 or ENCC2 and the load switches U301 and U302 ([Figure 28](#)).

The ENCC1 and ENCC2 signals drive both the MOSFETs Q301 and Q302 and the V_{CONN} switches U301 and U302. The U301 and U302 have an active-low enable pin while Q301 and Q302 work as active-high. So that, when a CC line is selected for the communication, the other one is eligible to provide the V_{CONN}.

MB1257C allows the user to have two sources of V_{CONN}. This can be provided by an external power supply connected on CN4 (see [Figure 27](#)) or, mainly for demo purpose, from the 5 V provided by the NUCLEO-F072RB board. In the case that an external power supply is providing the V_{CONN}, the jumpers J0 and JP1 must be closed between pins 2 and 3 otherwise, if no external power supply is available, these jumpers must be closed between pins 1 and 2 (see [Figure 40](#)). In the case of no external supply, V_{CONN} is powered by the same 5 V supplying all the NUCLEO-F072RB board.

2.7 MB1257 V_{BUS} management and discharge mechanism

The [Figure 29](#) describes the V_{BUS} management and discharge mechanism.

Figure 29. MB1257B (PORT_0): schematic view of the discharge mechanism stage**Figure 30. MB1257C (PORT_0): schematic view of the discharge mechanism stage**

The V_{BUS} path presents a discharge mechanism implemented by the MOSFET Q503 and the resistors connected on its drain.

If the Provider is matched with an external power supply through the power connector CN4 (see [Figure 32](#)), the V_{BUS} is on the supply path by means of the discrete load switch (Q501-Q502) driven by the MCU (GPIO10).

If an external power-supply is connected on CN4, the jumpers J500/JP500 (this jumper is labeled J500 on MB1257B and JP500 on MB1257C) and JP501 must be left open.

If no external power supply is available, fitting the jumper J500/JP500 allows to use the 5 V from the NUCLEO-F072RB board as V_{BUS}, and only for Provider role. **This is used mainly for demonstration purposes.**

Note: *The integrated Rp value is 4.7 kΩ at 3.3 V to advertise current capability of 3 A at 5 V. User has to change it according to the power supply capabilities.*

For the Consumer case, the same V_{BUS} path is managed by the STM32F072RBT6 MCU enabling the discrete load switch.

The MB1257C allows to skip the discrete load switch (Q501-Q502) driven by the MCU by means of a not mounted resistor (R538) that allows to turn it on definitively (see [Figure 30](#)).

2.8 MB1257 V_{BUS} load connectors

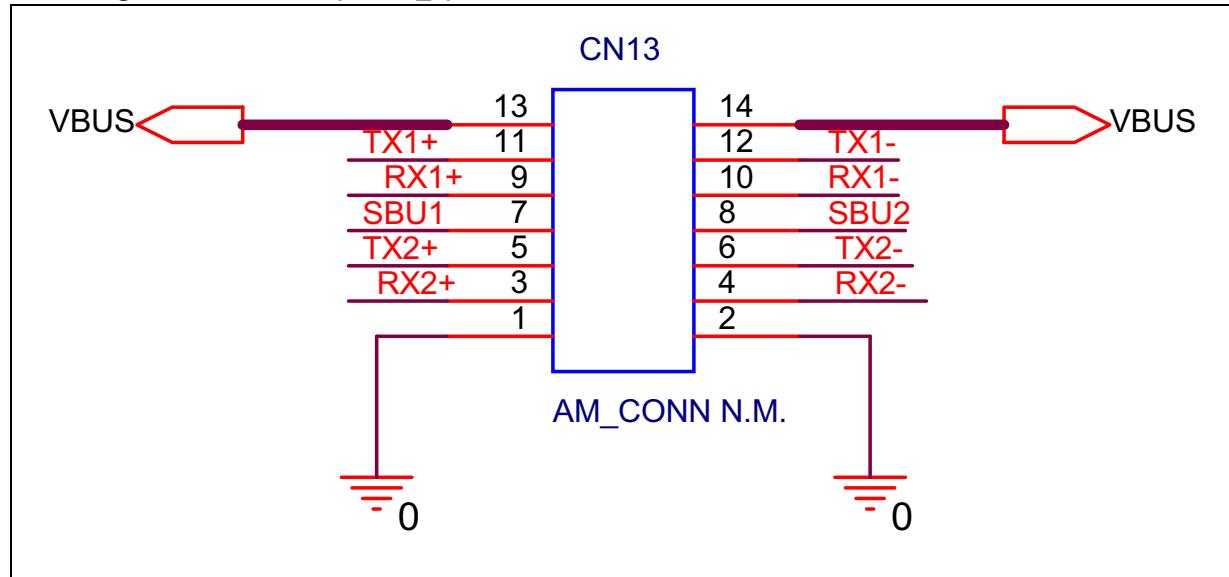
The two connectors CN11 and CN12, respectively associated to PORT_0 and PORT_1, are able to provide externally the V_{BUS} supplying any load connected to them.

2.9 MB1257 extension connectors

As anticipated, both ports support the USB PD and the USB Type-C specification (refer to [Section 7](#)) as well as the Alternate-Mode capability which enables the multi-purposing of the designated pins in the connector. Two dedicated connectors (CN13 and CN14) have been inserted to expose all the main pins and facilitate the design of applications using Alternate Modes.

The [Figure 31](#) reports the pins exposed on the Alternate-Mode connector CN13, related to the PORT_0.

Figure 31. MB1257 (PORT_0): schematic view of the alternate-mode connector CN13



2.10 MB1257 USB2.0 capability

The PORT_0 supports the USB 2.0 capability too, embedding the USBLC6-2 protection (U600), so that it is able to act as UFP.

2.11 MB1257 local-power management stage

About the power aspects, the MB1257 is equipped with a dedicated power connector, tagged CN4 and located on the bottom side of the board. The CN4 connector allows to connect the board to a selectable power supply that provides the right power objects (voltage and current couples) supporting the USB PD application.

The CN4 connector is an interface with the external power supply, its pinout is reported in the [Figure 32](#).

Figure 32. MB1257: CN4 pinout

V_{BUS1}	1	2	V_{BUS2}
V_{BUS1}	3	4	V_{BUS2}
$PGND_1$	5	6	$PGND_2$
$PGND_1$	7	8	$PGND_2$
I2C / GPIO	9	10	GPIO
I2C / GPIO	11	12	GPIO
ENABLE ₁ / GPIO	13	14	ENABLE ₂ / GPIO
DISCHARGE ₁ / GPIO	15	16	DISCHARGE ₂ / GPIO
POWER GOOD ₁ / GPIO	17	18	POWER GOOD ₂ / GPIO
V_{CONN1}	19	20	V_{CONN2}
V_{SYS}	21	22	V_{SYS}
GND	23	24	GND

Through CN4, the MB1257 is able to provide the V_{BUS} directly coming from the external board to its two Type-C™ receptacles CN0 and CN1. Moreover, two couples of CN4 pins can be used for acting on the power supply and selecting the right power requested by the application. The CN4 pins 9 and 11 are connected to two GPIO pins on the STM32F072RBT6 MCU which can be configured also as an I2C channel to act on smart power supplies.

When available, the enable and/or the discharge pins can be used to control the load switches on the power supply. The POWER GOOD pins can be used to check when the power supply is ready with the right power range to be provided. Finally there is also the possibility to receive the V_{CONN} voltage from the external power supply through the related pin.

V_{SYS} is a voltage between 5 V and 20 V to be used as supply voltage for the overall system. It can be used as voltage input of the embedded DC-DC.

Regarding the PD feature, the MB1257 board has been designed to provide power to the connected platforms either starting by an external power supply board, or by the standard USB port through the connector CN1 present on the NUCLEO-F072RB board. When the board is supplied by an external power supply, this may guarantee considerable power ranges; when the board is supplied by the USB port, the maximum power availability is limited to the standard 5 V, 500 mA of the PC USB current offer.

Only in this last case, the jumpers J500/JP500 and JP501 may enable the standard USB 5 V over V_{BUS} on the USB Type-C receptacles CN0 and CN1 (if the ports are configured as Provider). Two options are available:

- If the external power supply is plugged to the power connector CN4, J500/JP500 and JP501 must be left open: the V_{BUS} will be one of the voltage levels offered by the external power supply board.
- If the system is supplied by the standard USB port through the connector CN1 (without any other source on the power connector), J500/JP500 and JP501 must be closed and the V_{BUS} will be only 5 V, coming from U5V of NUCLEO-F072RB board.

The MB1257 embeds also a local power management stage mainly composed by two sets of load switches respectively implemented by the MOSFETs STL9P3LLH6 (Q100-Q101 and Q102-Q103) driven by the STM32F072RBT6 MCU (by means of DRP and /DRP), and the DC-DC converter L6984 (U100).

These two parts are respectively showed in [Figure 33](#) and [Figure 34](#).

Figure 33. MB1257: schematic view of the load switches of the local power management

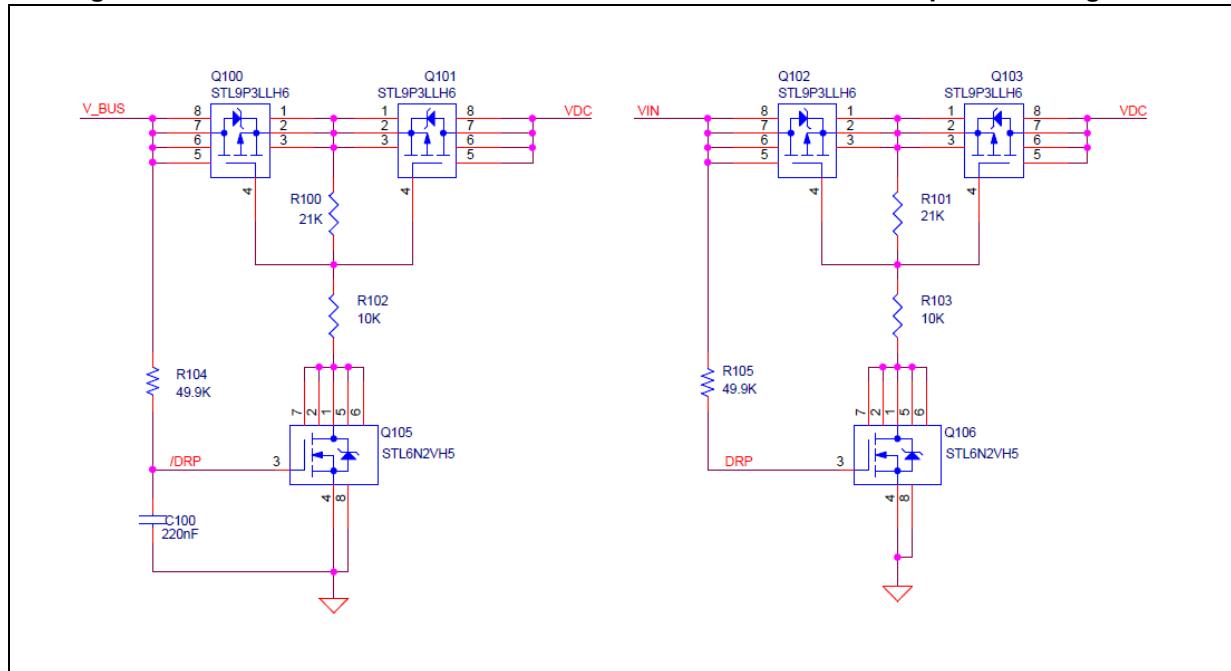
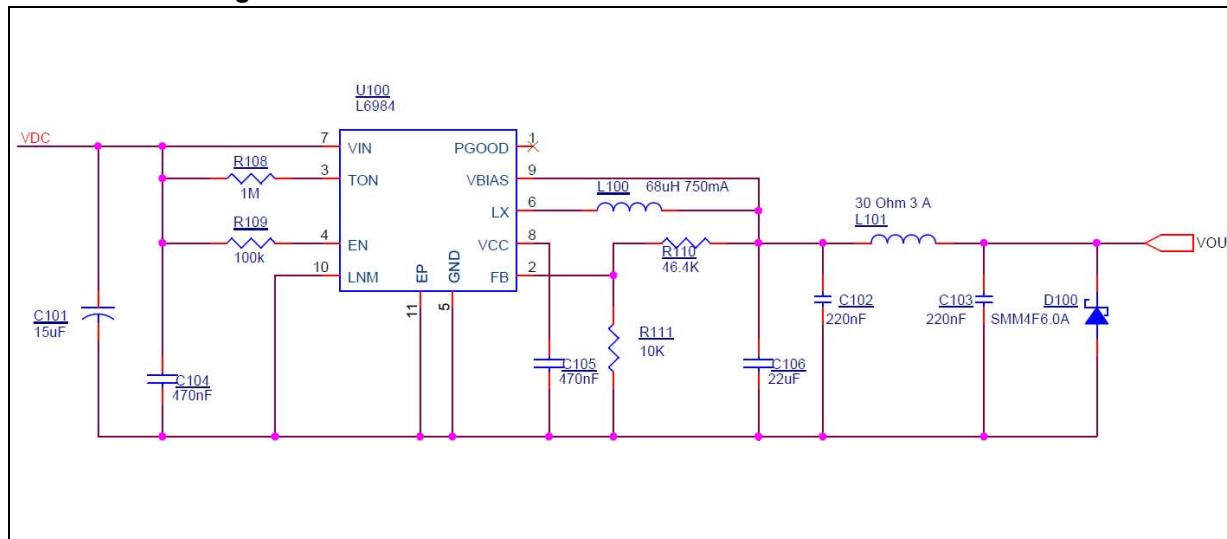


Figure 34. MB1257: schematic view of the local DC-DC converter

As supported by the USB PD specification, this stage is able to manage different power ranges, to supply the system. The Q100-Q101 and Q102-Q103 are set in back-to-back configuration and permit isolation on both directions of the supplying path.

In fact, it is possible to supply the P-NUCLEO-USB001 platform by the V_{BUS} delivered from a Provider connected to one of the ports, or alternatively from the V_{IN} provided by mean of the power connector (CN4): the two power paths are independent, exclusive and controlled directly by the STM32F072RBT6 MCU through the DRP and /DRP functions as shown in [Figure 33](#).

In particular, when the platform is in Consumer role and receives the V_{BUS} on one of the two ports, the jumper JP100 permits to set the PORT_0 (fitting the 2-3) or the PORT_1 (fitting the 1-2) in order to deliver V_{BUS} to the Q100-Q101 load switch and then supply the system by the DC-DC converter.

2.12 MB1257 user LEDs

For each port, three LEDs permit to identify the operative conditions when the application runs: the following [Table 5](#) describes the LEDs blinking functionalities when using the X-CUBE-USB-PD FW 1.2.0.

Table 5. LEDs blinking meaning

LED	Port	Function label	Color	Comment
D203	0	ROLE	Blue	The ROLE LEDs blinking mode provides information on the port power role: – “one blink” means the Port connected is a Provider; – “two blinks” means the Port connected is a Consumer; – “three blinks” means the Port is working as “DRP”
D200	1			

Table 5. LEDs blinking meaning (continued)

LED	Port	Function label	Color	Comment
D204	0	V_{BUS}	Green	When the V_{BUS} LED blinks, the V_{BUS} is provided (in case of Provider) or sunk (in case of Consumer) by the port.
D201	1			When the V_{BUS} LED is ON the two connected ports have established an explicit contract.
D205	0	CC	Orange	The CC LEDs blinking mode provides information on the CC Line connected for the communication: “one blink” means CC Line #1 is connected “two blinks” means CC Line #2 is connected
D202	1			

2.13 MB1257 serial communication connectors

The MB1257 board embeds a CN3 connector which allows a serial communication to send commands or to reach data from the application. The CN3 connector exposes the USART1 peripheral of the STM32F072RBT6 MCU when the expansion board is plugged on the NUCLEO-F072RB board. The connector CN3 is useful to implement the serial communication through the ST-LINK, connecting the application MCU with the STM32F103CBT6 (ST-LINK MCU) by its respective CN3 connector.

The two female wires included in the package can be used to enable serial communication, connecting the two CN3 connectors respecting the numeration (CN3_1-CN_RX, CN3_2-CN3_TX).

The CN2 connector (which exposes the STM32F072RBT6 I2C peripheral) improves the communication capabilities of the already present wide-range peripheral set of the MB1257 board.

For CN2 and CN3 pinout refer to [Figure 37](#) and [Figure 47](#) for MB1257B or MB1257C respectively.

2.14 Full-featured Type-C cable

A certified USB full-featured Type-C™ cable is provided with the pack.

3 System setup

This chapter describes how to set up the platform in two different configurations.

In each configuration the MB1257 board must be stacked on the NUCLEO-F072RB board through the ST morpho connector, paying attention to the mounting verse of the two boards. There is only one position allowed for this connection, the one where the stacked board MB1257 does not cover the two blue and black push-buttons on the NUCLEO-F072RB board (see the blue button B1 and black button B2 in the [Figure 12](#)).

3.1 Provider configuration

The Provider role can be managed with two different supply options that correspond to two configuration settings:

- The Provider is supplied by the on-board NUCLEO-F072RB voltage regulator, by mean of a USB Type-A to Mini-B cable plugged to the CN1 connector and then to a PC. This setting is similar to the one used for the demonstration showed in the *Getting started with the STM32 Nucleo pack* user manual (UM2051). For USB Type-C and PD:
 - On NUCLEO-F072RB board (see [Figure 12](#)), verify that the jumper JP1 is open, JP5 (PWR) closed on U5V (fitting the pins 1-2), and JP6 (IDD) closed.
 - On MB1257 expansion board (see [Figure 18](#), [Figure 19](#)), close the jumper related to the port chosen as Provider, between J500/JP500 for PORT_0 (J500 on MB1257B and JP500 on MB1257C) and JP501 for PORT_1.
- This setting allows to manage the V_{BUS} on the selected port, starting from the NUCLEO-F072RB USB PWR voltage (CN1 connector).
- The Provider is equipped with an external board by the power connector CN4:
 - On the NUCLEO-F072RB board (see [Figure 12](#)), the following jumper settings must be guaranteed: JP1 closed, JP5 (PWR) closed on E5V (fitting the pins 2-3), and JP6 (IDD) closed.
 - On the MB1257 expansion board (see [Figure 18](#), [Figure 19](#)), the jumpers JP100, J500/JP500 (J500 on MB1257B and JP500 on MB1257C) and JP501 must be left open.
- This setting configuration allows the external power board to supply the entire system and, particularly for the USB PD application, to offer a voltage level for the V_{BUS} of the port.

3.2 Consumer configuration

The system can manage two supply options for the Consumer configuration.

The first one is supplied by the NUCLEO-F072RB board, while the second configuration is more interesting from the application point of view, since it implements a specific feature of the USB PD solutions (for example when a Consumer is supplied by the Provider by mean of its V_{BUS}).

Each configuration must have its own settings (see [Figure 12](#)):

- If the Consumer is supplied by the NUCLEO-F072RB voltage regulator, the system setting is the following one:
 - On NUCLEO-F072RB board ([Figure 12](#)), verify that the jumper JP1 is open, JP5 (PWR) closed on U5V (fitting the pins 1-2), and JP6 (IDD) closed.
 - On MB1257 expansion board ([Figure 18](#), [Figure 19](#)), open the jumpers JP100, J500/JP500 (J500 on MB1257B and JP500 on MB1257C) and JP501.
- If the Consumer is supplied by the V_{BUS} delivered by the connected Provider through the USB Type-C cable, the system setting is the following one:
 - On the NUCLEO-F072RB board ([Figure 12](#)), the jumper JP1 must be closed, JP5 (PWR) closed on E5V (fitting the pins 2-3), and JP6 (IDD) closed.
 - On MB1257 expansion board ([Figure 18](#), [Figure 19](#)), while the jumpers J500/JP500 (J500 on MB1257B and JP500 on MB1257C) and JP501 are opened, the jumper JP100 must be set according to the port chosen for supplying the system (fit 2-3 for PORT_0 or 1-2 for PORT_1).

4 Ordering information

To order the USB Type-C™ and Power Delivery Nucleo pack based on the NUCLEO-F072RB board, the MB1257 expansion board and the USB full-featured Type-C Cable, use the order code: P-NUCLEO-USB001.

5 Electrical schematics

The main differences between MB1257B and MB1257C schematics are:

- The possibility to supply V_{CONN} with the same 5V supplying the NUCLEO-F072RB board (see [Figure 35](#) for MB1257B or [Figure 45](#) for MB1257C).
- The pinout of I2C connector CN2 has been changed (see [Figure 37](#) for MB1257B or [Figure 47](#) for MB1257C).
- The values of resistance of voltage divider made with R206/R207 have been changed (see [Figure 37](#) for MB1257B or [Figure 47](#) for MB1257C).
- Values of passives building the Analog Front End have been tuned and U303 and U403 have been added in order to improve PHY performances (see [Figure 38](#) and [Figure 39](#) for MB1257B or [Figure 48](#) and [Figure 49](#) for MB1257C).
- R538/R539 footprint have been added to allow default Consumer configuration (see [Figure 50](#) for MB1257C).
- C601/C701 have been added to better filter noise on V_{BUS} sensing (see [Figure 51](#) and [Figure 52](#) for MB1257C).

Refer to [Section 5.1](#) for MB1257B schematics and to [Section 5.2](#) for MB1257C schematics.

5.1 MB1257B revision B schematics

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UM2050 Rev 3

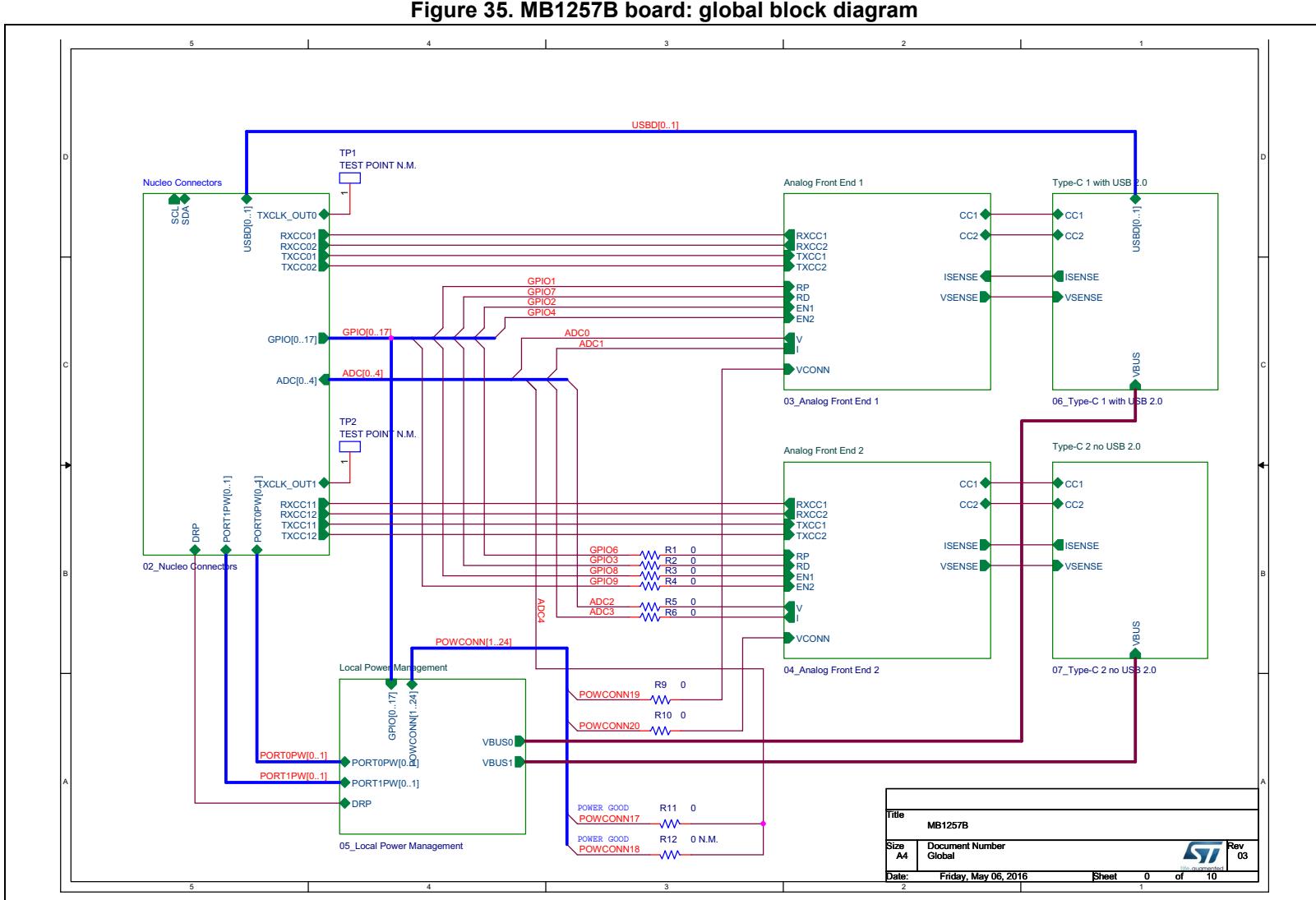
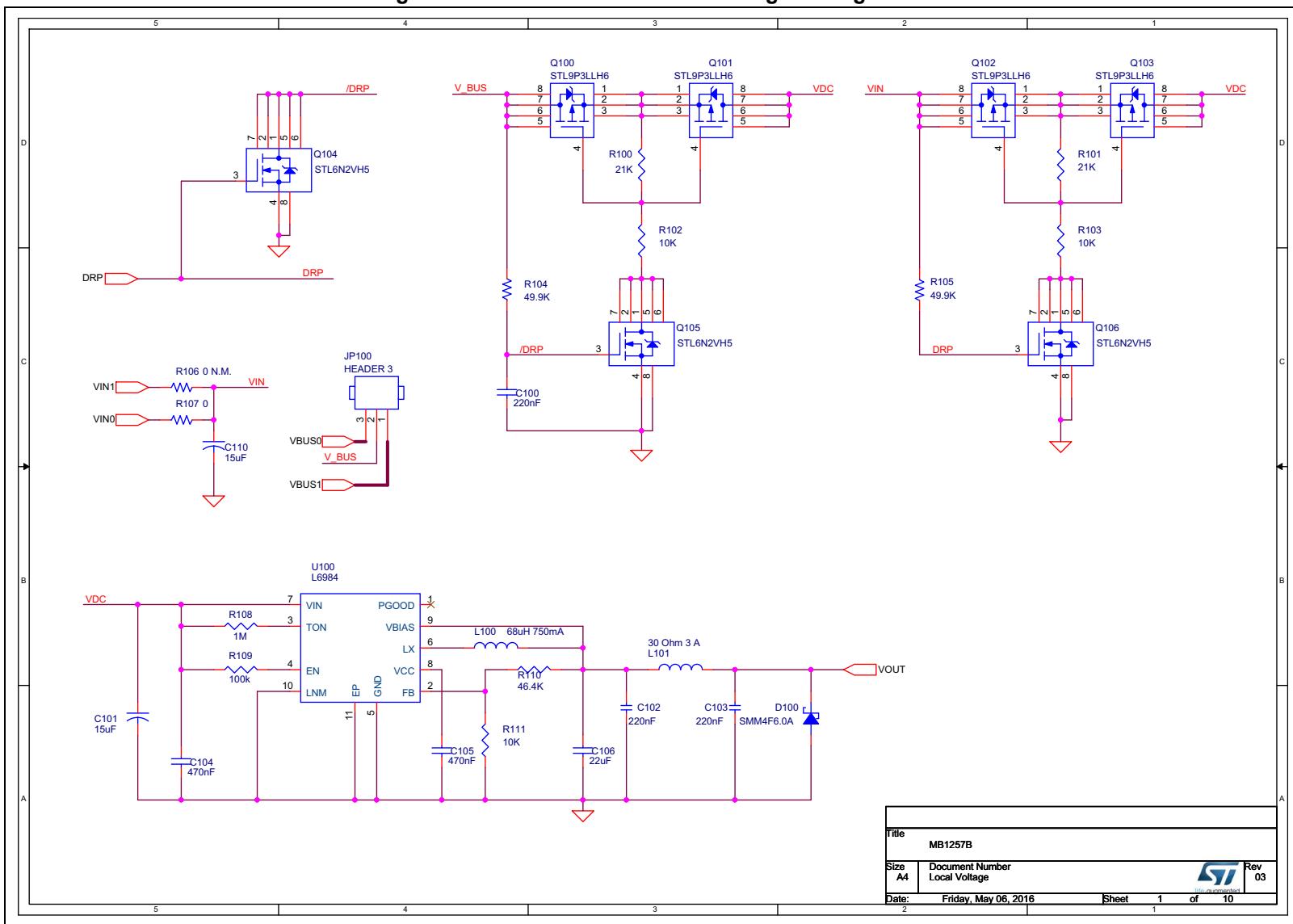


Figure 36. MB1257B board: local voltage management



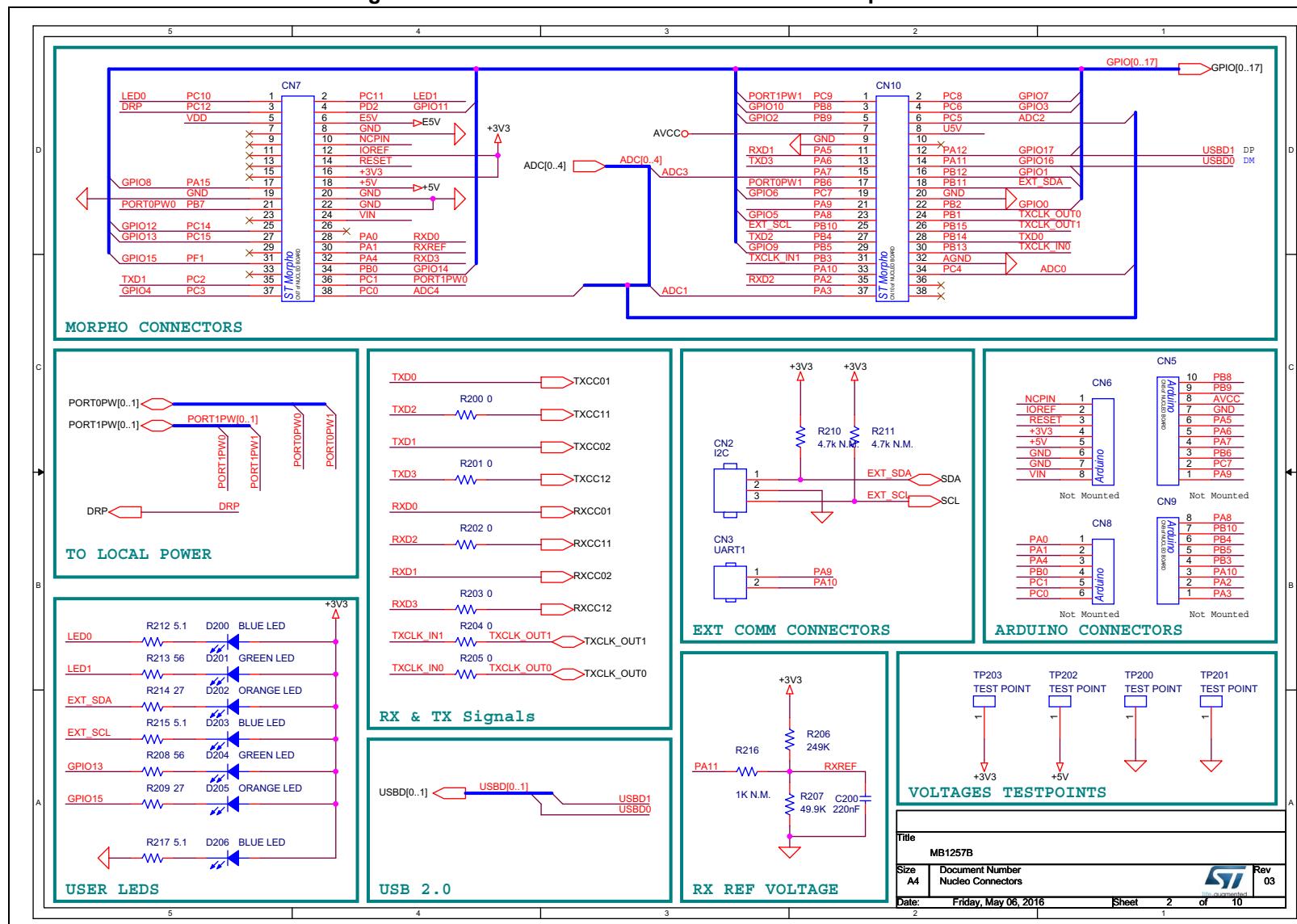
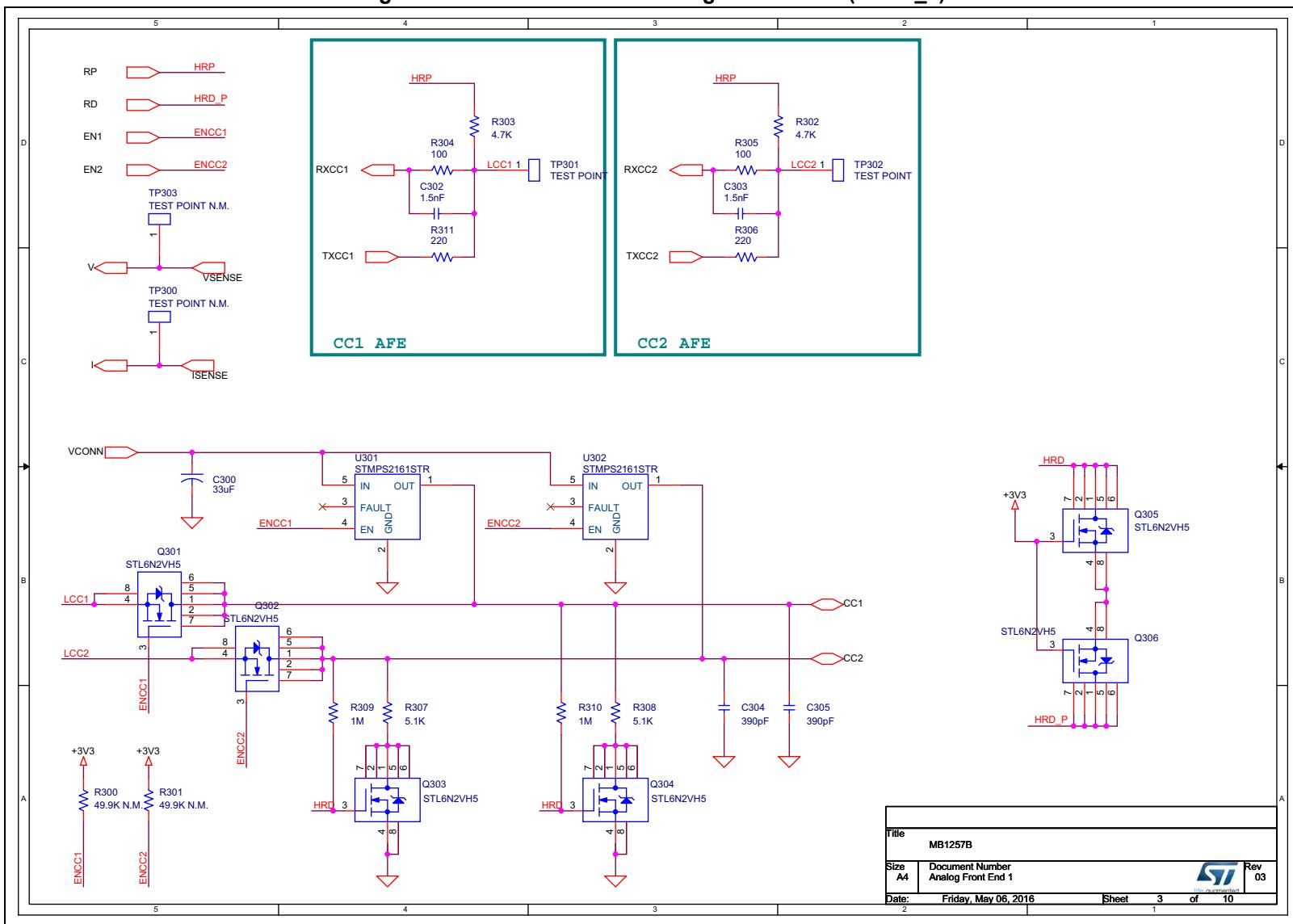


Figure 38. MB1257B board: Analog Front-End 1 (PORT_0)



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Figure 39. MB1257B board: Analog Front-End 2 (PORT_1)

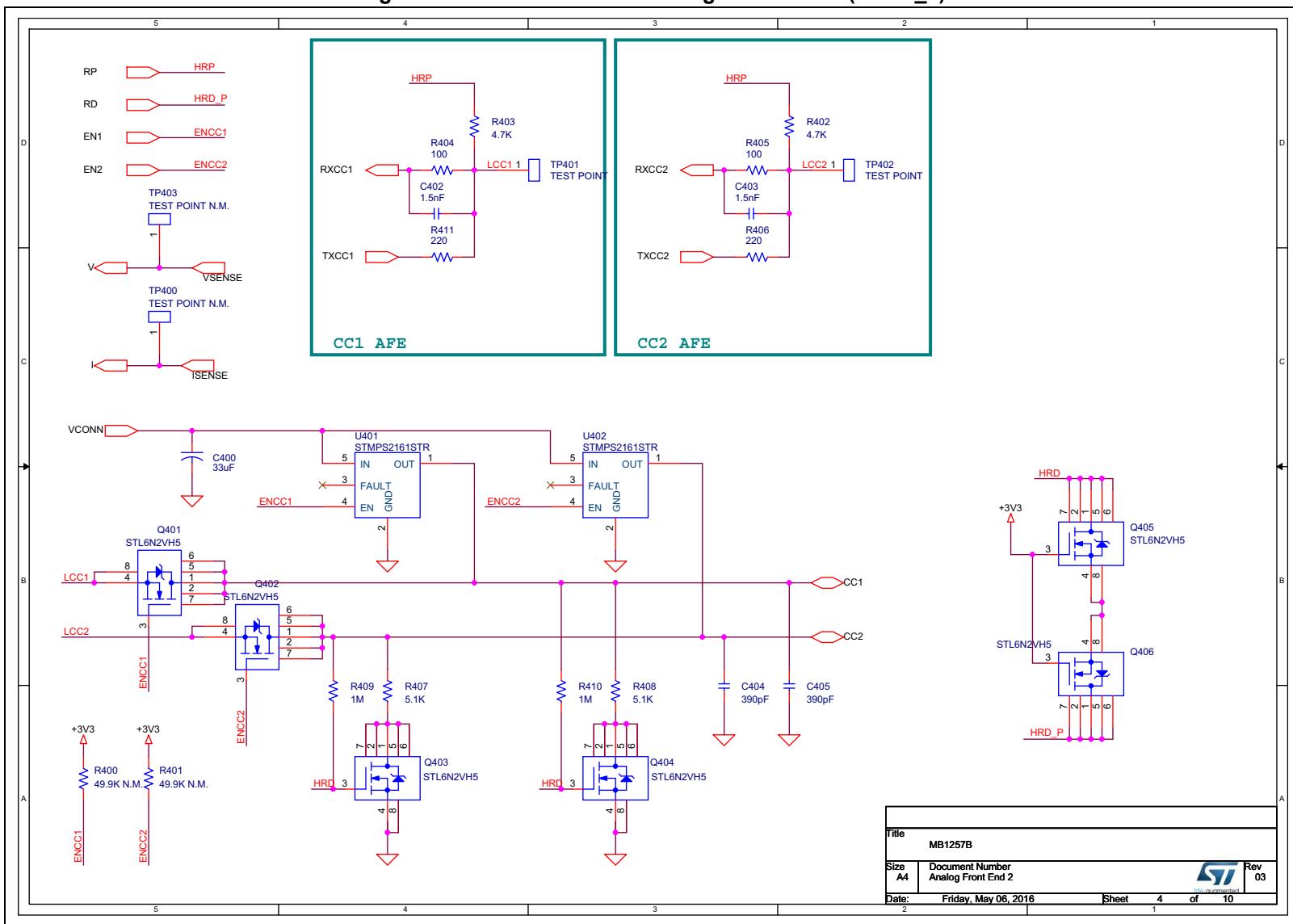
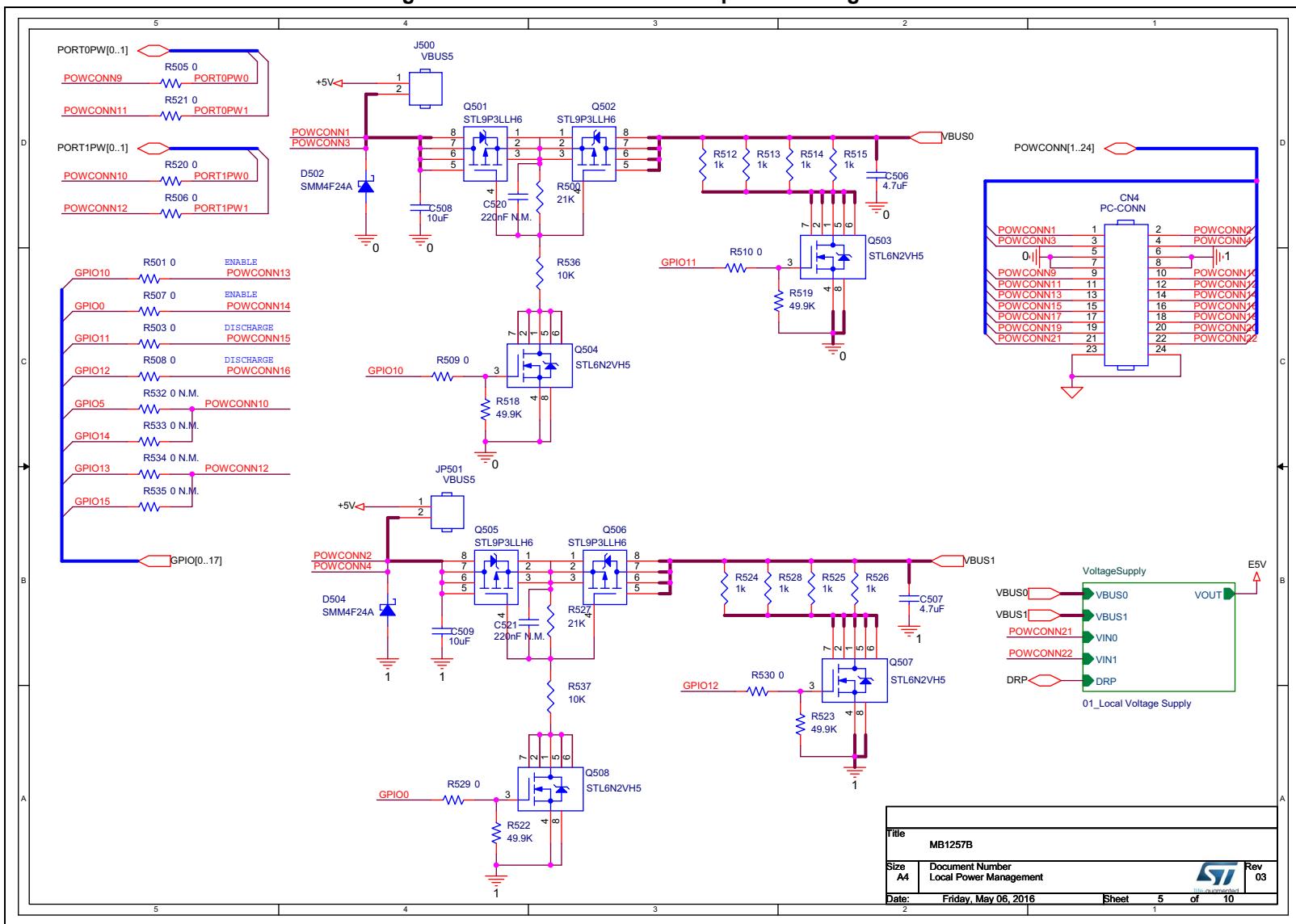


Figure 40. MB1257B board: local power management



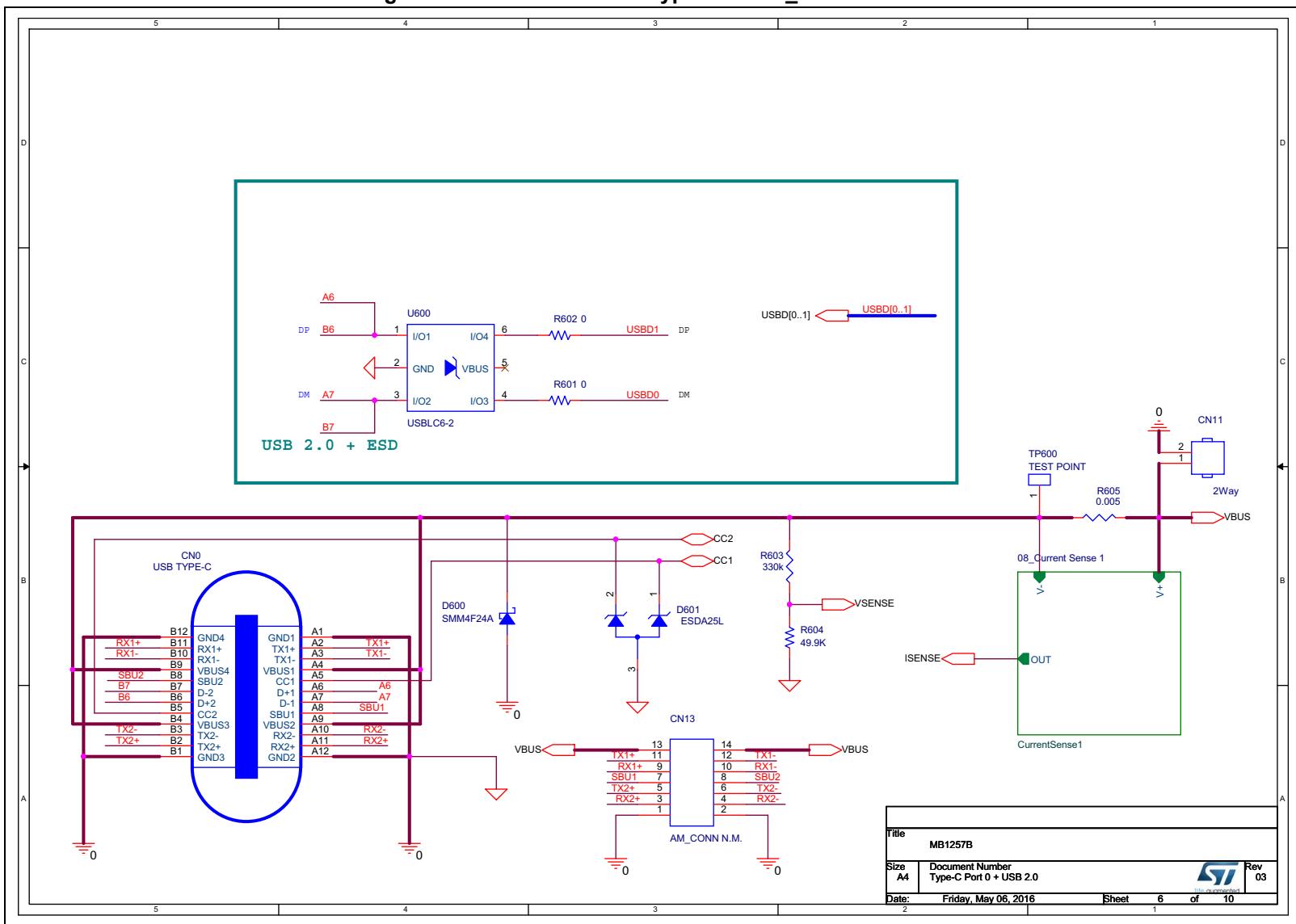


Figure 42. MB1257B board: Type-C PORT_1

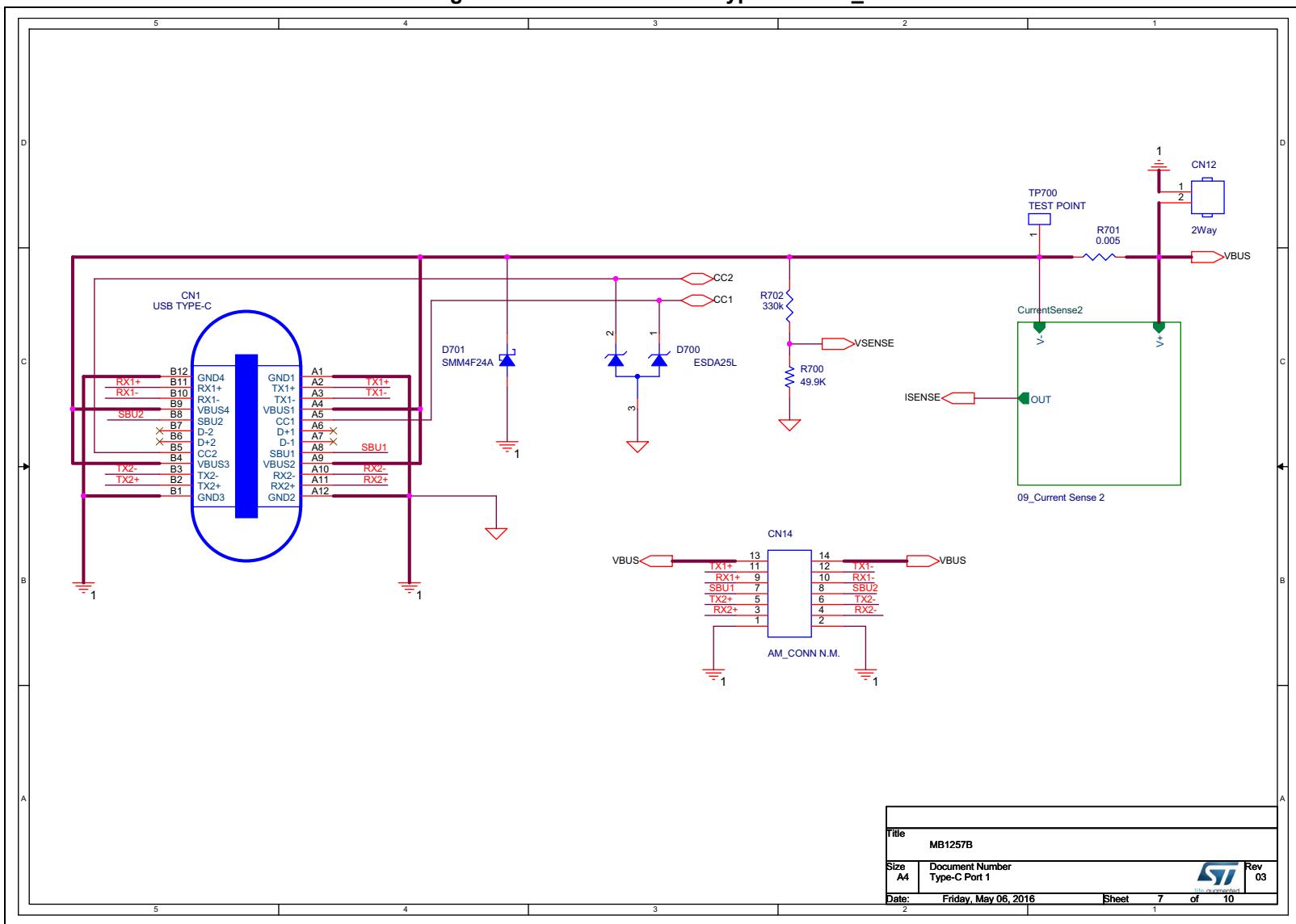


Figure 43. MB1257B board: current sense PORT_0

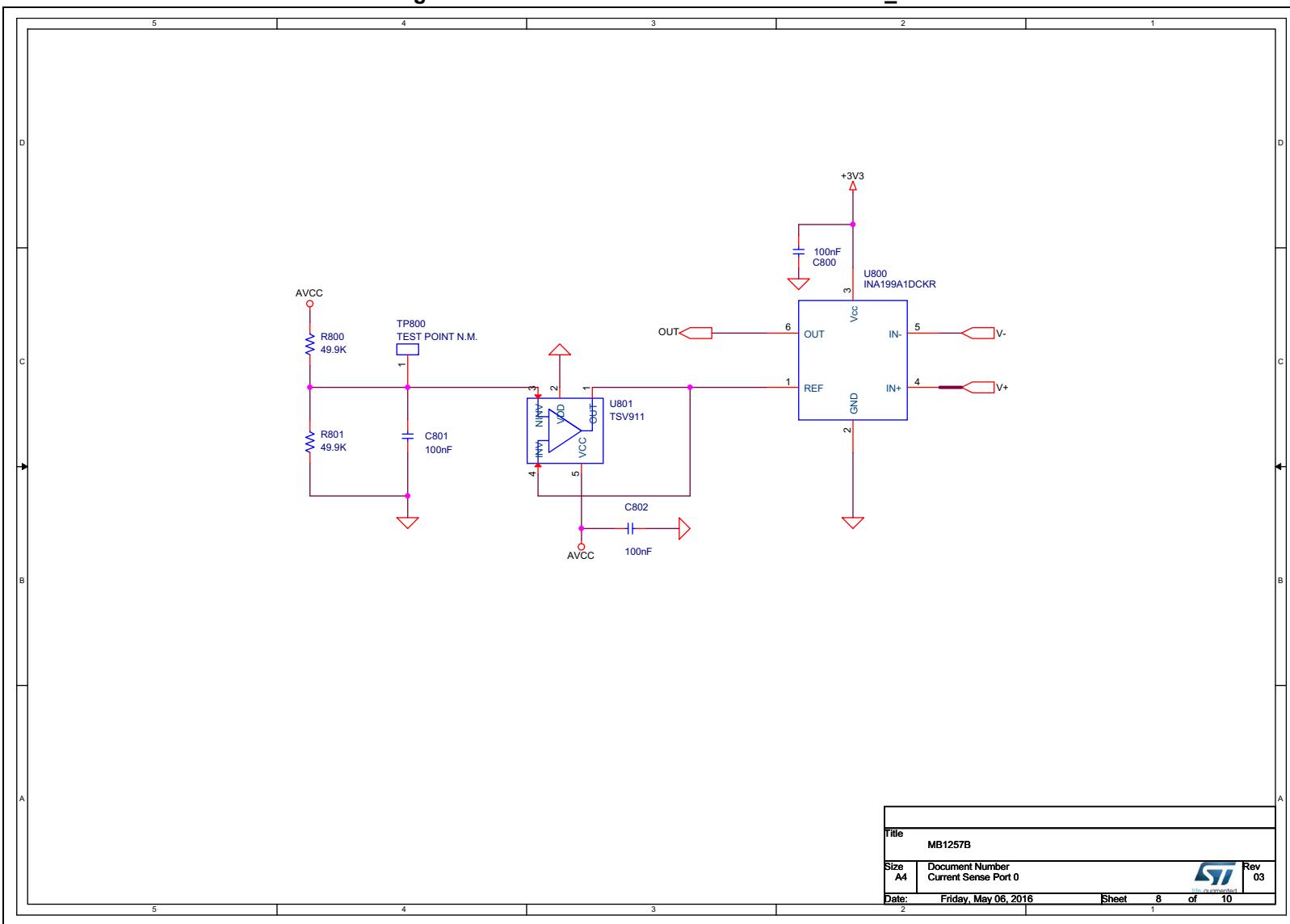
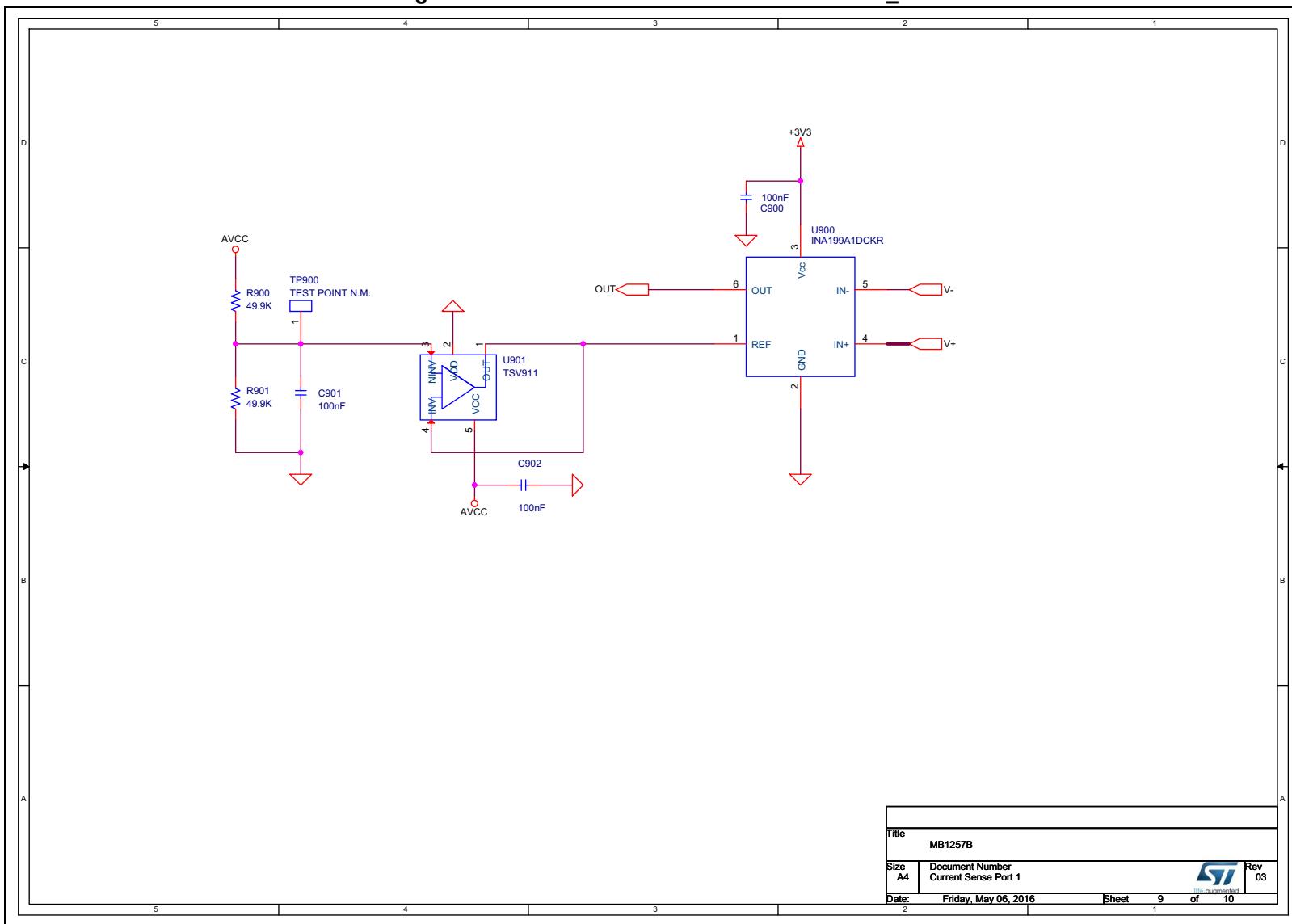


Figure 44. MB1257B board: current sense PORT_1



5.2 MB1257C revision C schematics

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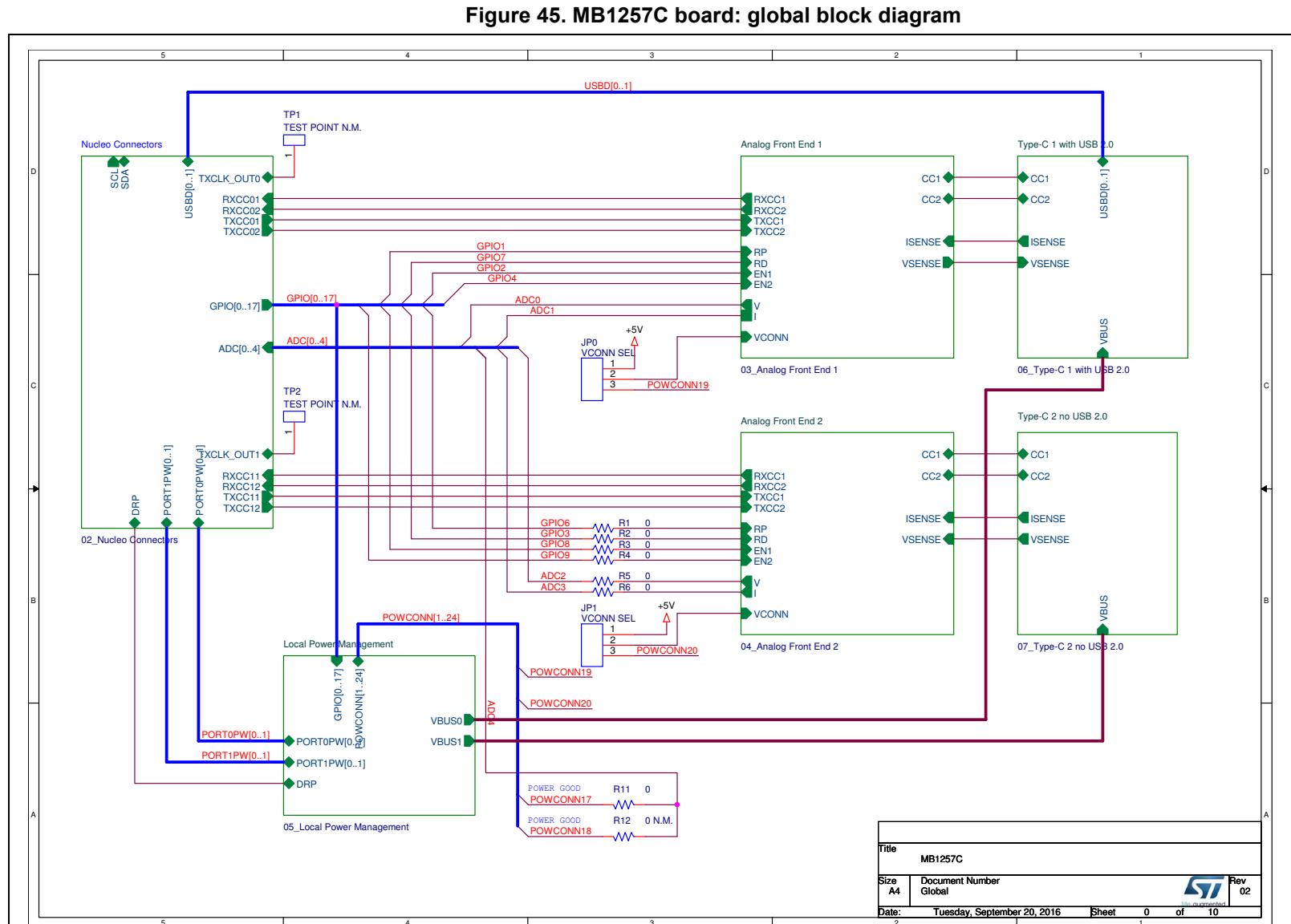


Figure 46. MB1257C board: Local voltage

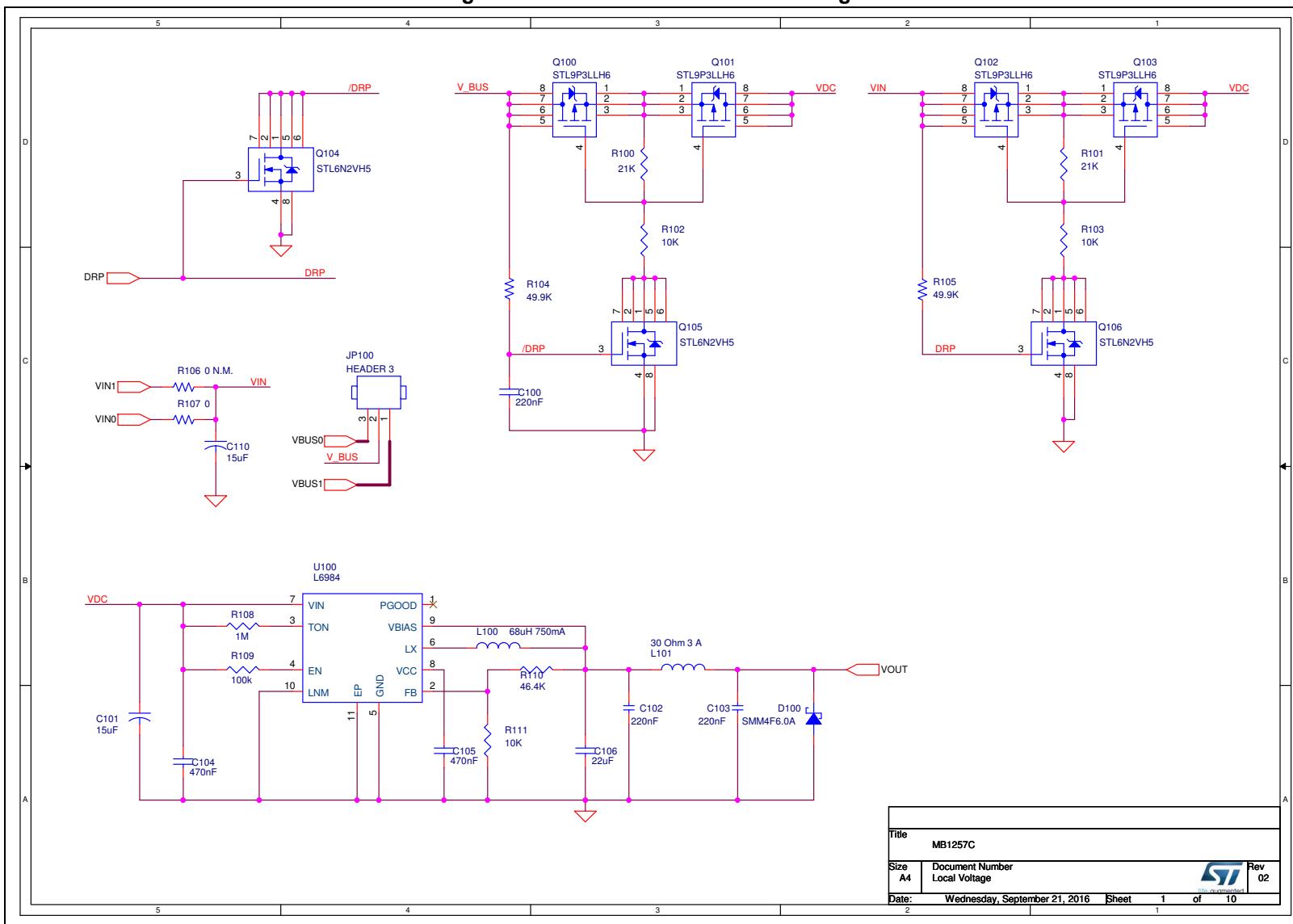


Figure 47. MB1257C board: Nucleo connector

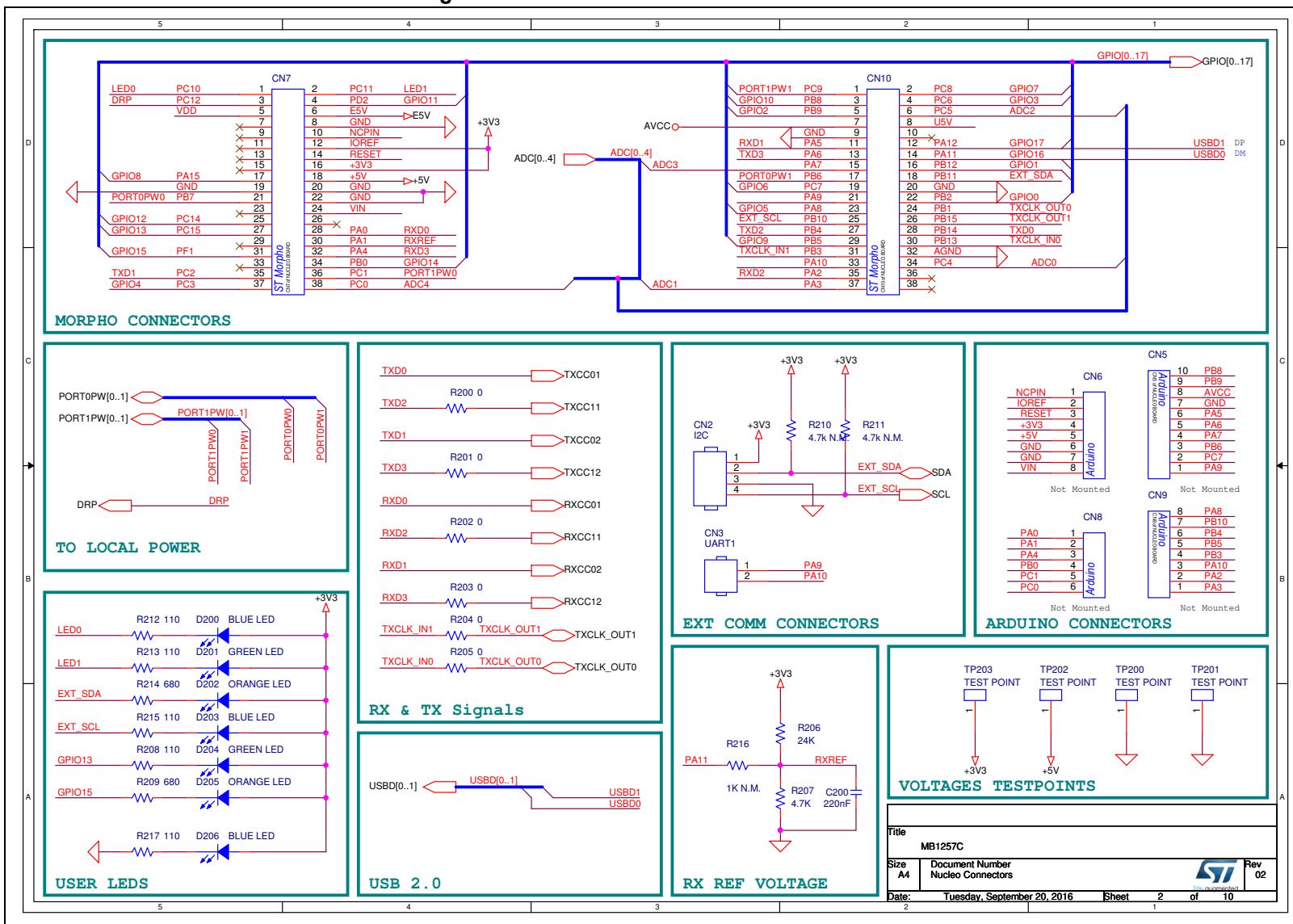
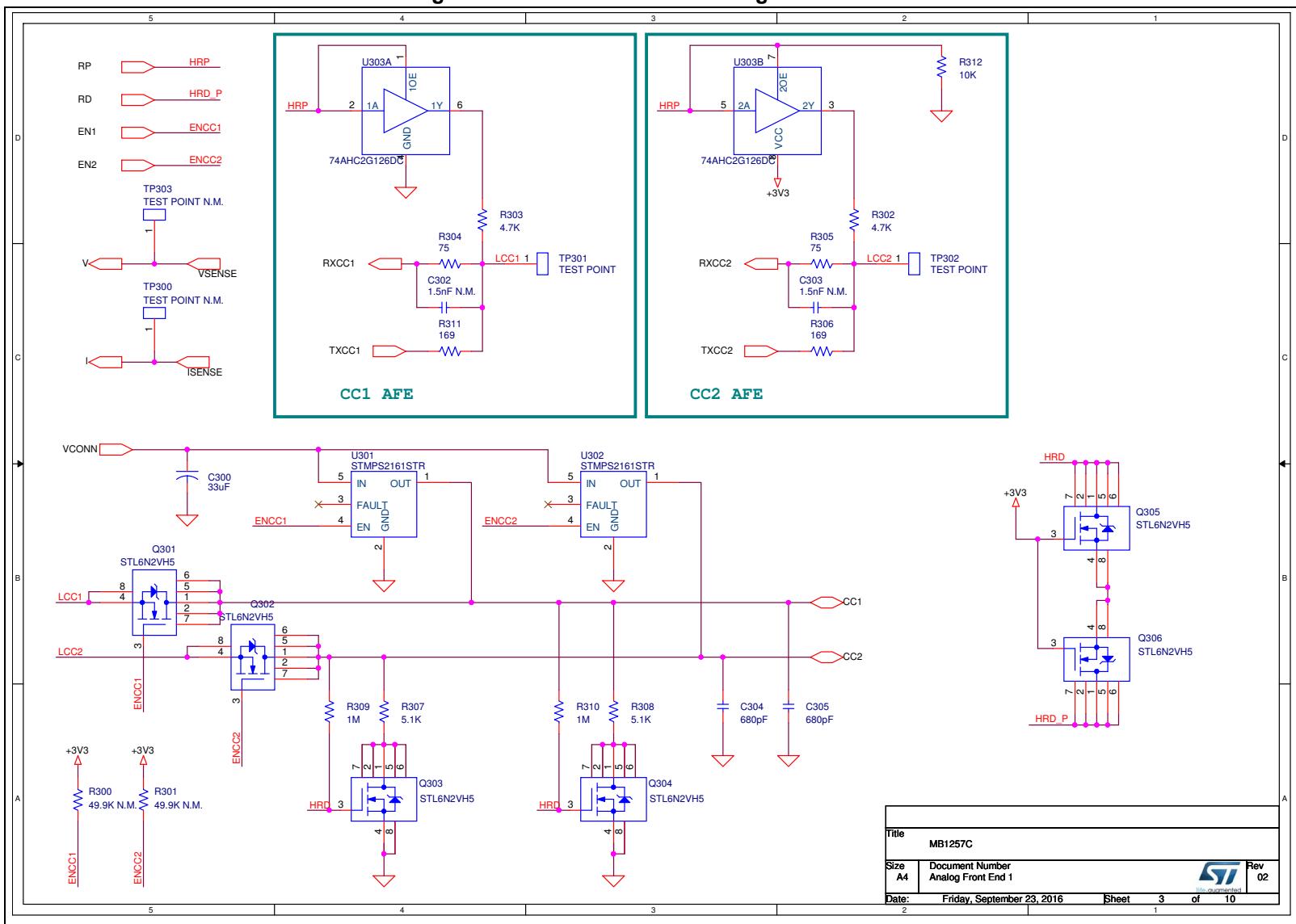
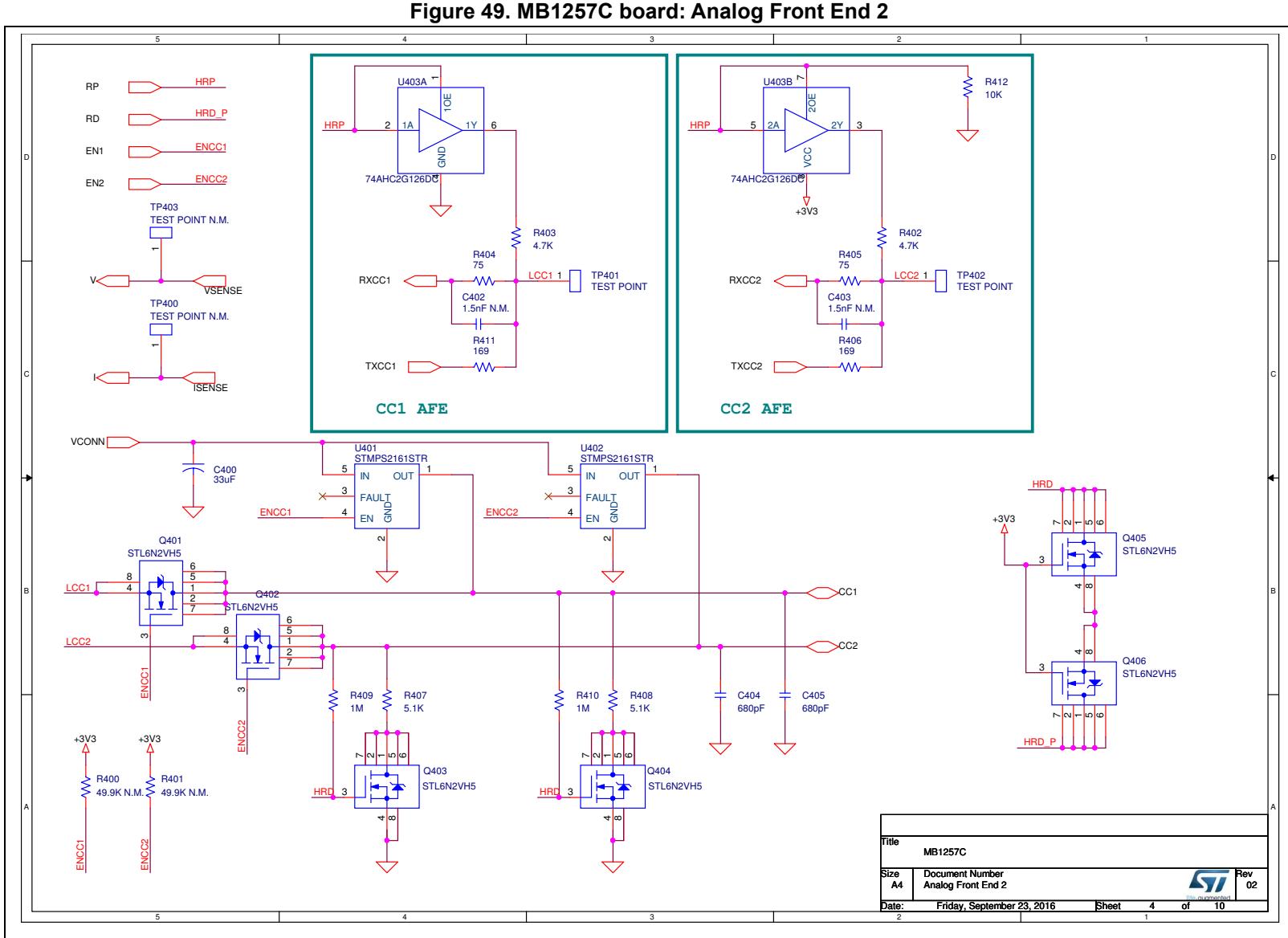
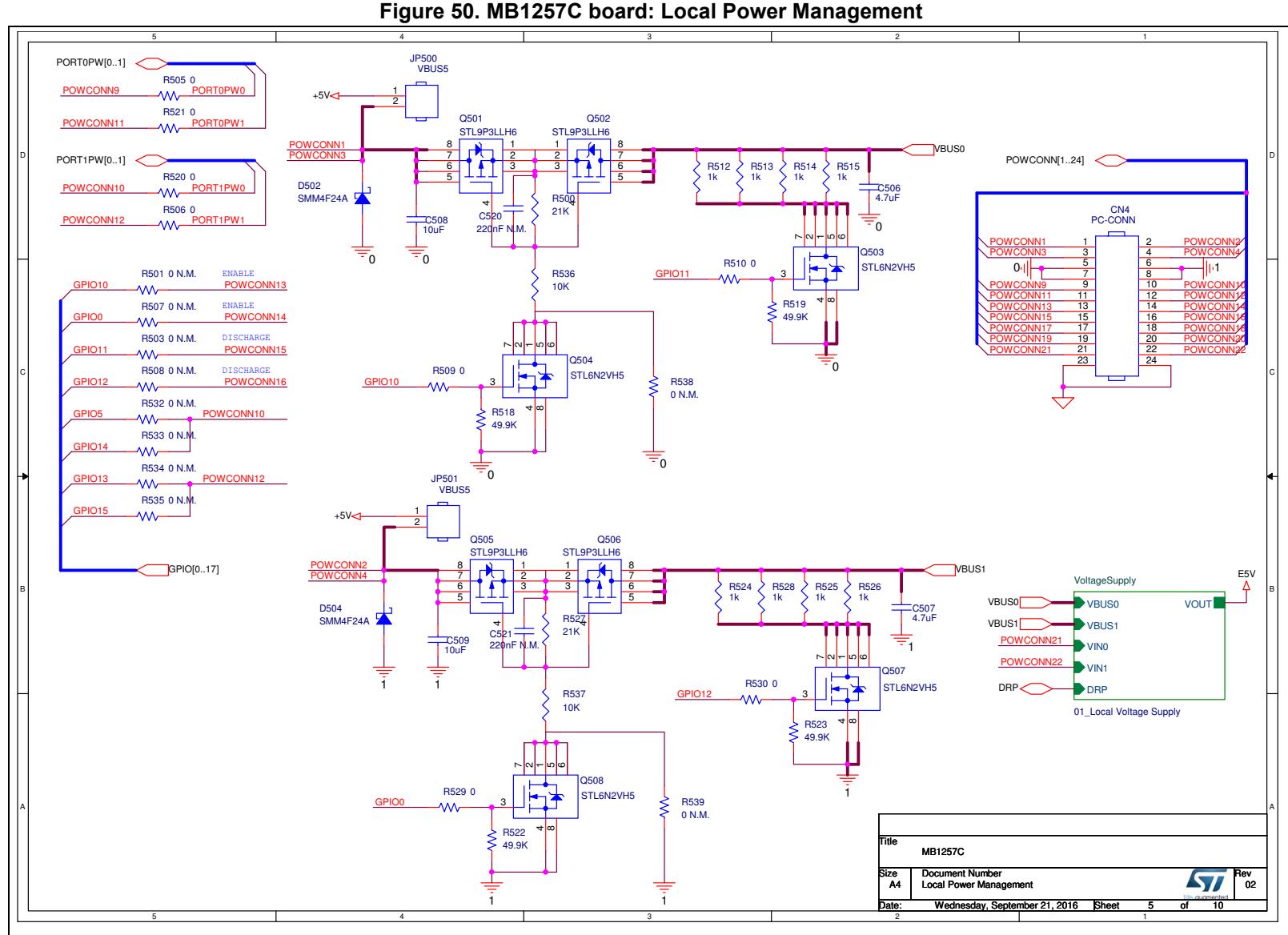


Figure 48. MB1257C board: Analog Front End 1



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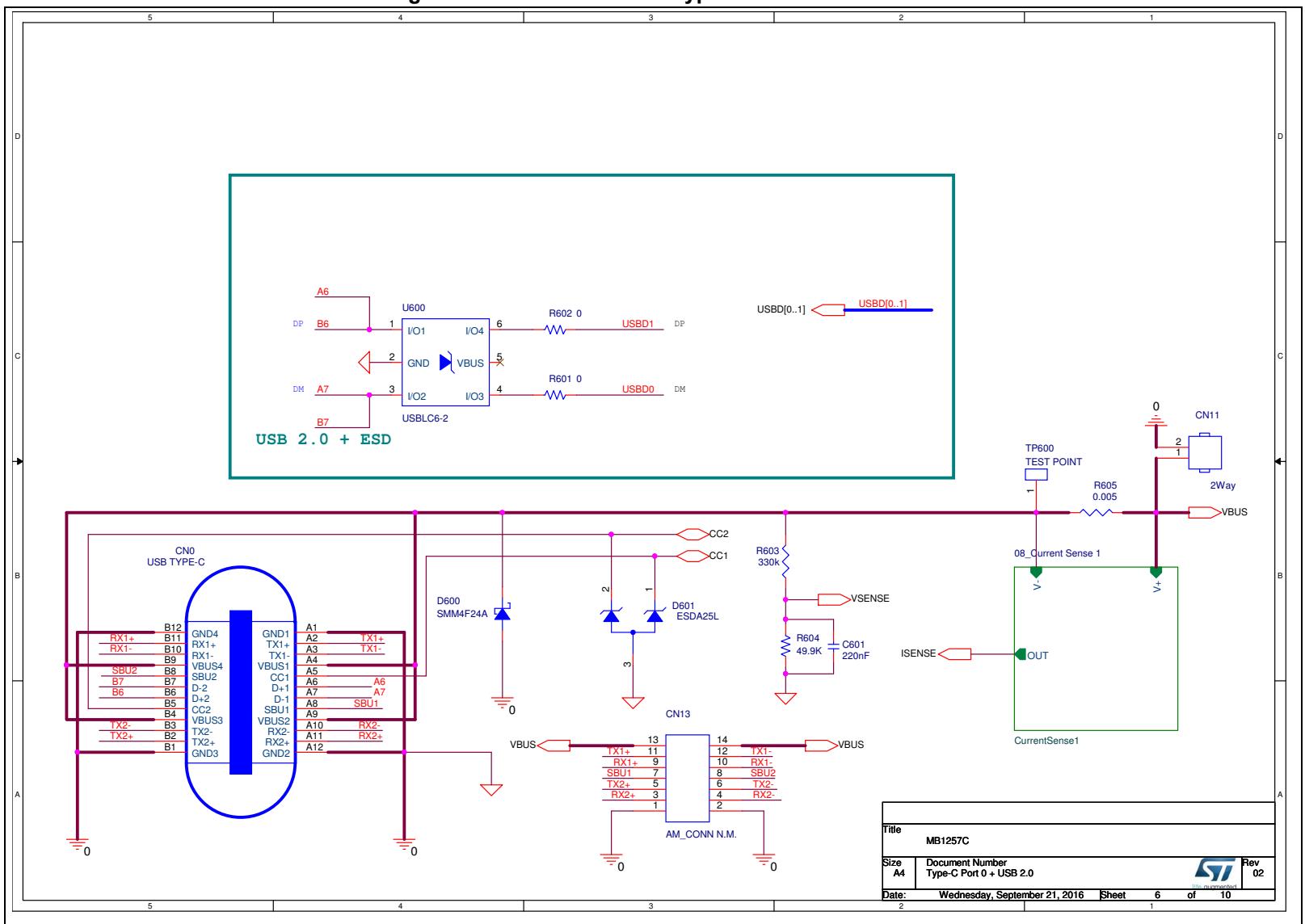


Figure 52. MB1257C board: Type-C Port 1

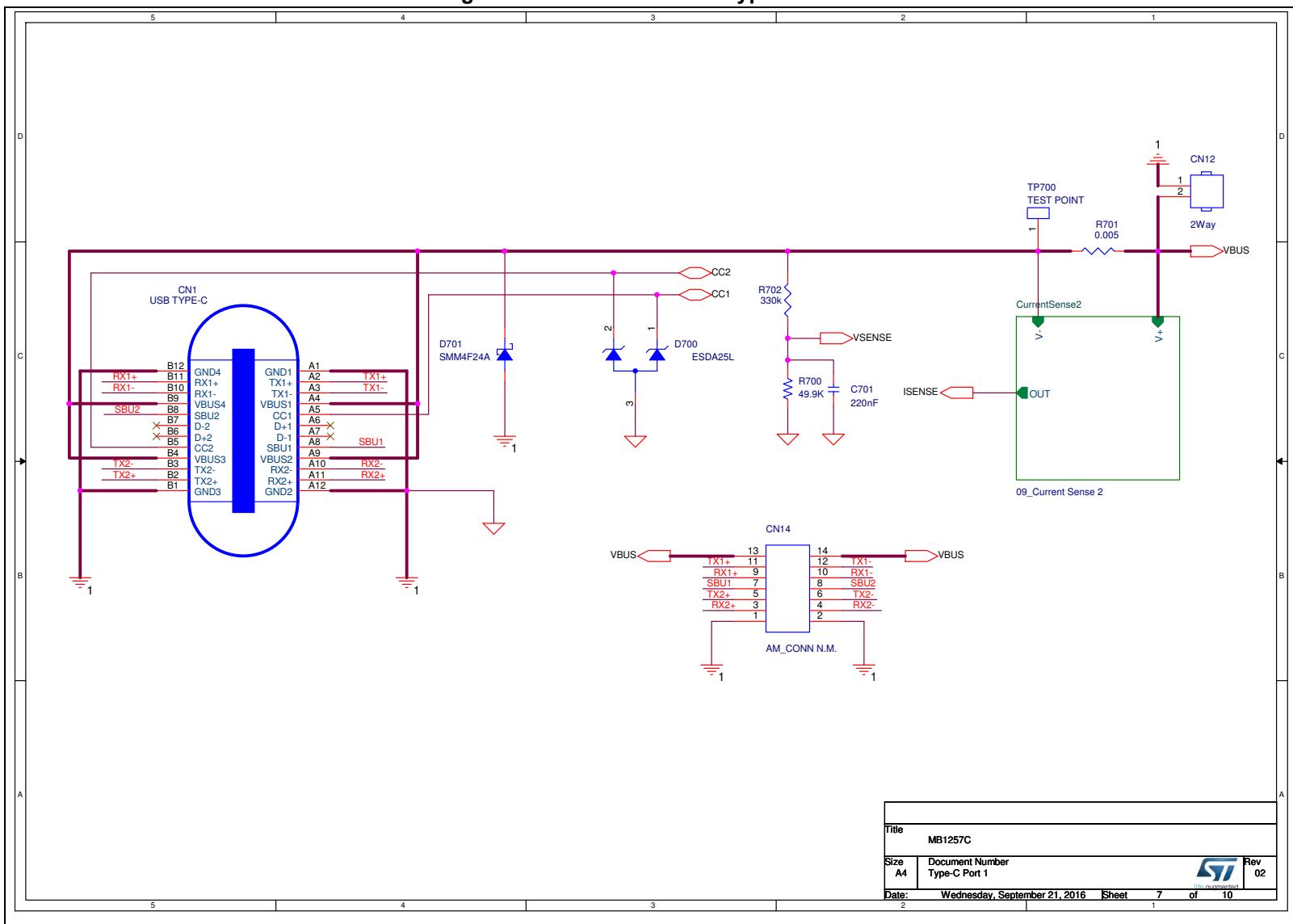


Figure 53. MB1257C board: Current Sense Port 0

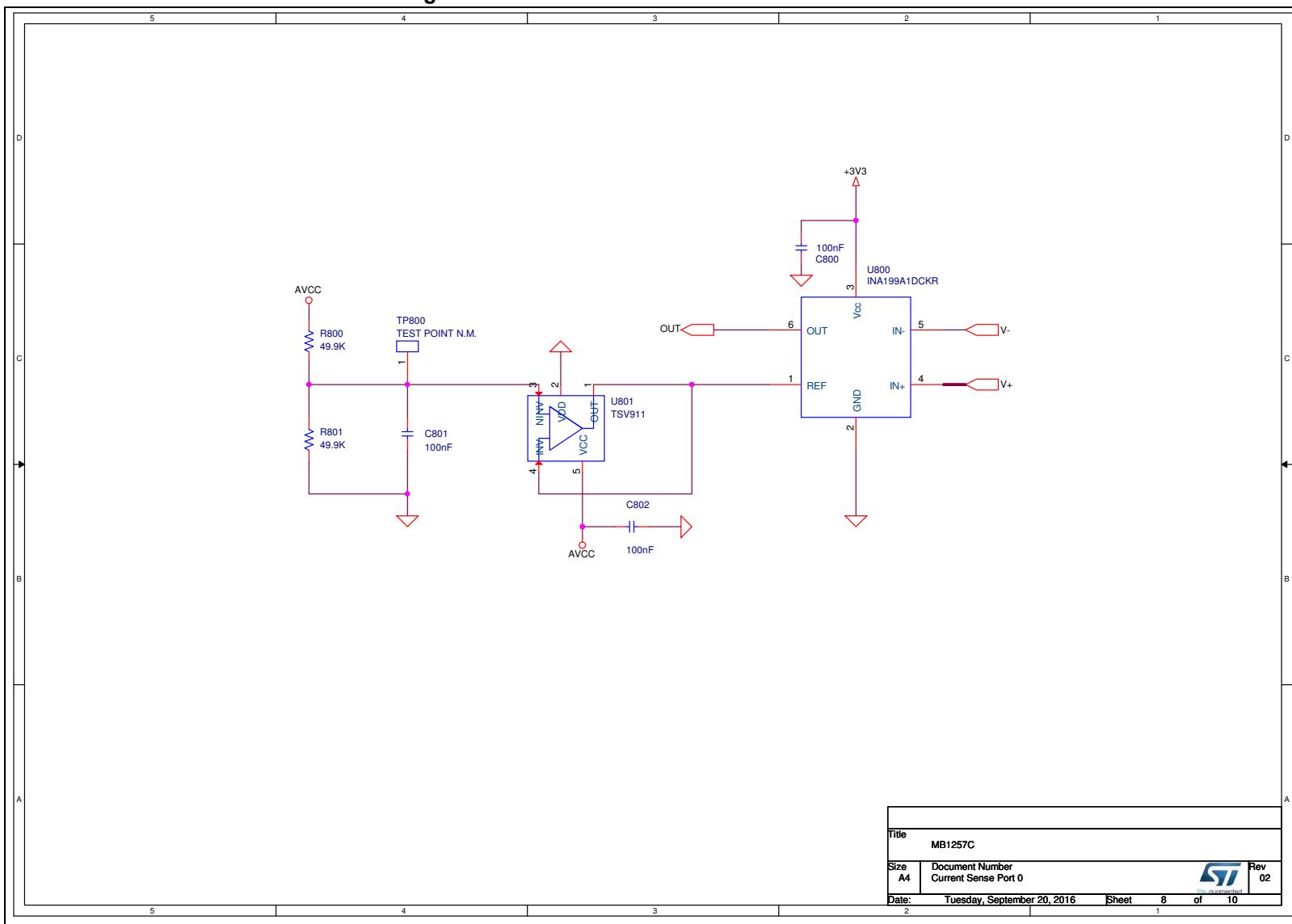
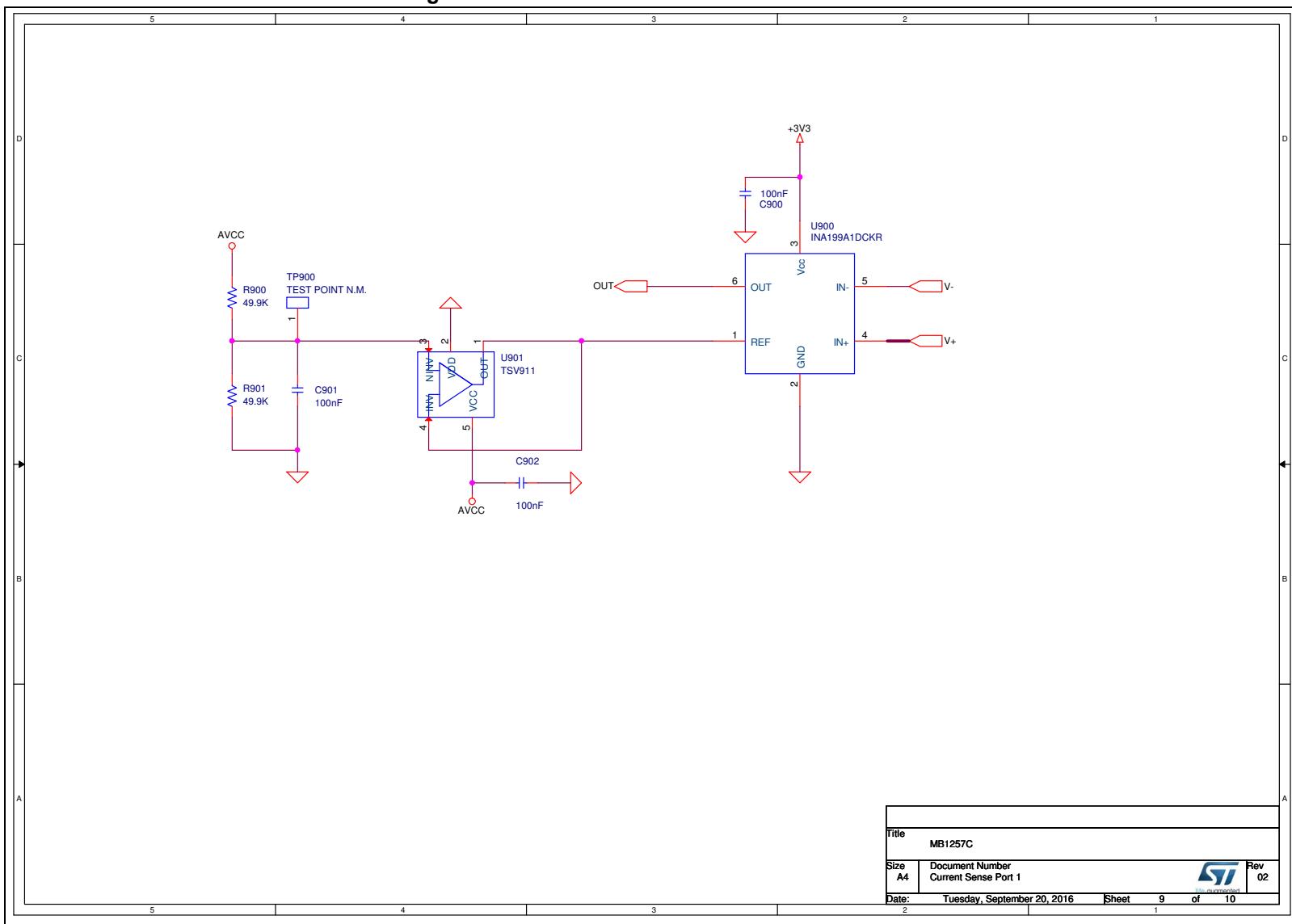


Figure 54. MB1257C board: current sense Port 1



6 Acronyms and abbreviations

Table 6. Acronyms and abbreviations

Acronym	Description
BMC	Biphase Marked Coding
DFP	Downstream Facing Port
EMC	Electronically Marked Cable
MCU	Microcontroller Unit
PD	Power Delivery
PHY	Physical Layer
UFP	Upstream Facing Port
USB	Universal Serial Bus
USB OTG	USB On-The-Go

7 References

- USB2.0 Universal Serial Bus Revision 2.0 Specification
- USB3.1 Universal Serial Bus Revision 3.1 Specification
- USB Type-C Cable and Connector Specification Revision 1.3
- USB PD USB Power Delivery Specification Revision 2.0, Version 1.3, January 12, 2017
- USB BC Battery Charging Specification Revision 1.2 (including errata and ECNs through March 15, 2015), March 15, 2012
- USB BB USB Device Class Definition for Billboard Devices rev1.0a April 15, 2015
- *Getting started with the STM32 Nucleo pack User manual (UM2051)* available from the www.st.com website

8 Revision history

Table 7. Document revision history

Date	Revision	Changes
07-Jun-2016	1	Initial version
23-Feb-2017	2	<p>The full document was updated to introduce the details of revision B and revision C of the MB1257 board, adding:</p> <ul style="list-style-type: none"> – Section 5.1: MB1257B revision B schematics – Section 5.2: MB1257C revision C schematics – Figure 15: MB1257B main connectors and jumpers for setting – Figure 16: MB1257C main connectors and jumpers for setting – Figure 17: MB1257B expansion board (view of the main blocks) – Figure 18: MB1257B expansion board (top view) – Figure 19: MB1257C expansion board (top view) – Figure 20: Bottom view of the MB1257B and MB1257C the expansion boards – Figure 21: MB1257B expansion board, silkscreen layout (top view) – Figure 22: MB1257C expansion board, silkscreen layout (top view) – Figure 23: Bottom view of the silkscreen layout for MB1257B and MB1257C expansion boards – Figure 24: MB1257B (PORT_0): schematic view of the receptacle and voltage-sensing stage – Figure 26: MB1257B (PORT_0): schematic view of the Analog Front-End – Figure 27: MB1257C (PORT_0): schematic view of the Analog Front-End – Figure 29: MB1257B (PORT_0): schematic view of the discharge mechanism stage – Figure 30: MB1257C (PORT_0): schematic view of the discharge mechanism stage – Figure 35: MB1257B board: global block diagram – Figure 35: MB1257B board: global block diagram – Figure 37: MB1257B board: main connectors and operations – Figure 38: MB1257B board: Analog Front-End 1 (PORT_0) – Figure 39: MB1257B board: Analog Front-End 2 (PORT_1) – Figure 40: MB1257B board: local power management – Figure 41: MB1257B board: Type-C PORT_0 and USB 2.0 – Figure 42: MB1257B board: Type-C PORT_1 – Figure 43: MB1257B board: current sense PORT_0 – Figure 44: MB1257B board: current sense PORT_1 – Figure 45: MB1257C board: global block diagram – Figure 46: MB1257C board: Local voltage – Figure 47: MB1257C board: Nucleo connector – Figure 48: MB1257C board: Analog Front End 1 – Figure 49: MB1257C board: Analog Front End 2

Table 7. Document revision history (continued)

Date	Revision	Changes
23-Feb-2017	2 (Continued)	<p>The full document was updated to introduce the details of revision B and revision C of the MB1257 board, adding (continuation):</p> <ul style="list-style-type: none"> – Figure 50: MB1257C board: Local Power Management – Figure 51: MB1257C board: Type-C Port 0 + USB 2.0 – Figure 52: MB1257C board: Type-C Port 1 – Figure 53: MB1257C board: Current Sense Port 0 – Figure 54: MB1257C board: current sense Port 1 <p>Additional updates:</p> <ul style="list-style-type: none"> – Integrated Section 1.12.1: Alternate pins reassignment and Section 1.12.2: Billboard inside of Section 1.12 – Figure 3: USB Type-C receptacle pinout – Figure 4: USB Type-C plug pinout – Figure 6: USB PD packet format – Figure 8: Pins available for reconfiguration over the full-featured cable – Figure 9: Pins available for reconfiguration for direct connect applications – Figure 14: Block scheme of the complete architecture
14-May-2018	3	<p>Updated:</p> <ul style="list-style-type: none"> – Section 1.2: USB Type-C vocabulary – Section 7: References

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