UM2179
User manual

STM32 Nucleo-144 boards

Introduction

The STM32 Nucleo-144 boards (NUCLEO-L496ZG, NUCLEO-L496ZG-P and NUCLEO-L4R5ZI) provide an affordable and flexible way for users to try out new concepts and build prototypes by choosing from the various combinations of performance and power consumption features, provided by the STM32 microcontroller. The ST Zio connector, which extends the Arduino™ Uno V3 connectivity, and the ST morpho headers provide an easy means of expanding the functionality of the Nucleo open development platform with a wide choice of specialized shields. The STM32 Nucleo-144 board does not require any separate probe as it integrates the ST-LINK/V2-1 debugger/programmer. The STM32 Nucleo-144 board comes with the STM32 comprehensive free software libraries and examples available with the STM32Cube package.

Figure 1. Nucleo-144 board (top view)

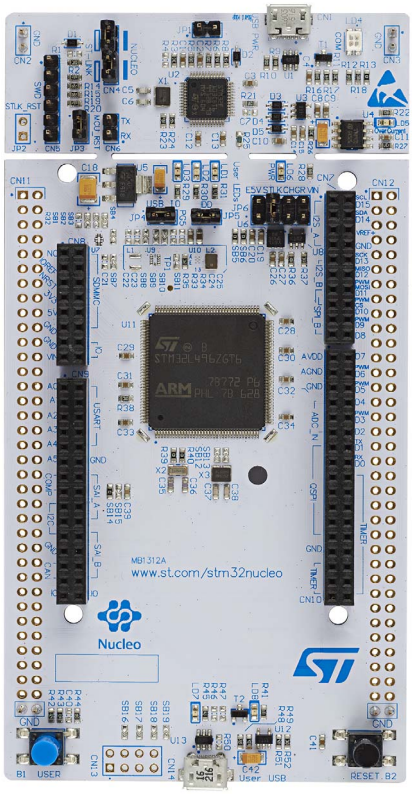
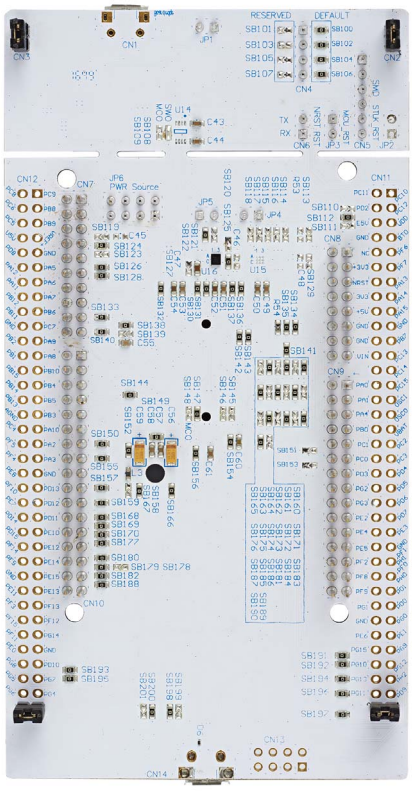


Figure 2. Nucleo-144 board (bottom view)



1. Pictures are not contractual.

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1 Features

The STM32 Nucleo-144 boards offer the following features:

- STM32 microcontroller in LQFP144 package
- SMPS: significantly reduces power consumption in Run mode, by generating Vcore logic supply from an external DC/DC converter. This function is only available on '-P' suffixed boards
- LSE crystal: 32.768 kHz crystal oscillator
- USB OTG FS
- 3 user LEDs
- 2 user and reset push-buttons
- Board connectors:
  - USB with Micro-AB
  - SWD
- Board expansion connectors:
  - ST Zio connector including Arduino™ Uno V3
  - ST morpho
- Flexible power-supply options:
  - ST-LINK USB V_{BUS} or external sources
- On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, virtual COM port and debug port
- Comprehensive free software libraries and examples available with the STM32Cube package
- Support of a wide choice of Integrated Development Environments (IDEs) including IAR™, Keil®, GCC-based IDEs

2 Product marking

Evaluation tools marked as “ES” or “E” are not yet qualified and therefore not ready to be used as reference design or in production. Any consequences deriving from such usage will not be at ST charge. In no event, ST will be liable for any customer usage of these engineering sample tools as reference design or in production.

“E” or “ES” marking examples of location:

- On the targeted STM32 that is soldered on the board (for illustration of STM32 marking, refer to the STM32 datasheet “Package information” paragraph at the *www.st.com* website).
- Next to the evaluation tool ordering part number that is stuck or silk-screen printed on the board.

2.1 System requirements

- Windows® OS (XP, 7, 8 and 10), Linux® 64-bit or macOS™
- USB Type-A to Micro-B cable

2.2 Development toolchains

- Keil® MDK-ARM(a)
- IAR™ EWARM(a)
- GCC-based IDEs including free SW4STM32 from AC6

2.3 Demonstration software

The demonstration software, included in the STM32Cube package corresponding to the on-board MCU, is preloaded in the STM32 Flash memory for easy demonstration of the device peripherals in standalone mode. The latest versions of the demonstration source code and associated documentation can be downloaded from the www.st.com/stm32nucleo webpage.

a. On Windows® only.

3 Ordering information

To order the Nucleo-144 board corresponding to the targeted STM32, use the order code given below in *Table 1*.

Table 1. Ordering information

Order code	Target STM32
NUCLEO-L496ZG	STM32L496ZGT6
NUCLEO-L496ZG-P	STM32L496ZGT6P
NUCLEO-L4R5ZI	STM32L4R5ZIT6

The meaning of the NUCLEO-TXXXRY codification is explained in *Table 2* with an example.

Table 2. Codification explanation

NUCLEO-TXXXRY(-P)	Description	Example: NUCLEO-L496ZG-P
TXXX	STM32 product line	STM32L496
R	STM32 package pin count	144 pins
Y	STM32 Flash memory size: – G for 1 Mbyte – I for 2 Mbytes	1 Mbyte
P	STM32 has SMPS function	SMPS

This order code is mentioned on a sticker placed on the top side of the board.

4 Conventions

Table 3 provides the conventions used for the ON and OFF settings in the present document.

Table 3. ON/OFF conventions

Convention	Definition
Jumper JPx ON	Jumper fitted
Jumper JPx OFF	Jumper not fitted
Solder bridge SBx ON	SBx connections closed by solder or 0 ohm resistor
Solder bridge SBx OFF	SBx connections left open

In this document the references for all information that is common to all sale types, are “STM32 Nucleo-144 board” and “STM32 Nucleo-144 boards”.

5 Quick start

This section describes how to start a development quickly using the STM32 Nucleo-144 board.

Before installing and using the product, accept the Evaluation Product License Agreement from the www.st.com/epla webpage. For more information on the STM32 Nucleo-144 board and for demonstration software, visit the www.st.com/stm32nucleo webpage.

5.1 Getting started

Follow the sequence below to configure the Nucleo-144 board and launch the demonstration application (for components location refer to *Figure 4: STM32 Nucleo-144 board top layout).*

1. Check the jumper position on the board:
   JP1 (PWR-EXT) OFF (see *Section 6.5.1: Power supply input from ST-LINK/V2-1 USB connector* for more details)
   JP6 (Power source) on STLK side (for more details see *Table 7: Power related jumper*)
   JP5 (IDD) ON (for more details see *Section 6.8: JP5 (IDD)*)
   CN4 ON selected (for more details see *Table 4: CN4 states of the jumpers*).
2. For the correct identification of the device interfaces from the host PC and before connecting the board, install the Nucleo USB driver available on the www.st.com/stm32nucleo website.
3. To power the board connect the STM32 Nucleo-144 board to a PC with a USB ‘Type-A to Micro-B’ cable through the USB connector CN1 on the ST-LINK. As a result, the green LED LD6 (PWR) and LD4 (COM) light up and the red LED LD3 blinks.

4. Press button B1 (left button).
5. Observe that the blinking frequency of the three LEDs LD1 to LD3 changes, by clicking on the button B1.
6. The software demonstration and the several software examples, that allow the user to use the Nucleo features, are available at the www.st.com/stm32nucleo webpage.
7. Develop an application, using the available examples.

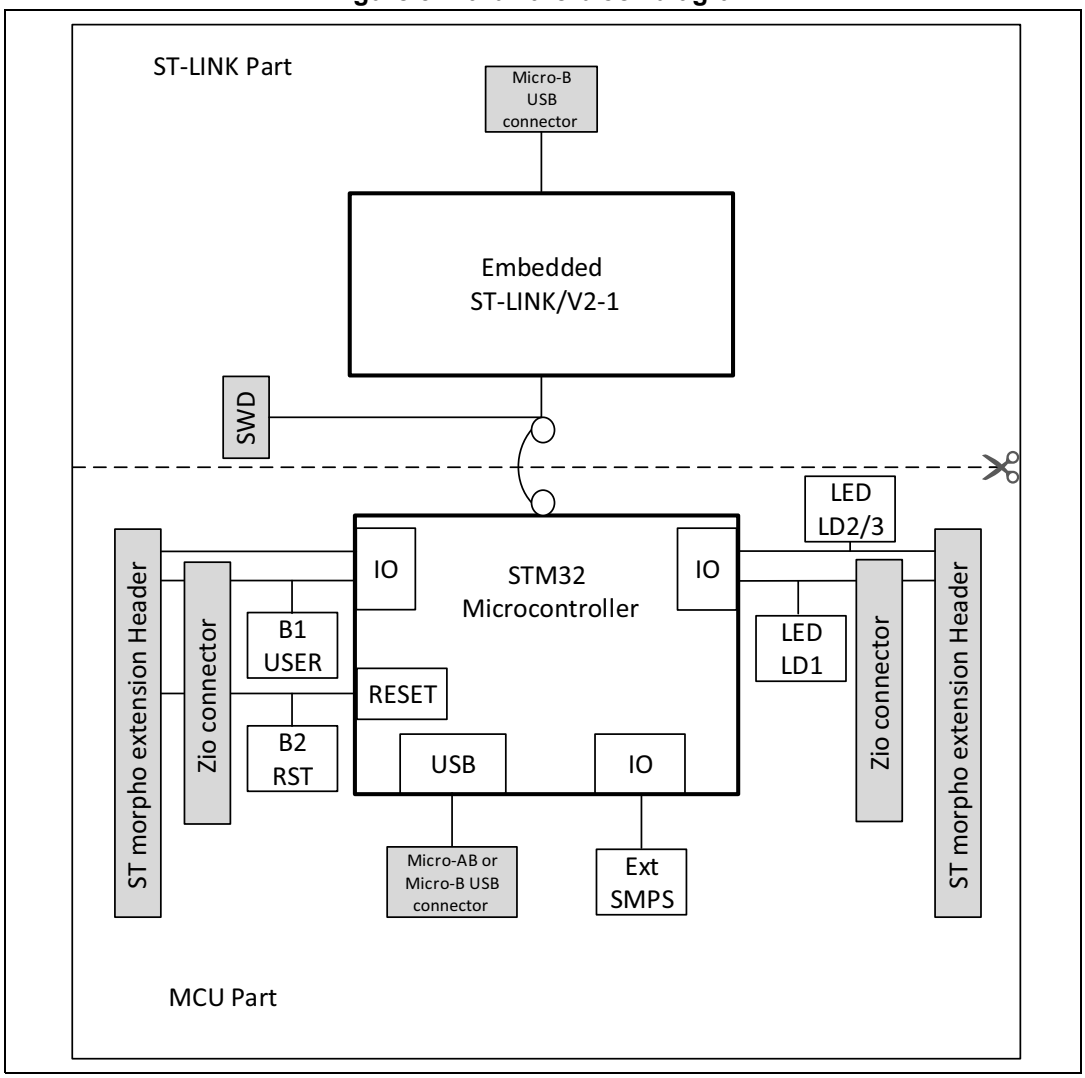
6 Hardware layout and configuration

The STM32 Nucleo-144 board is designed around the STM32 microcontrollers in a 144-pin LQFP package.

Figure 3 shows the connections between the STM32 microcontroller and its peripherals (ST-LINK/V2-1, push-buttons, LEDs, USB, ST Zio connectors and ST morpho headers).

Figure 4 and *Figure 5* show the location of these features on the STM32 Nucleo-144 board. *Figure 6* and *Figure 7* show the mechanical dimensions of the STM32 Nucleo-144 board.

Figure 3. Hardware block diagram



1. Ext SMPS function is only available on '-P' suffixed boards.

6.1 STM32 Nucleo-144 board layout

Figure 4. STM32 Nucleo-144 board top layout

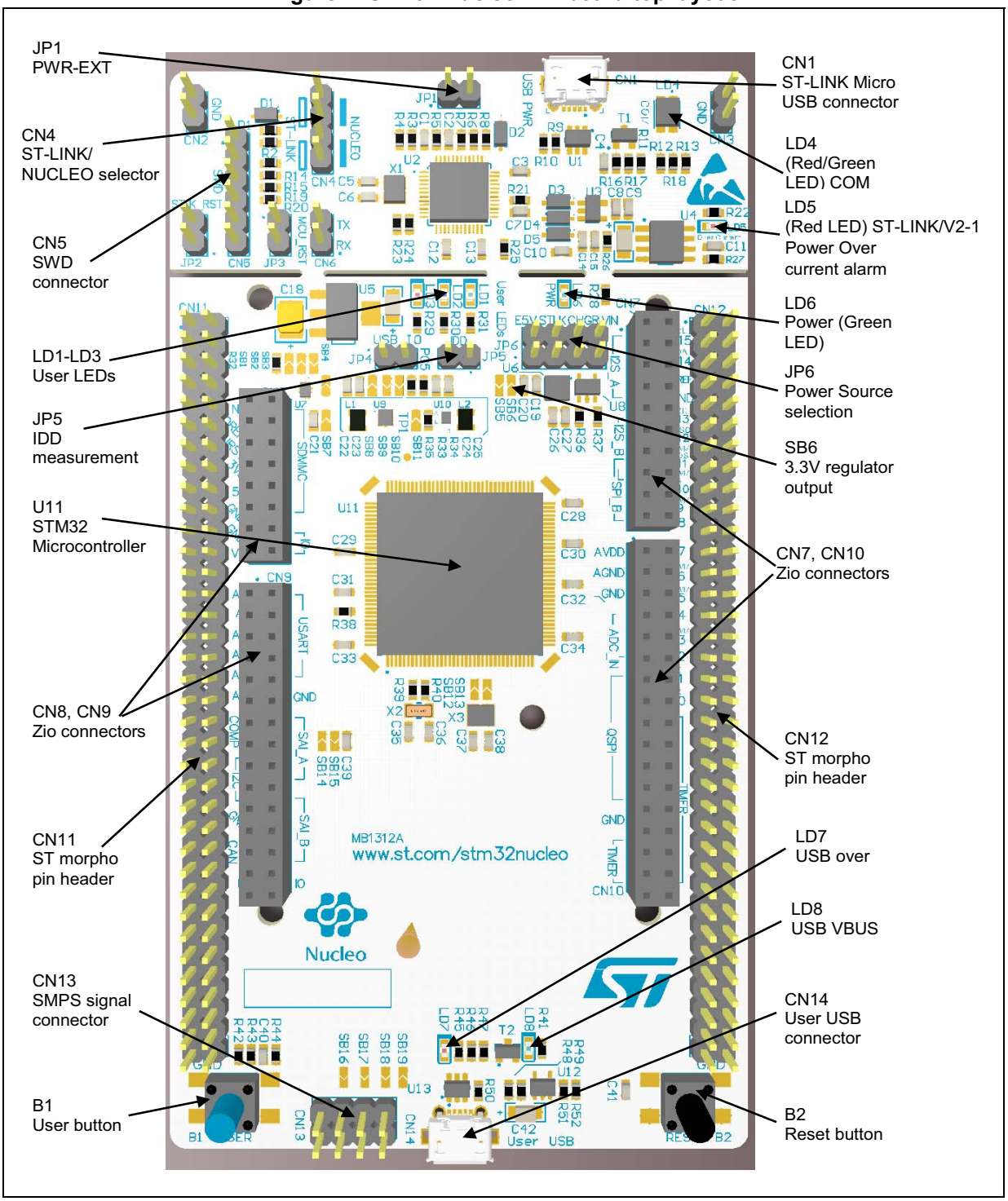
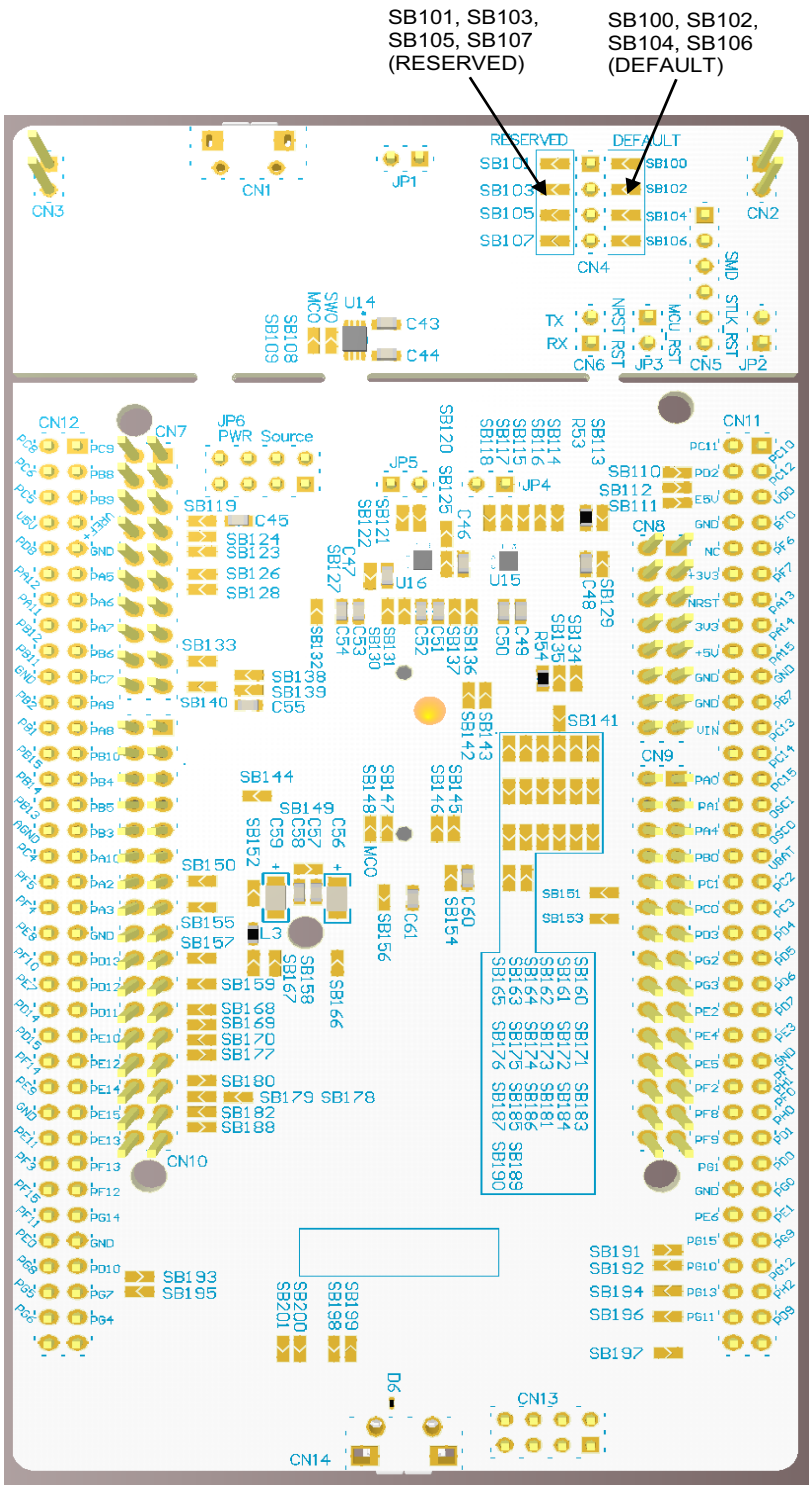


Figure 5. STM32 Nucleo-144 board bottom layout



6.2 STM32 Nucleo-144 board mechanical drawing

Figure 6. STM32 Nucleo-144 board mechanical drawing in millimeter

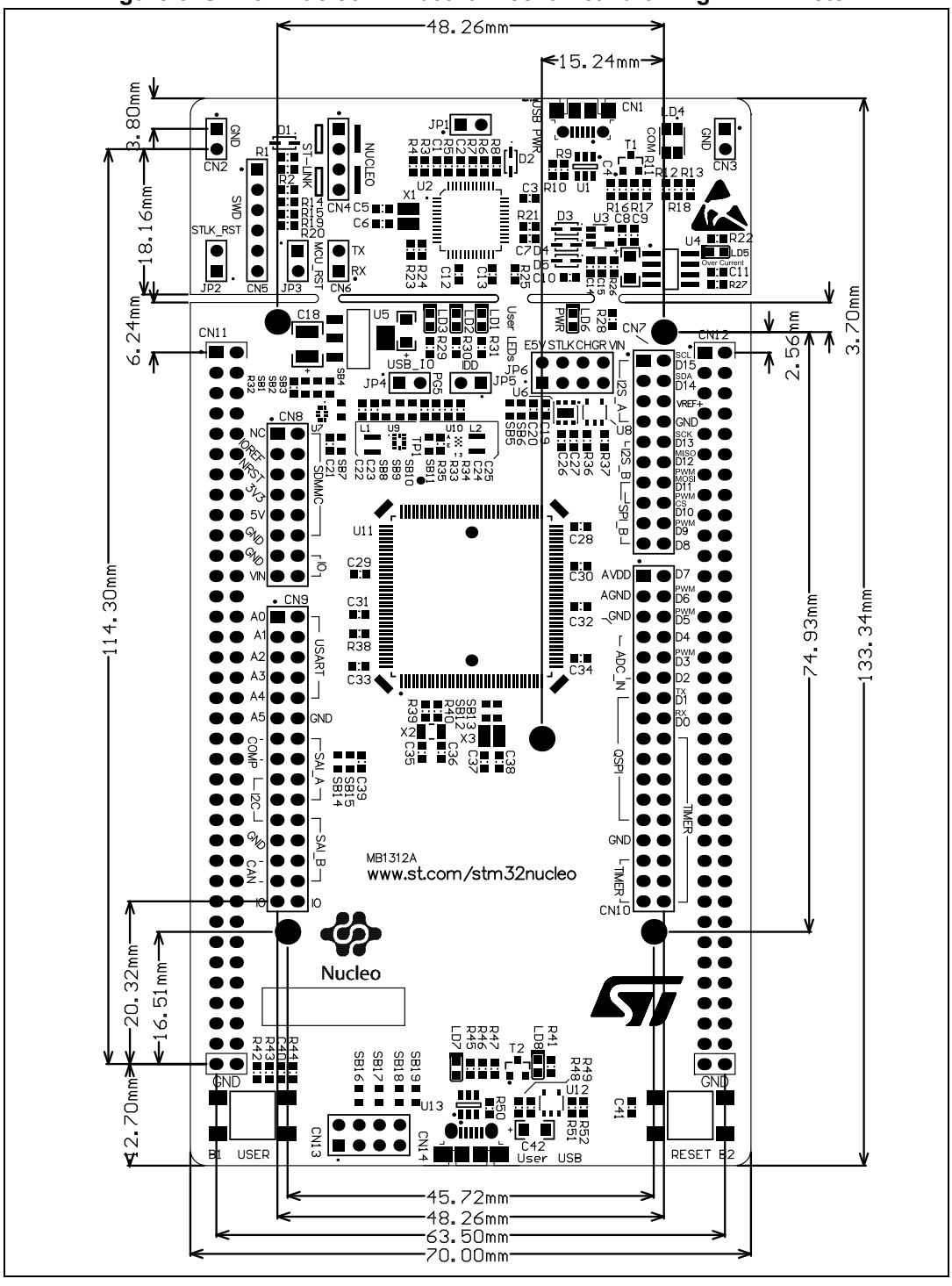
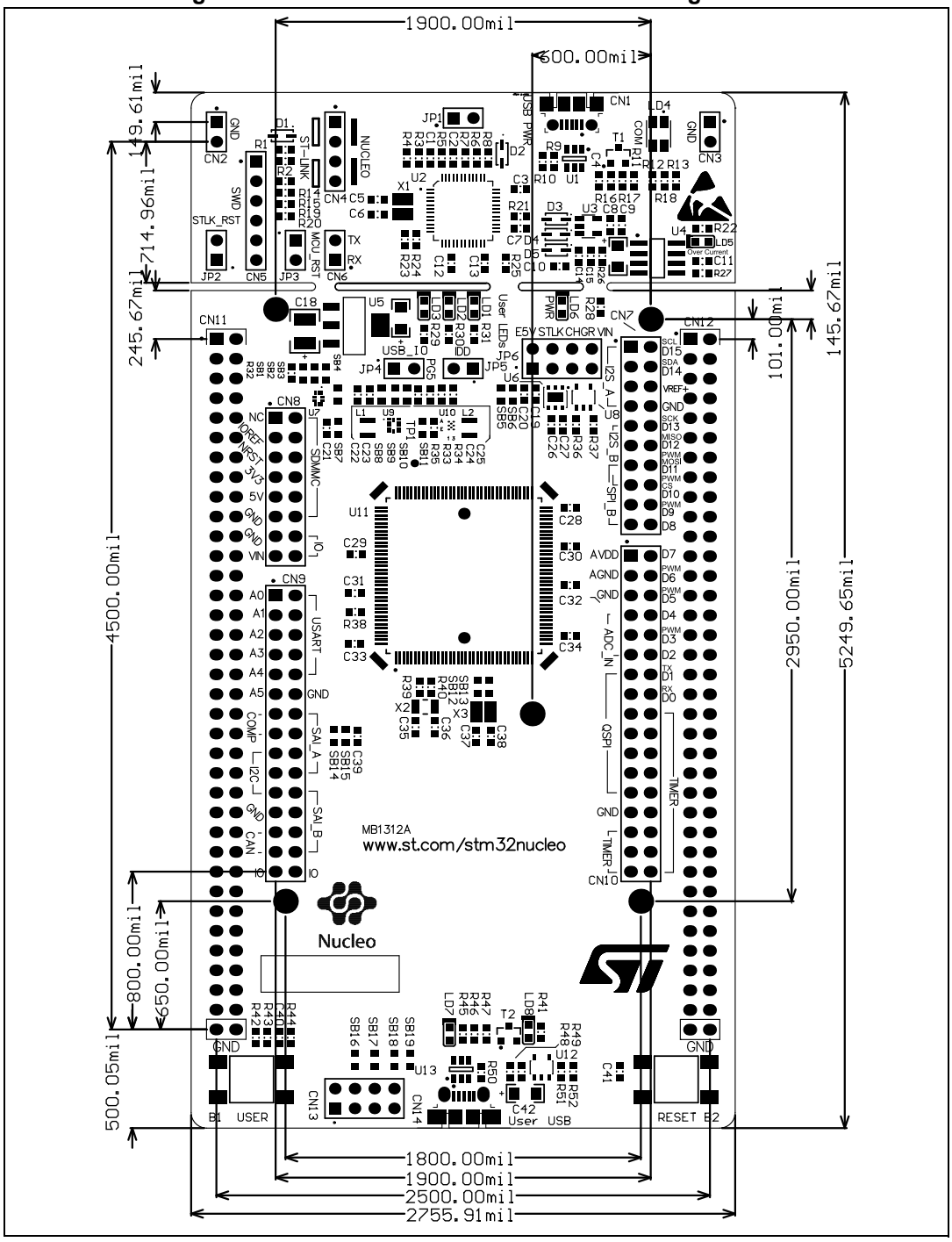


Figure 7. Nucleo-144 board mechanical drawing in mils



6.3 Cuttable PCB

The STM32 Nucleo-144 board is divided into two parts: ST-LINK and target STM32. The ST-LINK part of the PCB can be cut out to reduce the board size. In this case the remaining target STM32 part can only be powered by V_{IN}, E5V and 3.3 V on the ST morpho connector CN11, or by V_{IN} and 3.3 V on the ST Zio connector CN8. It is still possible to use the ST-LINK part to program the STM32, using wires between the CN5 and SWD available signals on the ST morpho connector (SWCLK CN11 pin 15, SWDIO CN11 pin 13 and NRST CN11 pin 14, same I/O level as VDD_MCU).

6.4 Embedded ST-LINK/V2-1

The ST-LINK/V2-1 programming and debugging tool is integrated in the STM32 Nucleo-144 board.

The embedded ST-LINK/V2-1 supports only SWD for STM32 devices. For information about debugging and programming features refer to *ST-LINK/V2 in-circuit debugger/programmer for STM8 and STM32*, User manual (UM1075), which describes in details all the ST-LINK/V2 features.

The changes versus ST-LINK/V2 version are listed below. New features supported on ST-LINK/V2-1:

- USB software re-enumeration
- Virtual COM port interface on USB
- Mass storage interface on USB
- USB power management request for more than 100 mA power on USB

Features not supported on ST-LINK/V2-1:

- SWIM interface
- Minimum supported application voltage limited to 3 V

There are two different ways to use the embedded ST-LINK/V2-1, depending on the jumper state (see *Table 4*):

- Program/debug the STM32 on board
- Program/debug the STM32 in an external application board, using a cable connected to SWD connector CN5

Table 4. CN4 states of the jumpers

Jumper state	Description
Both CN4 jumpers ON	ST-LINK/V2-1 functions enabled for on-board programming (default). See *Section 6.4.3*.
Both CN4 jumpers OFF	ST-LINK/V2-1 functions enabled for external CN5 connector (SWD supported). See *Section 6.4.4*.

6.4.1 Drivers

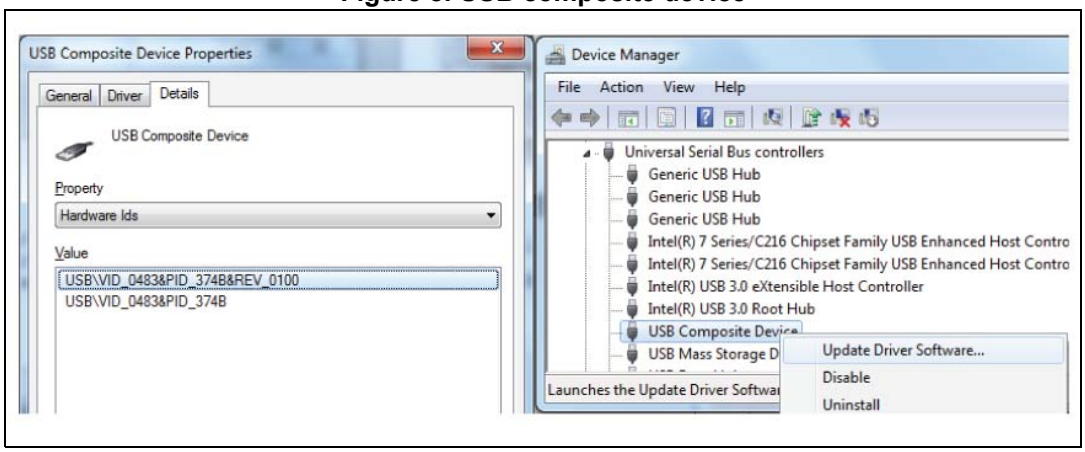
Before connecting the Nucleo-144 board to a Windows® (XP, 7, 8 and 10) PC via USB, install the driver for ST-LINK/V2-1 that can be downloaded from the *www.st.com* website.

If the STM32 Nucleo-144 board is connected to the PC before installing the driver, the PC device manager may report some Nucleo interfaces as “Unknown”.

To recover from this situation, after installing the dedicated driver, the association of “Unknown” USB devices found on the STM32 Nucleo-144 board to this dedicated driver, must be updated in the device manager manually.

Note: It is recommended to proceed by using USB Composite Device, as shown in Figure 8.

Figure 8. USB composite device



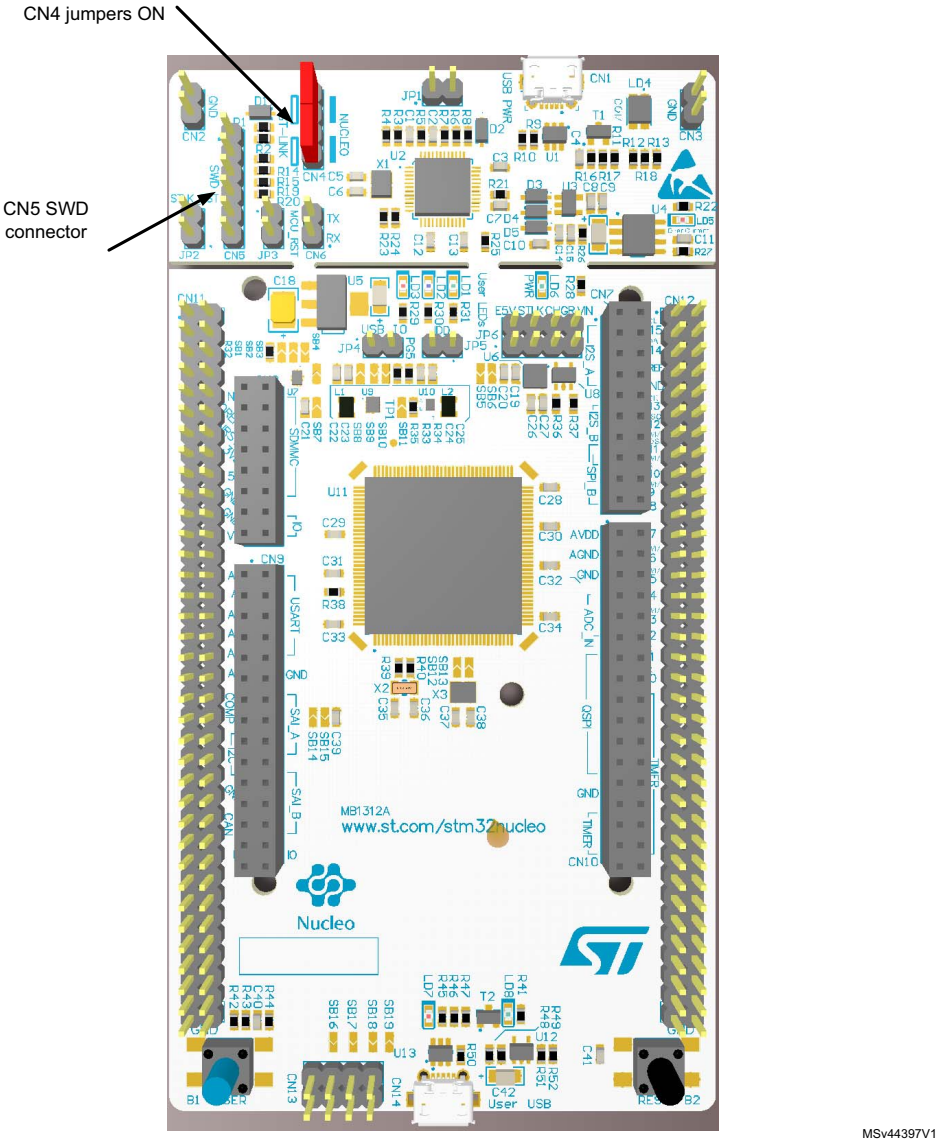
6.4.2 ST-LINK/V2-1 firmware upgrade

The ST-LINK/V2-1 embeds a firmware upgrade mechanism for in-situ upgrade through the USB port. As the firmware may evolve during the lifetime of the ST-LINK/V2-1 product (for example new functionalities, bug fixes, support for new microcontroller families), it is recommended to keep the ST-LINK/V2-1 firmware up to date before starting to use the STM32 Nucleo-144 board. The latest version of this firmware is available from the *www.st.com* website.

6.4.3 Using the ST-LINK/V2-1 to program and debug the on-board STM32

To program the on-board STM32, place the two jumpers marked in red on the connector CN4, as shown in *Figure 9*. The CN5 connector must not be used, since it could disturb the communication with the STM32 microcontroller of the Nucleo-144 board.

Figure 9. Connecting the STM32 Nucleo-144 board to program the on-board STM32



6.4.4 Using ST-LINK/V2-1 to program and debug an external STM32 application

It is very easy to use the ST-LINK/V2-1 to program the STM32 on an external application.

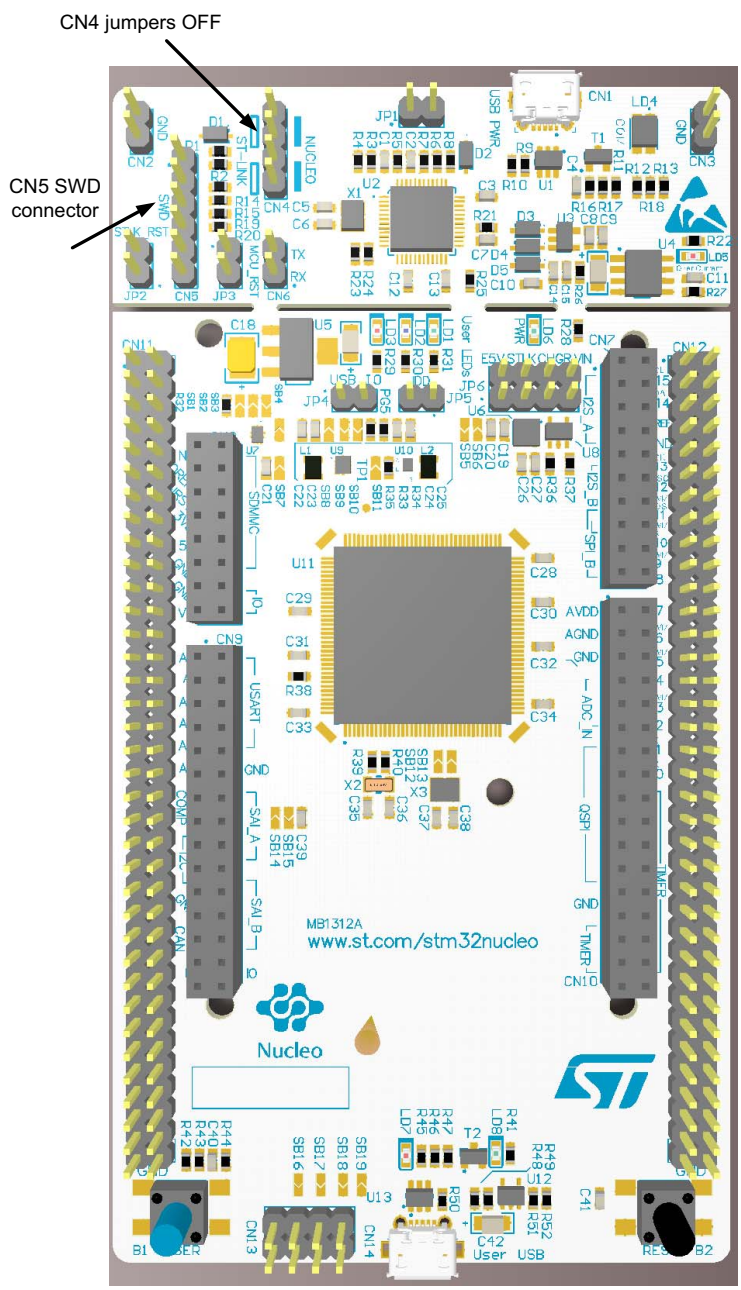
Simply remove the two jumpers from CN4, as shown in *Figure 10* and connect the application to the SWD debug connector according to *Table 5*.

Note: JP4 NRST (target STM32 RESET) must be open when CN3 pin 5 is used in an external application.

Table 5. Debug connector CN5 (SWD)

Pin	CN5	Description
1	VDD_TARGET	V_{DD} from application
2	SWCLK	SWD clock
3	GND	ground
4	SWDIO	SWD data input/output
5	NRST	RESET of target STM32
6	SWO	Reserved

Figure 10. Using ST-LINK/V2-1 to program an external STM32 application



6.5 Power supply and power selection

The power supply is provided either by the host PC through the USB cable or by an external source: V_{IN} (7 V-12 V), E5V (5 V) or +3.3 V power supply pins on CN8 or CN11. If V_{IN}, E5V or +3.3 V is used to power a Nucleo-144 board, this power source must comply with the standard EN-60950-1: 2006+A11/2009 and must be Safety Extra Low Voltage (SELV) with limited power capability.

If the power supply is +3.3 V, the ST-LINK is not powered and cannot be used.

6.5.1 Power supply input from ST-LINK/V2-1 USB connector

The STM32 Nucleo-144 board and shield can be powered from the ST-LINK USB connector CN1 (U5V), by placing a jumper between the pins 3 and 4 of JP6, as shown in *Table 7: Power related jumper*. Note that only the ST-LINK part is power supplied before the USB enumeration, as the host PC only provides 100 mA to the board at that time. During the USB enumeration, the STM32 Nucleo-144 board requires 300 mA of current to the host PC. If the host is able to provide the required power, the targeted STM32 microcontroller is powered and the green LED LD6 is turned ON, thus the STM32 Nucleo-144 board and its shield can consume a maximum current of 300 mA, not more. If the host is not able to provide the required current, the targeted STM32 microcontroller and the extension boards are not power supplied. As a consequence the green LED LD6 stays turned OFF. In such case it is mandatory to use an external power supply as explained in the next section.

After the USB enumeration succeeds, the ST-LINK U5V power is enabled, by asserting the PWR_EN pin. This pin is connected to a power switch (ST890), which powers the board.

This power switch also features a current limitation to protect the PC if a short-circuit happens on the board. If an overcurrent (more than 500 mA) happens on the board, the red LED LD5 lits up.

Warning: If the maximum current consumption of the STM32 Nucleo-144 board and its shield boards exceed 300 mA, it is mandatory to power the STM32 Nucleo-144 board, using an external power supply connected to E5V, V_{IN} or +3.3 V.

Note: If the board is powered by a USB charger, there is no USB enumeration, so the green LED LD6 stays in OFF state permanently and the target STM32 is not powered. In this specific case a jumper must be placed between pins 5 and 6 of JP6, to allow the board to be powered anyway.

6.5.2 External power supply inputs

Depending on the used voltage, an external power source supplies in three different ways the STM32 Nucleo-144 board and its shield boards. The three power sources are listed in *Table 6*.

When the STM32 Nucleo-144 board is power supplied by V_{IN} or E5V, the jumper configuration must be as showed below:

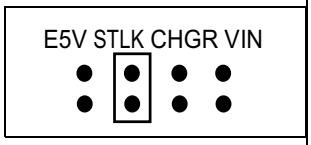
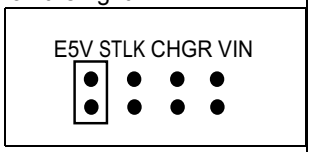
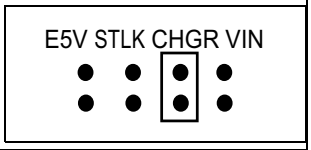
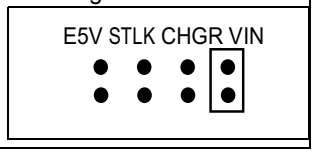
- Jumper JP6 on pin 1 and pin 2 for E5V or jumper JP3 on pin 7 and pin 8 for V_{IN}
- Jumper JP1 OFF

Table 6. External power sources

Input power name	Connector pins	Voltage range	Max current	Limitation
V_{IN}	CN8 pin 15 CN11 pin 24	7 V to 12 V	800 mA	From 7 V to 12 V only and input current capability is linked to input voltage: – 800 mA input current when V_{IN}=7 V – 450 mA input current when 7V<V_{IN}<9V – 250 mA input current when 9 V<V_{IN}<12 V
E5V	CN11 pin 6	4.75 V to 5.25 V	500 mA	-
+3.3 V	CN8 pin 7 CN11 pin 16	3 V to 3.6 V	-	Two possibilities: – ST-LINK PCB is cut – SB3 and SB111 OFF (ST-LINK not powered)

The 5 V power source is selected by the jumper JP6 as shown in *Table 7*.

Table 7. Power related jumper

Jumper	Description
JP6	STLK (ST-LINK V_{BUS}) is used as power source when JP6 is set as shown on the right (Default setting) 
	E5V is used as power source when JP6 is set as shown on the right: 
	CHGR (USB Charger on CN1) is used as power source when JP6 is set as shown on the right: 
	V_{IN} is used as power source when JP6 is set as shown on the right: 

Using V_{IN} or E5V as an external power supply

When powered by V_{IN} or E5V, it is still possible to use the ST-LINK for only programming or debugging, but it is mandatory to power the board first using V_{IN} or E5V, then to connect the USB cable to the PC. In this way the enumeration succeeds, thanks to the external power source.

The following power-sequence procedure must be respected:

1. Connect jumper JP6 between pin 1 and pin 2 for E5V or between pin 7 and pin 8 for V_{IN}
2. Check that JP1 is removed
3. Connect the external power source to V_{IN} or E5V
4. Power on the external power supply 7 V< V_{IN} < 12 V to V_{IN}, or 5 V for E5V
5. Check that the green LED LD6 is turned ON
6. Connect the PC to the USB connector CN1

If this order is not respected, the board may be powered by USB (U5V) first, then by V_{IN} or E5V as the following risks may be encountered:

1. If the board needs more than 300 mA, the PC may be damaged or the current supplied can be limited by the PC. As a consequence the board is not powered correctly.
2. 300 mA is requested during the enumeration phase (since JP1 must be OFF) so there is the risk that the request is rejected and the enumeration does not succeed if the PC cannot provide such current. Consequently the board is not power supplied (LED LD6 remains OFF).

External power supply input: + 3.3 V

If 3.3 V is provided by a shield board, it is worth using the +3.3 V (CN8 pin 7 or CN11 pin 16) directly as power input. In this case the ST-LINK is not powered thus the programming and debugging features are not available.

When the board is powered with +3.3 V, two different configurations are possible:

- ST-LINK is removed (PCB cut)
- SB6 (3.3 V regulator) and JP3 (NRST) are OFF

6.5.3 External power supply output

When powered by USB, V_{IN} or E5V, the +5 V (CN8 pin 9 or CN11 pin 18) can be used as output power supply for an ST Zio shield or an extension board. In this case the maximum current of the power source specified in *Table 6: External power sources* must be respected.

The +3.3 V (CN8 pin 7 or CN11 pin 16) can also be used as power supply output. The current is limited by the maximum current capability of the regulator U6 (500 mA max).

6.5.4 SMPS power supply

Power figures in Run Mode are significantly improved, by generating V_{core} logic supply from the external DC/DC converter (this function is only available on '-P' suffixed boards).

Board is populated with two different SMPS mounted on U15 and U16:

- SMPS U15 allows to dynamically supply the V_{DD_1V2} pins in Run mode at 1.1 V with a maximum current of 30 mA.
- SMPS U16 allows to supply the V_{DD_MCU} pins at 1.8 V with a maximum current of 50 mA. When SB125 is opened and SB120 closed, the SMPS can deliver higher

current but with higher consumption. This SMPS is disabled by default (See *Table 10: Configuration of the solder bridges and jumpers*).

V_{DD_MCU} solder bridge configuration:

- 3.3 V (default): SB122 closed, SB121 and SB127 open
- 1.8 V: SB122 open, and SB121 and SB127 closed (best ULPBench score)

Note: The ST-LINK is still available in this configuration thanks to the level shifter U14.

6.6 LEDs

User LD1: a green user LED is connected to the STM32 I/O PC7 (SB124 ON and SB123 OFF) or PA5 (SB123 ON and SB124 OFF) corresponding to the ST Zio D13. It only works when V_{CC_MCU} is 3.3 V.

User LD2: a blue user LED is connected to PB7.

User LD3: a red user LED is connected to PB14.

These user LEDs are on when the I/O is HIGH value, and are off when the I/O is LOW.

LD4 COM: the tricolor LED LD4 (green, orange and red) provides information about ST-LINK communication status. LD4 default color is red. LD4 turns to green to indicate that the communication is in progress between the PC and the ST-LINK/V2-1, with the following setup:

- Slow blinking red/off: at power-on before USB initialization
- Fast blinking red/off: after the first correct communication between PC and ST-LINK/V2-1 (enumeration)
- Red LED on: when the initialization between the PC and ST-LINK/V2-1 is complete
- Green LED on: after a successful target communication initialization
- Blinking red/green: during communication with target
- Green on: communication finished and successful
- Orange on: communication failure

LD5 USB power fault: LD5 indicates that the board power consumption on USB exceeds 500 mA, consequently the user must power the board using an external power supply.

LD6 PWR: the green LED indicates that the STM32 part is powered and +5 V power is available on CN8 pin 9 and CN11 pin 18.

LD7 and LD8 USB FS: refer to *Section 6.12: USB FS OTG* .

Note:1 LD1 is connected to U8 and it is driven by PC7 or PA5 which may be changed to 1.8 V I/O, so LD1 cannot be lit when V_{DD} is set to 1.8 V.

Note:2 LD2, LD3 cannot work with V_{DD_MCU}= 1.8 V

6.7 Push-buttons

B1 USER: the user button is connected to the I/O PC13 by default (Tamper support, SB197 ON and SB178 OFF) or PA0 (Wakeup support, SB178 ON and SB197 OFF) of the STM32.

B2 RESET: this push-button is connected to NRST and is used to RESET the STM32.

6.8 JP5 (IDD)

The jumper JP5, labeled IDD, is used to measure the STM32 microcontroller consumption by removing the jumper and by connecting an ammeter:

- JP5 ON: STM32 is powered (default)
- JP5 OFF: an ammeter must be connected to measure the STM32 current. If there is no ammeter, the STM32 is not powered

6.9 OSC clock

6.9.1 OSC clock supply

There are four ways to configure the pins corresponding to the external high-speed clock (HSE):

- **HSE not used (Default):** PF0/PH1 and PF1/PH1 are used as GPIOs instead of as clock. The configuration must be:
  - SB147 and SB156 ON
  - SB109 and SB148 (MCO) OFF
  - SB12 and SB13 removed
- **MCO from ST-LINK:** MCO output of ST-LINK is used as input clock. This frequency cannot be changed, it is fixed at 8 MHz and connected to the
- PF0/PH0-OSC_IN of STM32 microcontroller. The configuration must be:
  - SB147 OFF
  - SB109 and SB148 ON
  - SB12 and SB13 OFF
- **HSE on-board oscillator from X3 crystal (not provided):** for typical frequencies and its capacitors and resistors, refer to the STM32 microcontroller datasheet and for the oscillator design guide refer to the *Oscillator design guide for STM8S, STM8A and STM32 microcontrollers* Application note *(*AN2867). The X3 crystal has the following characteristics: 8 MHz, 8 pF, 20 ppm. It is recommended to use the NX3225GD-8.000M-EXS00A-CG04874 crystal manufactured by NIHON DEMPA KOGYO CO., LTD. The configuration must be:
  - SB147 and SB156 OFF
  - SB12 and SB13 soldered
  - C37 and C38 soldered with 4.3 pF capacitors
  - SB109 and SB148 OFF
- **Oscillator from external PF0/PH0:** from an external oscillator through the pin 29 of the CN11 connector. The configuration must be:
  - SB147 ON
  - SB109 and SB148 OFF
  - SB12 and SB13 removed

6.10 OSC 32 KHz clock supply

There are three ways to configure the pins corresponding to low-speed clock (LSE):

- **On-board oscillator (Default):** X2 crystal. Refer to the *Oscillator design guide for STM8S, STM8A and STM32 microcontrollers* Application note *(*AN2867) for oscillator design guide for STM32 microcontrollers. It is recommended to use the NX3214SA-32.768KHZ-EXS00A-MU00525 (32.768 KHz, 6 pF load capacitance, 200 ppm) crystal from Nihon Dempa Kogyo CO, LTD.
- **Oscillator from external PC14:** from external oscillator through the pin 25 of CN11 connector. The configuration must be:
  - SB145 and SB146 ON
  - R39 and R40 removed
- **LSE not used:** PC14 and PC15 are used as GPIOs instead of low-speed clock. The configuration must be:
  - SB145 and SB146 ON
  - R39 and R40 removed

6.11 LPUART1 communication

The LPUART1 interface available on PG7 and PG8 of the STM32 can be connected to the ST-LINK or to the ST morpho connector. Another option to do this connection is to set the related solder bridges. By default the LPUART1 communication between the target STM32 and the ST-LINK is enabled, to support the virtual COM port (SB130 and SB131 ON). Refer to *Table 8*.

Table 8. LPUART1 pin configuration

Pin name	Function	Virtual COM port (default configuration)	ST morpho connection
PG7	LPUART1 TX	SB131 ON and SB195 OFF	SB131 OFF and SB95 ON
PG8	LPUART1 RX	SB130 ON and SB193 OFF	SB130 OFF and SB193 ON

6.12 USB FS OTG

The STM32 Nucleo-144 board supports the USB OTG as host or as device-full-speed communication through a USB Micro-AB connector (CN14) and USB power switch (U12) connected to V_{BUS}.

Warning: The USB Micro-AB connector (CN14) cannot power a Nucleo-144 board. To avoid damaging the STM32, it is mandatory to power the board before connecting a USB cable on CN14. Otherwise there is a risk of current injection on STM32 I/Os.

A green LED LD8 lits up in one of these cases:

- Power switch (U12) is ON and STM32 Nucleo-144 board works as a USB host
- V_{BUS} is powered by another USB host when the STM32 Nucleo-144 board works as a USB device.

The red LED LD7 lits up if overcurrent occurs when +5 V is enabled on V_{BUS} in USB host mode.

Note:1 It is recommended to power the Nucleo-144 board with an external power supply when using the USB OTG or the host function.

Note:2 JP4 must be closed when using the USB OTG FS.

Note:3 Limitation: when the cable is not connected, PA9 (V_{BUS}) is not floating, because internal pull up of PA12 (D+) impacts PA9 through ESD protection part USBLC6-2SC6 (U13).

For pin configuration refer to *Table 9*.

Table 9. USB pin configuration

Pin name	Function	Configuration when using USB connector	Configuration when using ST morpho connector	Remark
PA8	USB SOF	-	-	Test point TP1
PA9	USB V_{BUS}	SB135 ON	SB135 OFF	-
PA10	USB ID	SB134 ON	SB134 OFF	-
PA11	USB DM	SB142 ON	SB142 OFF	-
PA12	USB DP	SB143 ON	SB143 OFF	-
PG6	USB GPIO OUT	OTG:SB201 OFF, SB200 ON	OTG:SB200 OFF	OTG:USB power switch control
PG5	USB GPIO IN	JP4 ON, SB199 OFF SB198 ON	JP4 OFF	USB overcurrent alarm

6.13 Solder bridges and jumpers

SBxx are located on top layer and SB1xx-SB2xx on bottom layer of the STM32 Nucleo-144 board. The configuration of the solder bridges and jumpers is showed in *Table 10*.

Table 10. Configuration of the solder bridges and jumpers

Bridge/jumper	State(1)	Description
SB5 (+3V3_PER)	**ON**	Peripheral power +3V3_PER is connected to +3.3 V.
	OFF	Peripheral power +3V3_PER is not connected.
SB6 (3.3 V)	**ON**	Output of voltage regulator LD39050PU33R is connected to 3.3 V.
	OFF	Output of voltage regulator LD39050PU33R is not connected.

Table 10. Configuration of the solder bridges and jumpers (continued)

Bridge/jumper	State(1)	Description
SB195, SB193 (GPIO)	**ON**	PG7 and PG8 on STM32 are connected to ST morpho connectors CN12. If these pins are used on ST morpho connectors, SB130 and SB131 should be OFF.
	OFF	PG7 and PG8 on STM32 are disconnected to ST morpho connectors CN12.
SB131, SB130 (ST-LINK-USART)	**ON**	PA2 and PA3 on ST-LINK STM32F103CBT6 are connected to PG7 and PG8 to enable the virtual COM port. Thus PG7 and PG8 on ST morpho connectors cannot be used.
	OFF	PA2 and PA3 on ST-LINK STM32F103CBT6 are disconnected to PG7 and PG8 on STM32.
SB152 (V_{DDA})	**ON**	V_{DDA} on STM32 MCU is connected to V_{DD}.
	OFF	V_{DDA} on STM32 MCU is disconnected to V_{DD}.
SB100,102,104,106 (DEFAULT)	ON	Reserved, do not modify.
SB101,103,105,107 (RESERVED)	**OFF**	Reserved, do not modify.
SB141 (SWO)	**ON**	SWO signal of the STM32 (PB3) is connected to ST-LINK SWO input.
	OFF	SWO signal of STM32 is not connected.
SB110, SB111,SB112 (IOREF)	**OFF, OFF, ON**	IOREF is connected to V_{DD_MCU}.
	ON, OFF, OFF	IOREF is connected to +3.3 V.
	OFF, ON, OFF	IOREF is connected to +3V3_PER.
SB119 (V_{REF+})	**OFF**	Pin 6 of CN7 and Pin 7 of CN12 are disconnected to V_{REF+} on STM32.
	ON	Pin 6 of CN7 and Pin 7 of CN12 are connected to V_{REF+} on STM32.
SB137 (SDMMC_D0), SB136 (SDMMC_D1)	**ON**	These pins are connected to ST morpho connector CN12.
	OFF	These pins are disconnected from ST morpho connector CN12 to avoid stub of SDMMC data signals on PCB.
SB124, SB123 (LD1-LED)	**ON, OFF**	Green user LED LD1 is connected to PC7.
	OFF,ON	Green user LED LD1 is connected to D13 of Arduino signal (PA5).
	OFF, OFF	Green user LED LD1 is not connected.
	ON,ON	Forbidden.
SB172 (Legacy) SB173 (SMPS) (LD2-LED)	ON	Blue user LED LD2 is connected to PB7.
	OFF	Blue user LED LD2 is not connected.

Table 10. Configuration of the solder bridges and jumpers (continued)

Bridge/jumper	State(1)	Description
SB132 (LD3-LED)	**ON**	Red user LED LD3 is connected to PB14.
	OFF	Red user LED LD3 is not connected.
SB145,146 (X2 crystal)	**OFF**	PC14, PC15 are not connected to ST morpho connector CN11. (X2 used to generate 32 KHz clock).
	ON	PC14, PC15 are connected to ST morpho connector CN11. (R37 and R38 should be removed).
SB147 (PH0), SB156 (PH1) (Main clock)	**ON, ON**	PH0 and PH1 are connected to ST morpho connector CN11. (SB12, SB13 and SB148 must be removed).
	OFF, ON	PH0 is not connected to ST morpho PH1 is connected to ST morpho connector CN11 (MCO is used as main clock for STM32 on PH0).
	OFF, OFF	PH0, PH1 are not connected to ST morpho connector CN11 (X3, C37, C38, SB12 and SB13 provide a clock as shown in *Section Appendix A: Electrical schematics*. In this case SB148 must be removed).
SB109, SB148 (MCO)	**OFF**	MCO of ST-LINK (STM32F103CBT6) is not connected to PH0 of STM32.
	ON	MCO of ST-LINK (STM32F103CBT6) is connected to PH0 of STM32.
SB12, SB13 (external 8M crystal)	**OFF**	PH0 and PH1 are not connected to external 8 MHz crystal X3.
	ON	PH0 and PH1 are connected to external 8 MHz crystal X3.
SB154 (V_{BAT})	**ON**	V_{BAT} pin of STM32 is connected to V_{DD}.
	OFF	V_{BAT} pin of STM32 is not connected to V_{DD}.
SB197, SB178 (B1-USER)	**ON, OFF**	B1 push-button is connected to PC13.
	OFF, ON	B1 push-button is connected to PA0 (Set SB179 OFF if ST Zio connector is used).
	OFF, OFF	B1 push-button is not connected.
SB179 (PA0)	**ON**	PA0 is connected to ST Zio connector (Pin 29 of CN10).
	OFF	PA0 is not connected to ST Zio connector (Pin 29 of CN10).
SB151,SB153-	**OFF**	Default setting.
	ON	Forbidden.
SB158, SB167 (A_{VDD})	**ON, OFF**	A_{VDD} on STM32 is connected to V_{DD}.
	OFF, ON	A_{VDD} on STM32 is connected to VDD_MCU.
SB142 (PA11), SB143 (PA12)	**ON**	These pins are used as D+ and D- on USB connector CN14.
	OFF	These pins are used as GPIOs on ST morpho connectors.
SB149 (V_{REF+})	**ON**	V_{REF+} on STM32 is connected to A_{VDD}.
	OFF	V_{REF+} on STM32 is disconnected to A_{VDD}.

Table 10. Configuration of the solder bridges and jumpers (continued)

Bridge/jumper	State[1]	Description
SB144 (QSPI_IO1)	**ON**	These pins are connected to ST morpho connector CN11.
	OFF	These pins are disconnected from ST morpho connector CN11 to avoid stub of QSPI_IO1 signals on PCB.
JP2[2] (STM_RST)	**OFF**	No incidence on ST-LINK STM32F103CBT6 NRST signal.
	ON	ST-LINK STM32F103CBT6 NRST signal is connected to GND (ST-LINK reset to reduce power consumption).
JP3 (NRST)	**ON**	Board RESET signal (NRST) is connected to ST-LINK reset control I/O (T_NRST).
	OFF	Board RESET signal (NRST) is not connected to ST-LINK reset control I/O (T_NRST).
SB122, SB121, SB127 (V_{DD_MCU})	**ON, OFF,OFF**	V_{DD_MCU} is connected to V_{DD} directly (3.3 V fixed).
	OFF, ON, ON	V_{DD_MCU} is connected to output of DC-DC (1.8 V fixed).

1. Default SBx state is shown in bold.
2. The jumper JP2 is not mounted on the board by default.

All the other solder bridges present on the STM32 Nucleo-144 board are used to configure several I/Os and power supply pins for compatibility of features and pinout with the target STM32 supported.

STM32 Nucleo-144 boards are delivered with the solder bridges configured according to the target STM32 supported.

6.14 Expansion connectors

For each STM32 Nucleo-144 board the *Figure 11*, *Figure 12* and *Figure 13* show the signals connected by default to the ST Zio connectors (CN7, CN8, CN9 and CN10), including the support for Arduino Uno V3.

Figure 11. NUCLEO-L496ZG

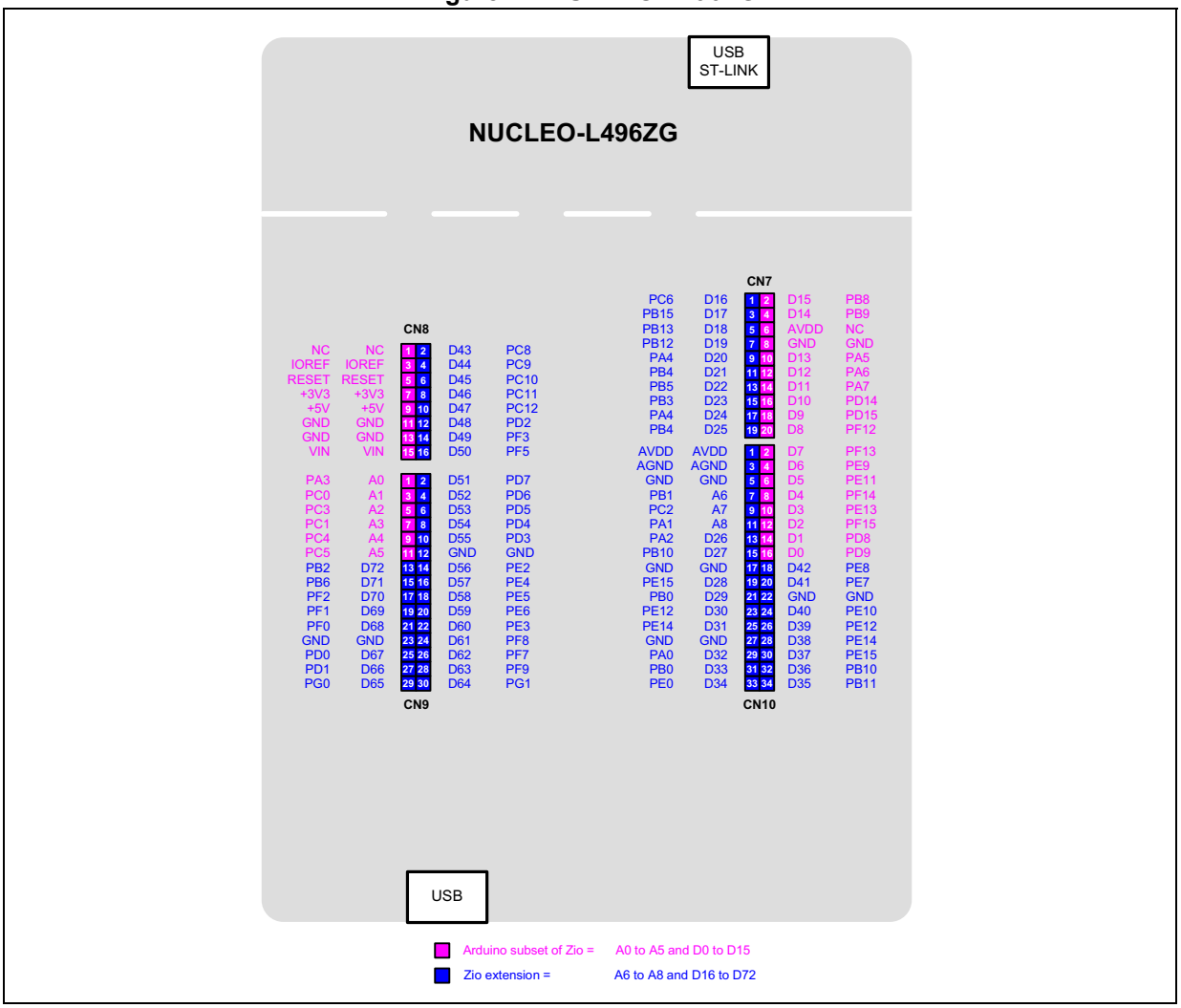


Figure 12. NUCLEO-L496ZG-P

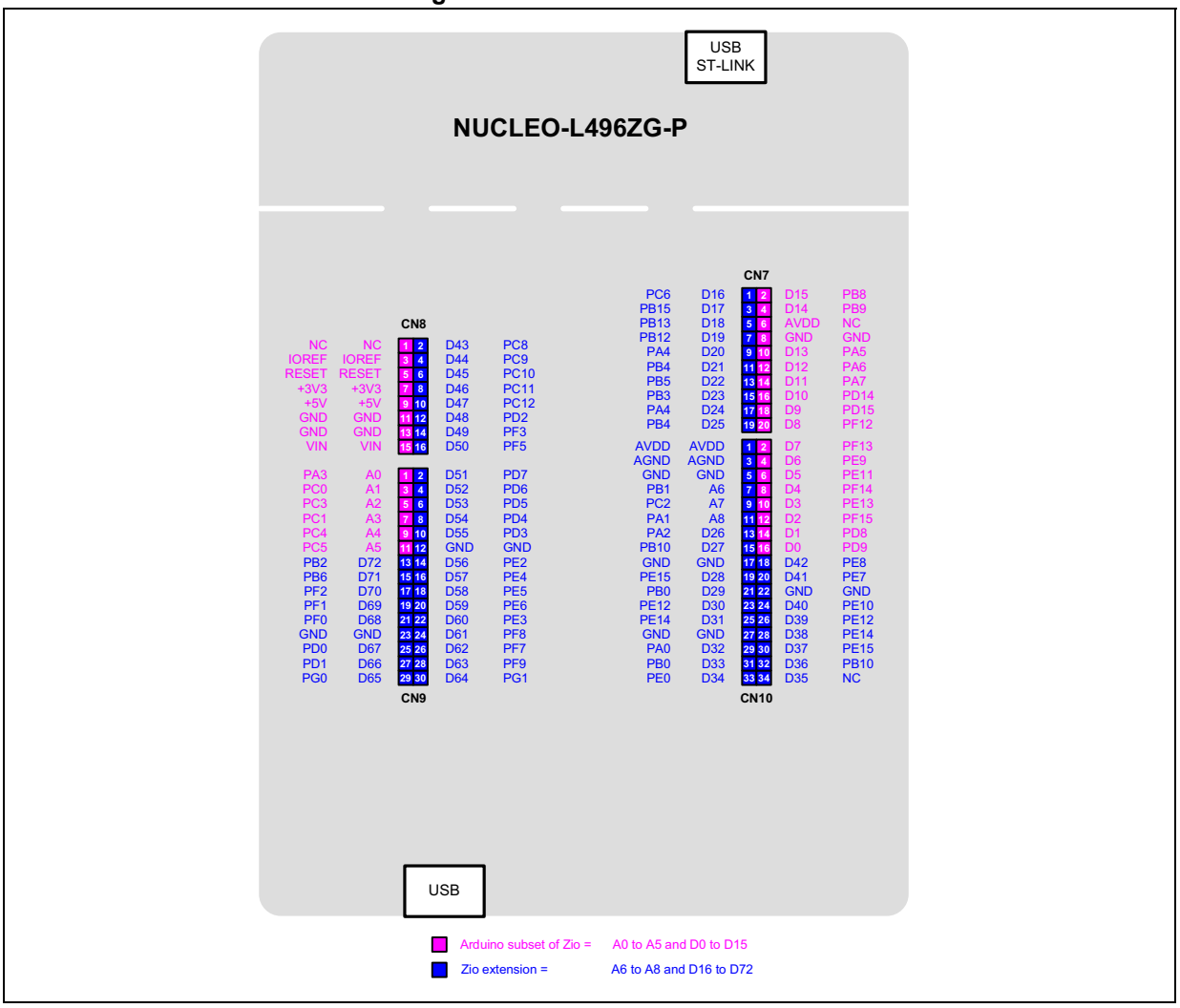
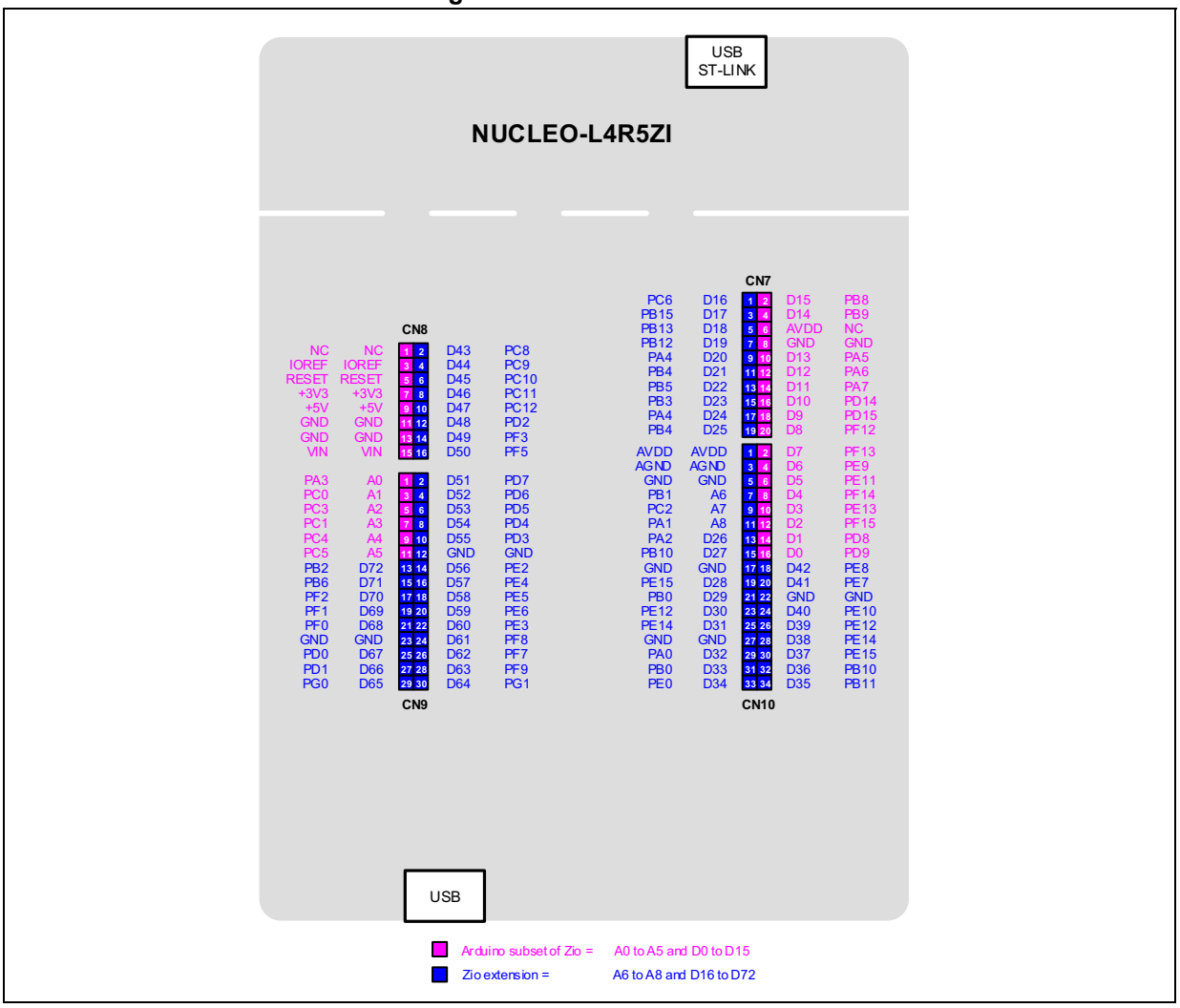


Figure 13. NUCLEO-L4R5ZI



6.15 ST Zio connectors

The connectors CN7, CN8, CN9 and CN10 are female on top side and male on bottom side of the STM32 Nucleo-144 board. They include support for Arduino Uno V3. Most shields designed for Arduino Uno V3 can fit to the STM32 Nucleo-144 board.

Caution: The I/Os of the STM32 microcontroller are 3.3 V compatible, while Arduino Uno V3 is 5 V compatible.

Table 11 shows the pin assignments for the STM32 on the ST Zio connector.

Table 11. NUCLEO-L496ZG, NUCLEO-L496ZG-P and NUCLEO-L4R5ZI pin assignments

Connector	Pin	Pin name	Signal name	STM32 pin	Function	Remark
Left connectors						
CN8	1	NC	NC	-	-	Arduino support
	3	IOREF	IOREF		3.3 V Ref	
	5	RESET	RESET	NRST	RESET	
	7	+3.3 V	+3.3 V	-	3.3 V input/output	
	9	+5 V	+5 V		5 V output	
	11	GND	GND		ground	
	13	GND	GND			
	15	V_{IN}	V_{IN}		Power input	
	2	D43	SDMMC_D0	PC8	SDMMC/I2S_A	-
	4	D44	SDMMC_D1/ I2S_A_CKIN	PC9		
	6	D45	SDMMC_D2	PC10		
	8	D46	SDMMC_D3	PC11		
	10	D47	SDMMC_CK	PC12		
	12	D48	SDMMC_CMD	PD2		
	14	D49	I/O	PF3	I/O	
	16	D50	I/O	PF5		
CN9	1	A0	ADC	PA3	ADC12_IN8	Arduino support
	3	A1	ADC	PC0	ADC123_IN1	
	5	A2	ADC	PC3	ADC123_IN4	
	7	A3	ADC	PC1	ADC123_IN2	
	9	A4(1)	ADC	PC4	ADC12_IN13	
	11	A5(1)	ADC	PC5	ADC12_IN14	
	13	D72	COMP1_INP	PB2	COMP	-
	15	D71	COMP2_INP	PB6	I2C_2	
	17	D70	I2C_B_SMBA	PF2		
	19	D69	I2C_B_SCL	PF1		
	21	D68	I2C_B_SDA	PF0		
	23	GND	GND	-	ground	
	25	D67	CAN_RX	PD0	CAN_1	
	27	D66	CAN_TX	PD1		
	29	D65	I/O	PG0	I/O	
	2	D51	USART_B_SCLK	PD7	USART_2	

Table 11. NUCLEO-L496ZG, NUCLEO-L496ZG-P and NUCLEO-L4R5ZI pin assignments (continued)

Connector	Pin	Pin name	Signal name	STM32 pin	Function	Remark
CN9	4	D52	USART_B_RX	PD6	USART_2	-
	6	D53	USART_B_TX	PD5		
	8	D54	USART_B_RTS	PD4		
	10	D55	USART_B_CTS	PD3		
	12	GND	GND	-	ground	
	14	D56	SAI_A_MCLK	PE2	SAI_1_A	
	16	D57	SAI_A_FS	PE4		
	18	D58	SAI_A_SCK	PE5		
	20	D59	SAI_A_SD	PE6		
	22	D60	SAI_B_SD	PE3	SAI_1_B	
	24	D61	SAI_B_SCK	PF8		
	26	D62	SAI_B_MCLK	PF7		
	28	D63	SAI_B_FS	PF9		
	30	D64	I/O	PG1	I/O	
Right connectors						
CN7	1	D16	I2S_A_MCK	PC6	SAI_2_A	-
	3	D17	I2S_A_SD	PB15		
	5	D18	I2S_A_CK	PB13		
	7	D19	I2S_A_WS	PB12		
	9	D20	I2S_B_WS	PA4	SAI_1_B/ SPI3(2)	
	11	D21	I2S_B_MCK	PB4		
	13	D22	I2S_B_SD/ SPI_B_MOSI	PB5		
	15	D23	I2S_B_CK/ SPI_B_SCK	PB3		
	17	D24	SPI_B_NSS	PA4		
	19	D25	SPI_B_MISO	PB4		
	2	D15	I2C_A_SCL	PB8	I2C1_SCL	Arduino support
	4	D14	I2C_A_SDA	PB9	I2C1_SDA	
	6	AREF	AREF	-	VREF+(3)	
	8	GND	GND		ground	
	10	D13	SPI_A_SCK	PA5	SPI1_SCK	
	12	D12	SPI_A_MISO	PA6	SPI1_MISO	
	14	D11	SPI_A_MOSI/ TIM_E_PWM1	PA7	SPI1_MOSI/ TIM17_CH1	

Table 11. NUCLEO-L496ZG, NUCLEO-L496ZG-P and NUCLEO-L4R5ZI pin assignments (continued)

Connector	Pin	Pin name	Signal name	STM32 pin	Function	Remark
CN7	16	D10	SPI_A_CS/ TIM_B_PWM3	PD14	SPI1_CS/ TIM4_CH3	Arduino support
	18	D9	TIMER_B_PWM2	PD15	TIM4_CH4	
	20	D8	I/O	PF12	-	
CN10	1	AVDD	AVDD	-	Analog VDD	-
	3	AGND	AGND		Analog ground	
	5	GND	GND		ground	
	7	A6	ADC_A_IN	PB1	ADC12_IN16	
	9	A7	ADC_B_IN	PC2	ADC123_IN3	
	11	A8	ADC_C_IN	PA1	ADC12_IN6	
	13	D26	QSPI_CS	PA2(4)	QSPI_BK1	
	15	D27	QSPI_CLK	PB10(4)	QSPI_CLK	
	17	GND	GND	-	ground	
	19	D28	QSPI_BK1_IO3	PE15(4)	QSPI_BK1	
	21	D29	QSPI_BK1_IO1	PB0(4)		
	23	D30	QSPI_BK1_IO0	PE12(4)		
	25	D31	QSPI_BK1_IO2	PE14(4)		
	27	GND	GND	-	ground	
	29	D32	TIMER_C_PWM1	PA0(4)	TIM2_CH1	
	31	D33	TIMER_D_PWM1	PB0(4)	TIM3_CH3	
	33	D34	TIMER_B_ETR	PE0	TIM4_ETR	
	2	D7	I/O	PF13	-	Arduino support
	4	D6	TIMER_A_PWM1	PE9	TIM1_CH1	
	6	D5	TIMER_A_PWM2	PE11	TIM1_CH2	
	8	D4	I/O	PF14	-	
	10	D3	TIMER_A_PWM3	PE13	TIM1_CH3	
	12	D2	I/O	PF15	-	
	14	D1	USART_A_TX	PD8	USART3	
	16	D0	USART_A_RX	PD9		
	18	D42	TIMER_A_PWM1N	PE8	TIM1_CH1N	-
	20	D41	TIMER_A_ETR	PE7	TIM1_ETR	
	22	GND	GND	-	ground	
	24	D40	TIMER_A_PWM2N	PE10	TIM1_CH2N	
	26	D39	TIMER_A_PWM3N	PE12(4)	TIM1_CH3N	

Table 11. NUCLEO-L496ZG, NUCLEO-L496ZG-P and NUCLEO-L4R5ZI pin assignments (continued)

Connector	Pin	Pin name	Signal name	STM32 pin	Function	Remark
CN10	28	D38	I/O	PE14(4)	I/O	-
	30	D37	TIMER_A_BKIN1	PE15(4)	TIM1_BKIN1	
	32	D36	TIMER_C_PWM2	PB10(4)	TIM2_CH3	
	34	D35	TIMER_C_PWM3	PB11(5)	TIM2_CH4	

1. To be compatible with the previous versions of the Arduino Uno V3 board, A4/A5 do not support I^2C.
2. I2S_B group has the same port as SAI_B group, but they have a different pin map.
3. V_{REF+} is not connected to CN7 by default.
4. QSPI signals (PA2, PB10, PE15, PB0, PE12 and PE14) are shared with timer signals on CN10.
5. PB11 is not available on the NUCLEO-L496ZG-P board.

6.16 ST morpho connector

The ST morpho connector consists in male pin header footprints CN11 and CN12 (not soldered by default). They can be used to connect the STM32 Nucleo-144 board to an extension board or a prototype/wrapping board placed on top of the STM32 Nucleo-144 board. All signals and power pins of the STM32 are available on the ST morpho connector. This connector can also be probed by an oscilloscope, logical analyzer or voltmeter.

Table 12 shows the pin assignments for the STM32 on the ST morpho connector.

Table 12. ST morpho connector pin assignments

CN11 odd pins		CN11 even pins		CN12 odd pins		CN12 even pins	
Pin	Pin name	Pin	Pin name	Pin	Pin name	Pin	Pin name
1	PC10	2	PC11	1	PC9	2	PC8
3	PC12	4	PD2	3	PB8	4	PC6
5	V_{DD}	6	E5V	5	PB9	6	PC5
7	PH3-BOOT0(1)	8	GND	7	V_{REF+}(2)	8	U5V(3)
9	PF6	10	-	9	GND	10	PD8
11	PF7	12	IOREF	11	PA5	12	PA12
13	PA13(4)	14	RESET	13	PA6	14	PA11
15	PA14(4)	16	+3.3 V	15	PA7	16	PB12
17	PA15	18	+5 V	17	PB6	18	PB11
19	GND	20	GND	19	PC7	20	GND
21	PB7	22	GND	21	PA9	22	PB2
23	PC13	24	V_{IN}	23	PA8	24	PB1
25	PC14	26	-	25	PB10	26	PB15
27	PC15	28	PA0	27	PB4	28	PB14

Table 12. ST morpho connector pin assignments (continued)

CN11 odd pins		CN11 even pins		CN12 odd pins		CN12 even pins	
Pin	Pin name	Pin	Pin name	Pin	Pin name	Pin	Pin name
29	PH0	30	PA1	29	PB5	30	PB13
31	PH1	32	PA4	31	PB3	32	AGND
33	V_{BAT}	34	PB0	33	PA10	34	PC4
35	PC2	36	PC1	35	PA2	36	PF5
37	PC3	38	PC0	37	PA3	38	PF4
39	PD4	40	PD3	39	GND	40	PE8
41	PD5	42	PG2	41	PD13	42	PF10
43	PD6	44	PG3	43	PD12	44	PE7
45	PD7	46	PE2	45	PD11	46	PD14
47	PE3	48	PE4	47	PE10	48	PD15
49	GND	50	PE5	49	PE12	50	PF14
51	PF1	52	PF2	51	PE14	52	PE9
53	PF0	54	PF8	53	PE15	54	GND
55	PD1	56	PF9	55	PE13	56	PE11
57	PD0	58	PG1	57	PF13	58	PF3
59	PG0	60	GND	59	PF12	60	PF15
61	PE1	62	PE6	61	PG14	62	PF11
63	PG9	64	PG15(5)	63	GND	64	PE0
65	PG12	66	PG10	65	PD10	66	PG8
67	-	68	PG13	67	PG7	68	PG5
69	PD9	70	PG11	69	PG4	70	PG6

1. Default state of BOOT0 is 0. It can be set to 1 when a jumper is plugged on the pins 5-7 of CN11.
2. V_{REF+} is not connected to CN12 by default.
3. U5V is the +5V power signal, coming from the ST-LINKV2-1 USB connector. It rises before the +5V signal of the board.
4. PA13 and PA14 are shared with SWD signals connected to ST-LINK/V2-1. If ST-LINK part is not cut, it is not recommended to use them as I/O pins.
5. PB11 and PG15 are not available on the NUCLEO-L496ZG-P board.

Appendix A Electrical schematics

This section provides the design schematics for the STM32 Nucleo-144 board:

- Top and Power (see *Figure 14*)
- MCU (see *Figure 15*)
- ST-LINK/V2-1 (see *Figure 16*)
- USB (see *Figure 17*)
- Extension connector (see *Figure 18*)
- SMPS power supply (see *Figure 19*)

Figure 14. Top and power

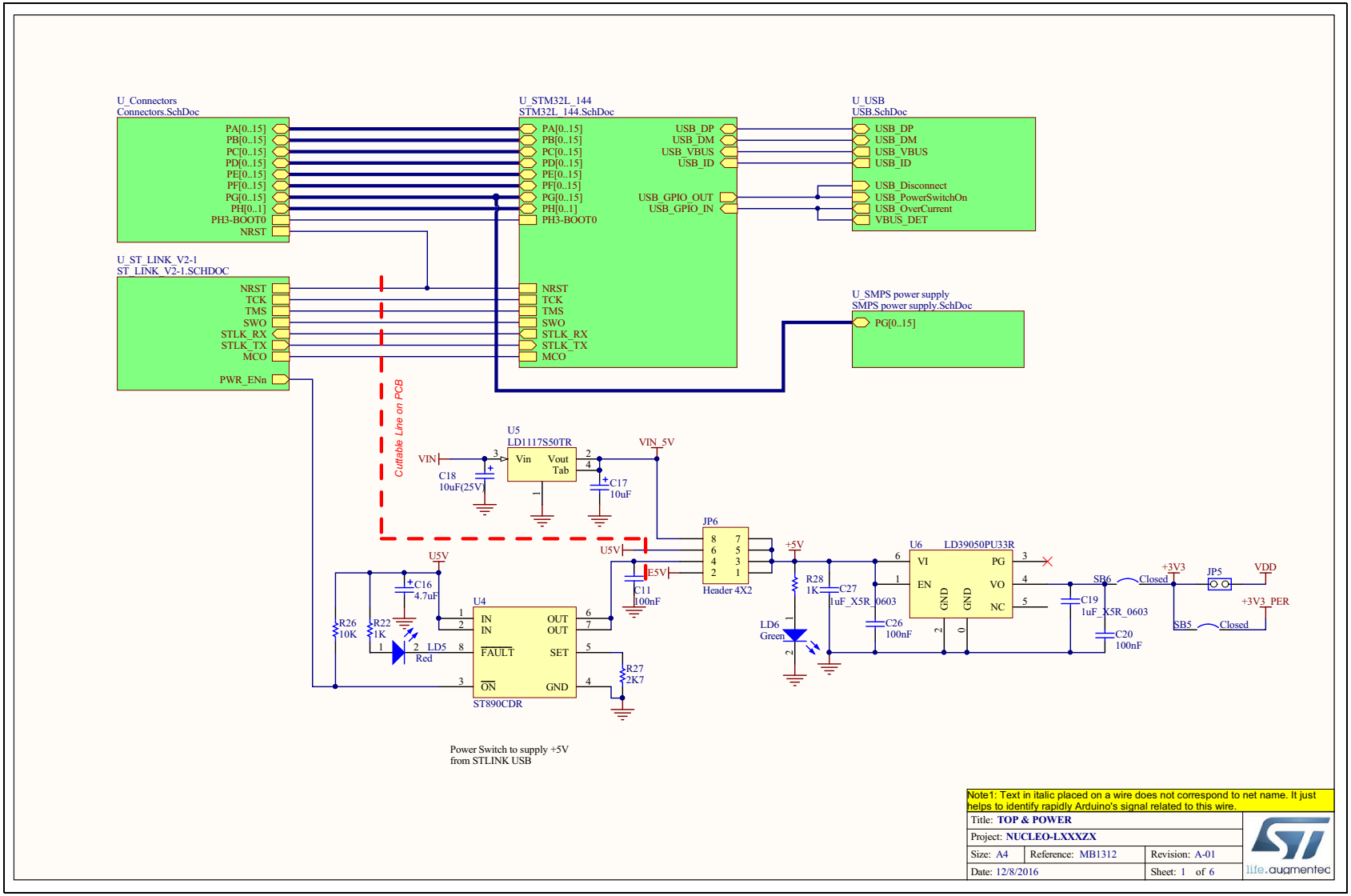


Figure 15. MCU

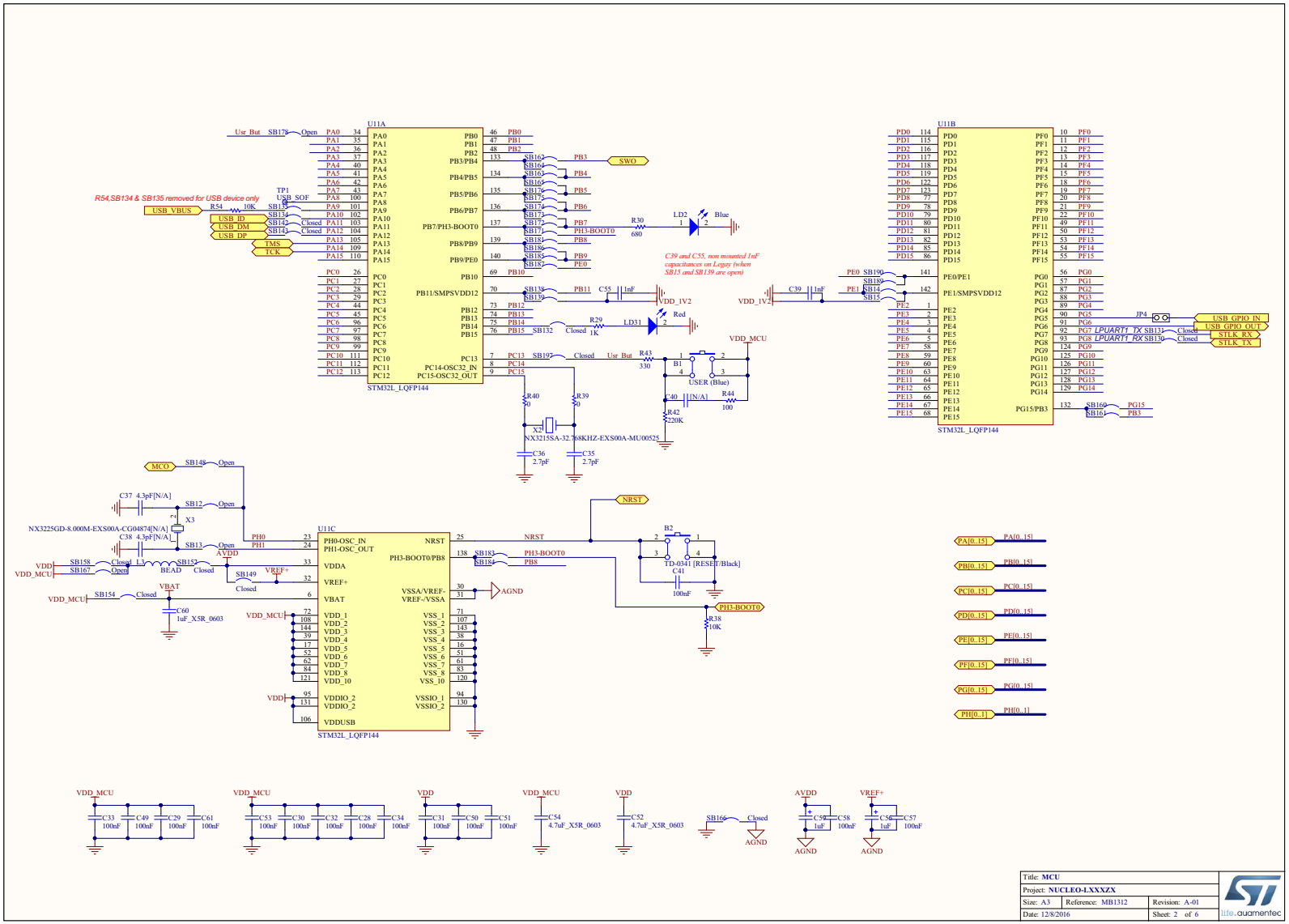


Figure 16. ST-LINK/V2-1

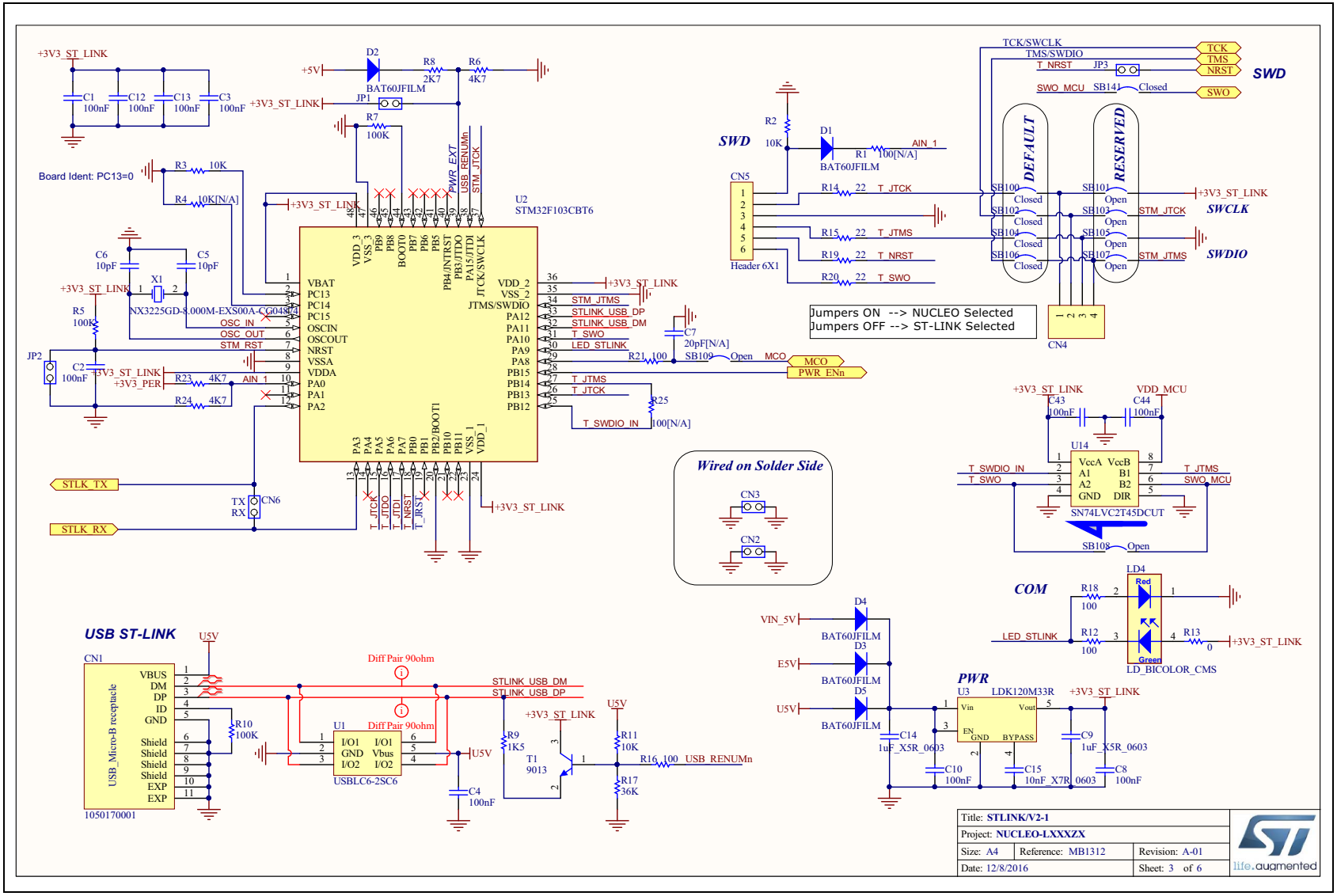


Figure 17. USB

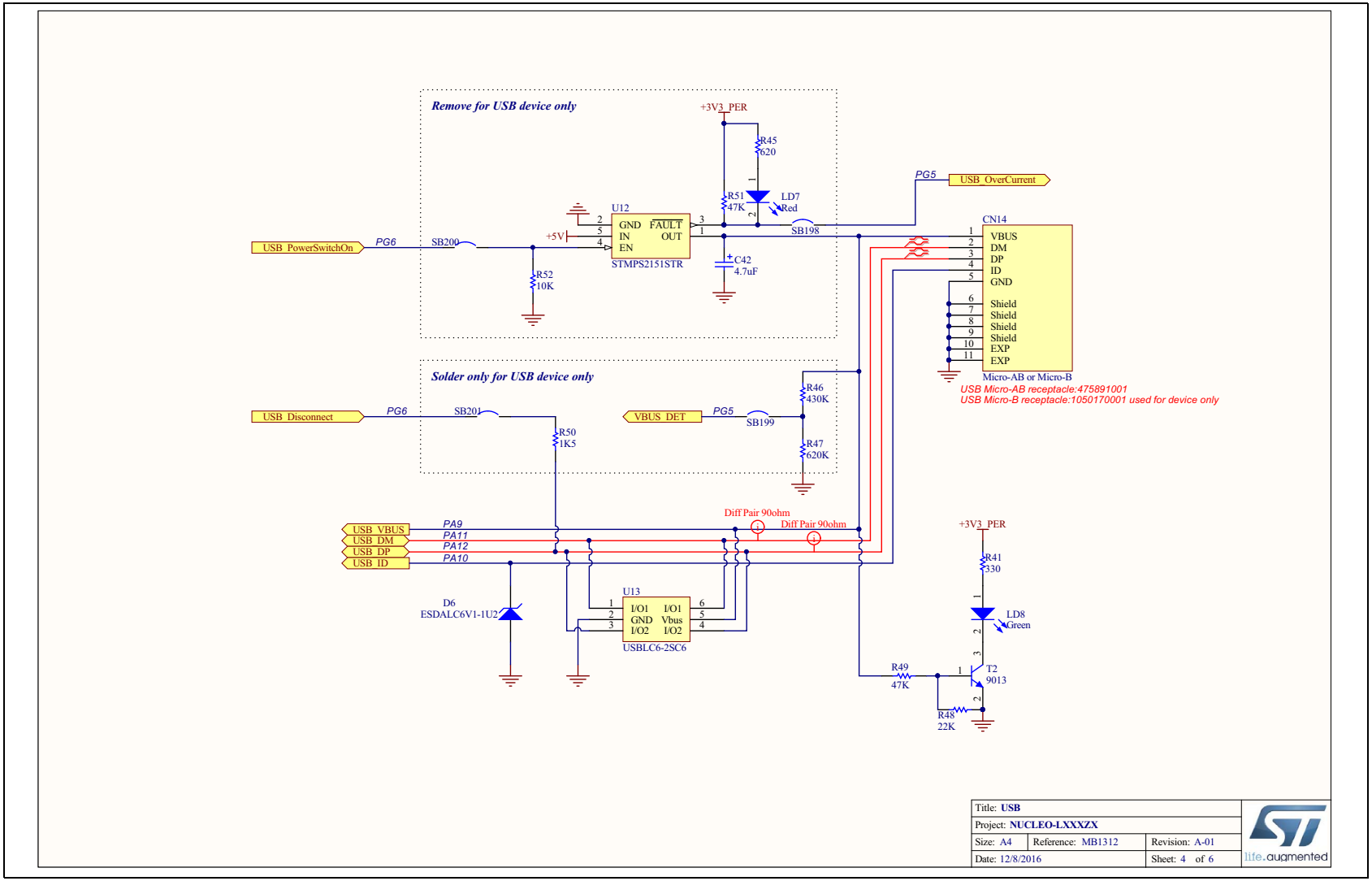


Figure 18. Extension connectors

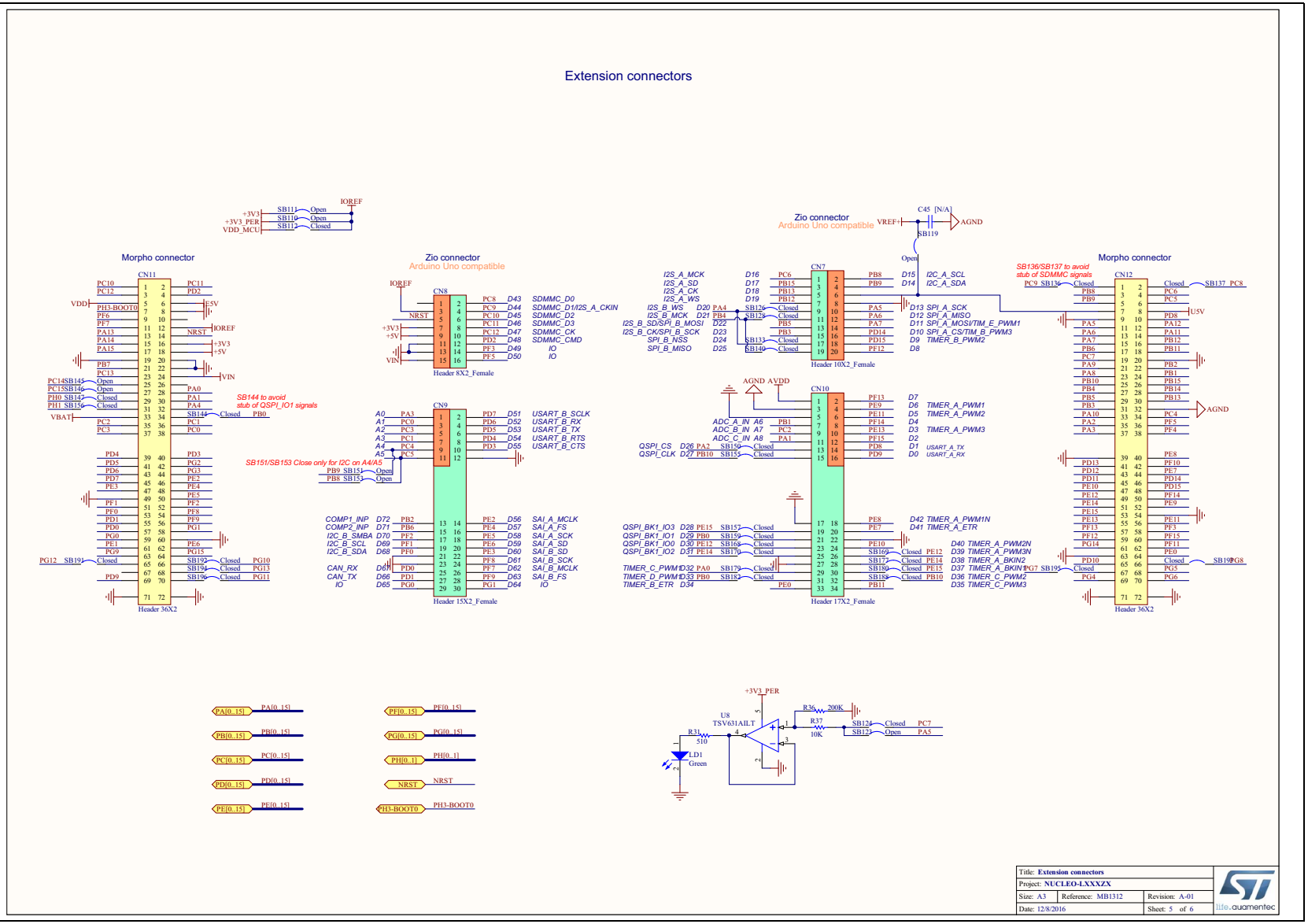
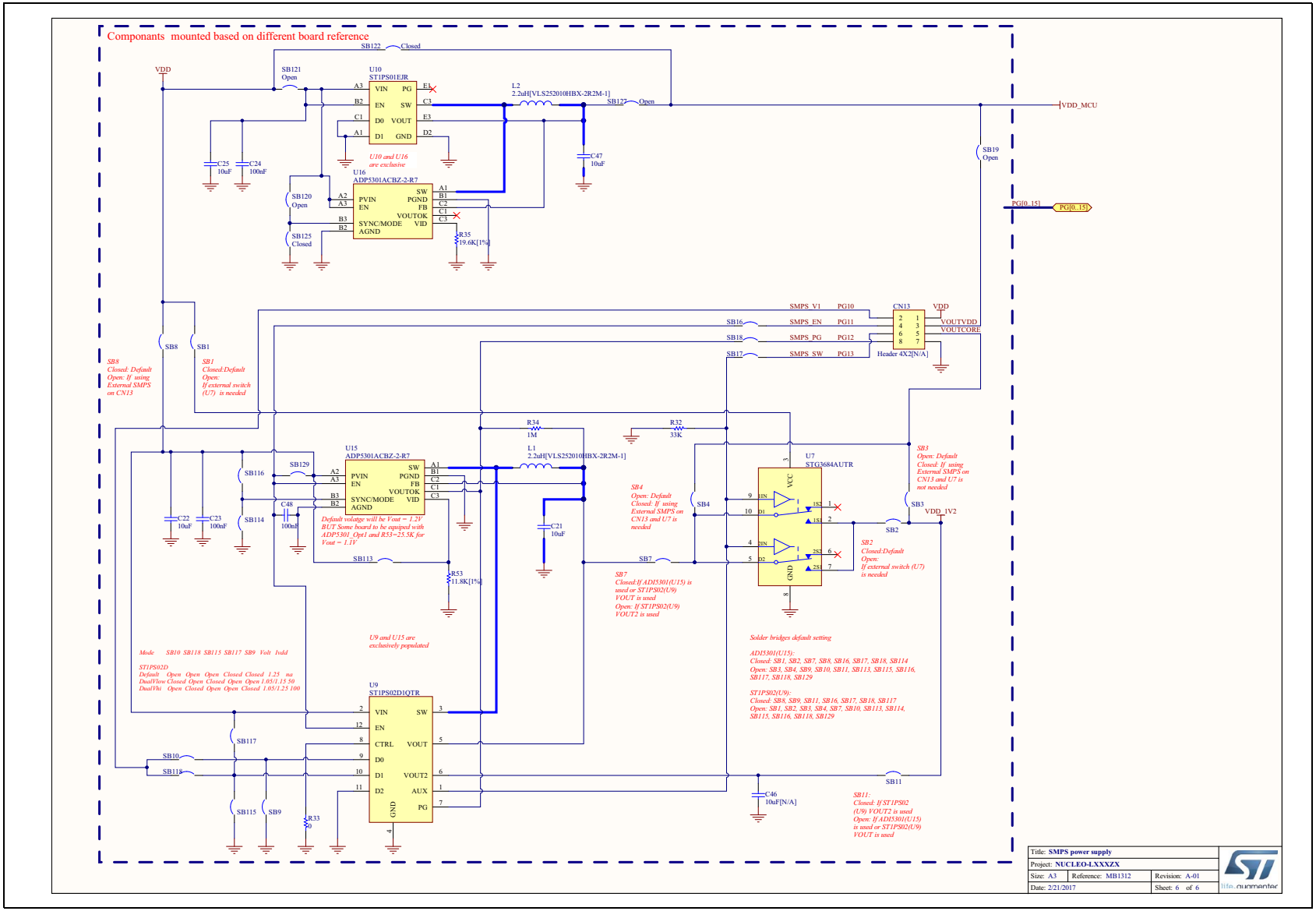


Figure 19. SMPS power supply



Appendix B Board revision history and limitations

Table 13. Board revision history and limitations

Board	Version	Revision details	Known limitations
MB1312	A-04	Initial version	A4/A5 on Arduino Uno V3 connector CN9 cannot be used as I^2C function.
MB1312 (SMPS)	A-03	Initial version for NUCLEO-L496ZG-P	A4/A5 on Arduino Uno V3 connector CN9 cannot be used as I^2C function.

Appendix C Federal Communications Commission (FCC) and Industry Canada (IC) Compliance

This kit is designed to allow:

- (1) Product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and
- (2) Software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of 47 CFR, Chapter I (“FCC Rules”), the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

Revision history

Table 14. Document revision history

Date	Revision	Changes
28-Feb-2017	1	Initial version.
27-Mar-2017	2	Document now also scopes NUCLEO-L496ZG-P product. Added: *Section 6.5.4: SMPS power supply* *Figure 12: NUCLEO-L496ZG-P* Updated: – cover page features (to cover LL library) – cover page description – *Section 1: Features* (SMPS function) – *Section 6.6: LEDs* – *Section 6.13: Solder bridges and jumpers* – *Section Appendix B: Board revision history and limitations* – *Table 1: Ordering information* – *Table 2: Codification explanation* – *Table 11: NUCLEO-L496ZG, NUCLEO-L496ZG-P and NUCLEO-L4R5ZI pin assignments* – *Figure 3: Hardware block diagram* – *Figure 4: STM32 Nucleo-144 board top layout* – *Figure 5: STM32 Nucleo-144 board bottom layout*
08-Aug-2017	3	Document now also scopes NUCLEO-L4R5ZI product. Added *Figure 13: NUCLEO-L4R5ZI*. Updated: – The cover page *Introduction* – *Table 1: Ordering information* – *Table 2: Codification explanation*
31-Aug-2017	4	Updated *Table 1: Ordering information*.