UM3097

User manual

Source measurement unit (SMU) and debugger/programmer for STM32 microcontrollers

Introduction

STLINK-V3PWR is a two-in-one standalone debugger probe and a source measurement unit (SMU) designed to synchronize code execution with a power consumption of STM32 applications in real time. This tool is specifically adapted for power consumption optimization (patent pending).

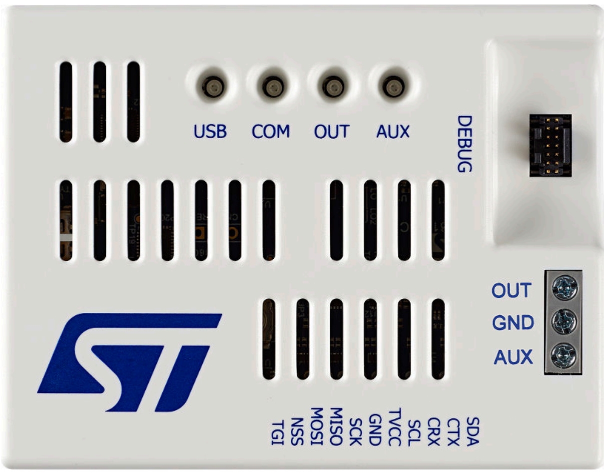
STLINK-V3PWR can be used as a standalone source measurement unit to supply power and measure the current consumption of the target application. The product keeps the output voltage constant during a fast current transient from a very low current to a high current.

STLINK-V3PWR is also a standalone debugging and programming probe for STM32 microcontrollers. The product embeds a multipath bridge interface with an integrated level shifter to adapt to the target application I/Os voltage.

STLINK-V3PWR USB Type-C® connector allows data communication with the host PC and sinks up to 5 V/3 A to supply both the probe and the target application, via the SMU and the auxiliary output.

The ST-LINK firmware upgrade tool (*STSW-LINK007*) can update the STLINK-V3PWR firmware. For optimal performance, the STLINK-V3PWR firmware must be updated to the latest version.

Figure 1. STLINK-V3PWR top view



Picture is not contractual.

1 Features

- 1-Quadrant source measurement unit with high resolution, and measurement flexibility:
  - Programmable voltage source from 1.6 to 3.6 V
  - Output current rating 500 mA with overcurrent protection (OCP) at 550 mA
  - Programmable sampling rate from 1 SPS to 100 kSPS
  - Dynamic measurement:
    - A few nA to 500 mA current
    - Up to 1.65 W power measurements
    - 50 kHz bandwidth/1.6 MHz acquisition/down to +/-0.5% accuracy
    - Compatible with EEMBC® ULPMark™ tests
- Auxiliary output voltage source from 1.6 to 3.6 V under up to 2 A (no current measurement, OCP at 2.5 A)
- Debugging of embedded applications:
  - JTAG / Serial Wire Debug (SWD):
    - SWD (Serial Wire Debug) and SWV (Serial Wire Viewer) communication support up to 10 MHz
    - JTAG communication support up to 20 MHz
  - UART interface on Virtual COM port (VCP) with frequency up to 12 MHz
  - Multipath bridge USB to SPI/I^{2}C/CAN/GPIOs
  - Integrated level shifter I/O voltage 1.6 to 3.6 V adaptable
- Four bicolor LEDs providing probe state
- Three STDC14 to MIPI10 / STDC14 / MIPI20 flat cables with 1.27 mm pitch connectors
- Four cables (two male/male and two male/female)
- USB Type-C® connector:
  - Powered through USB Type-C® (5 V/1.5 A minimum)
  - USB 2.0 high-speed interface
  - Probe firmware update through USB
- Direct support from STM32CubeMonitor-Power software tool

2 Ordering information

To order the STLINK-V3PWR SMU and in-circuit debugger/programmer for STM32, refer to Table 1.

Table 1. Ordering information

Order code	Reference	Description
STLINK-V3PWR	STLINK-V3PWR	Debug board for STM32 microcontrollers including simultaneous current measurement

3 Development environment

STLINK-V3PWR runs with an STM32 32-bit microcontroller based on the Arm® Cortex®-M core.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

3.1 System requirements

- Multi-OS support: Windows® 10 or beyond, Linux® 64-bit, or macOS®
- USB Type-A or USB Type-C® to USB Type-C® cable

Note: macOS® is a trademark of Apple Inc., registered in the U.S. and other countries and regions.
Linux® is a registered trademark of Linus Torvalds.
Windows is a trademark of the Microsoft group of companies.

3.2 Development toolchains

- IAR Systems® - IAR Embedded Workbench®[1]
- Keil® - MDK-ARM[1]
- STMicroelectronics - STM32CubeIDE

1. *On Windows® only.*

3.3 Toolchain versions

Table 2. Glossary

Toolchain	Description	Minimum version
STM32CubeProgrammer	ST programming tool for ST microcontrollers	1.12.0
IAR Systems® EWARM	Third-party debugger for STM32 including current measurement support	9.32.2
Keil® MDK-ARM	Third-party debugger for STM32 including current measurement support	5.38
STM32CubeMonitor-Power	ST monitoring tool for power consumption	1.2.0
STM32CubeIDE	ST debugger for STM32	1.12.0
STLINK-V3-BRIDGE	ST software package: C++ API compatible with the bridge interface of STLINK-V3 and STLINK-V3PWR	1.1.0

3.4 Drivers and firmware upgrade

The driver installation is not mandatory since Windows® 10 but allocates an ST-specific name to the ST-LINK COM port in the system device manager. For detailed information regarding the ST-LINK USB driver, refer to the technical note *Overview of ST-LINK derivatives* (TN1235).

STLINK-V3PWR embeds a firmware upgrade (*STSW-LINK007*) mechanism through the USB port. As the firmware might evolve during the lifetime of the STLINK-V3PWR product, to add new functionalities, fix bugs, and support new microcontroller families, it is recommended to visit the *www.st.com* website before starting to use STLINK-V3PWR and periodically, to stay up to date with the latest firmware version. For detailed information about firmware upgrades, refer to the technical note *Overview of ST-LINK derivatives* (TN1235).

4 Glossary

Table 3. Glossary

Term	Meaning
AUX	Auxiliary output voltage
Target application	Target product application embedding an STM32 MCU with peripherals
GND	Ground
OCP	Over current protection
OUT	Main output voltage
OVP	Over voltage protection
SMU	Source measure unit

5 Product information

5.1 Product content

The STLINK-V3PWR kit contains:

- STLINK-V3PWR probe
- Four wires:
  - Two wires male/male (red and black)
  - Two wire male/female (red and black)
- Three debug cables allowing the connection from the STDC14 (DEBUG port) to:
  - STDC14 connector (1.27 mm pitch) Samtec FFSD-07-D-05.90-01-N
  - MIPI10/ARM10-compatible connector (1.27 mm pitch) Samtec FFSD-05/07-D-05.90-01-N
  - MIPI20/ARM20-compatible connector (1.27 mm pitch) Samtec FFSD-10/07-D-05.90-01-N

Note: To support the JTAG interface, in 2.54 mm pitch, use a dedicated dongle MIPI/ARM20 to JTAG (2.54 mm) (for example: dongle "JTAG 20 pin 2.54 mm to 10 pin 1.27 mm adapter")

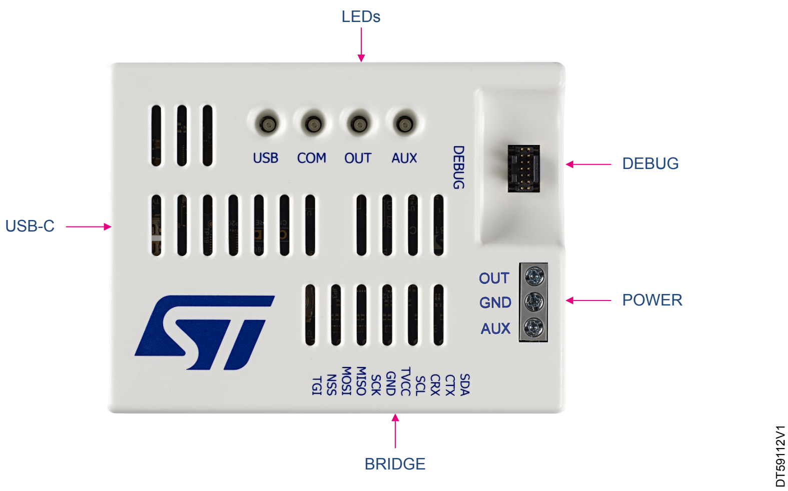
5.2 STLINK-V3PWR connectors and LED identification

This section aims to identify the location of the STLINK-V3PWR connectors and LEDs.

They are illustrated with the silkscreen on the casing serving as a functional reference for most connectors. A connection overview is given here:

- **USB-C**: USB Type-C® receptacle for host PC connection using a USB Type-C® to USB Type-C® cable for the STLINK-V3PWR power supply and data transfer. Refer to Section 5.3: USB connection with a host PC.
- **DEBUG**: STDC14 2x7-pin male connector with 1.27 mm pitch for connection to an STM32 target application for debugging operations. Three different flat cables are included in the packaging to connect with standard connectors MIPI10/ARM 10, STDC14, and ARM 20. Refer to Section 9.3: DEBUG (STM32 JTAG/SWD and VCP).
- **BRIDGE**: 2x11-pin male connector with 2.54 mm pitch for connection to an STM32 target application for data communication (typically STM32's bootloader) with several common interfaces via a proprietary USB interface. Refer to Section 9.4: BRIDGE (I^2C, CAN, SPI, UART, and GPIO).
- **POWER**: 3-pin screw connector with a 5 mm pitch allows supplying the target application via two independent programmable power sources: OUT (refer to Section 7.2: SMU output (OUT)) and AUX (refer to Section 7.3: Auxiliary power source output (AUX).
- **LEDs**: 4x3-color LED to indicate the state of the product. Refer to Section 7.6: LEDs management.

Figure 2. STLINK-V3PWR connections



Note: USB-C, DEBUG, BRIDGE, POWER connectors, and LED terminologies used in this document are referring to the namings defined in Figure 2.

5.3 USB connection with a host PC

5.3.1 Prerequisite

The STLINK-V3PWR's USB-C® must be connected to a USB Type-A host PC or hub port **supporting charging** (having a "spark" logo) or to a USB Type-C® host PC or hub port. Refer to Table 4 for details.

The USB LED indicates if STLINK-V3PWR is connected to a USB port supporting charging:

- USB LED in green color: The USB host port supports charging and the STLINK-V3PWR SMU (OUT) and auxiliary output (AUX) are enabled.
- USB LED in orange" color: The USB host port does not support charging and the STLINK-V3PWR SMU (OUT) and auxiliary output (AUX) are disabled.

Note: The debugger and bridge interfaces are always functional even if the STLINK-V3PWR's USB-C® is connected onto a standard USB HS (high-speed) host port.

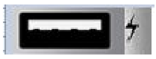
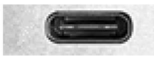
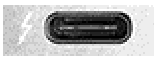
5.3.2 Detailed description

For the data interface, the STLINK-V3PWR's USB-C® must be connected to a USB HS host port. USB FS (full speed) or USB LS (low speed) modes are not supported. Connecting STLINK-V3PWR to a USB SS (super speed) host port is also possible as the USB SS port runs in the HS mode.

For the power, the STLINK-V3PWR internal circuitry, including the SMU output (OUT), and the auxiliary output (AUX) are powered by USB-C®. Accordingly, the host PC must be capable of supplying them, especially for the SMU output (OUT) and the auxiliary output (AUX) that can require a significant peak of energy to power supply a complete target application.

STLINK-V3PWR automatically detects the power budget advertised by the host PC USB port. As mentioned in Section 5.3.1, the STLINK-V3PWR's USB-C® must be connected to a USB host PC or USB hub port that can provide 5 V/1.5 A minimum, typically a USB host port supporting charging. Refer to Table 4 for details.

Table 4. USB host PC or hub port identification

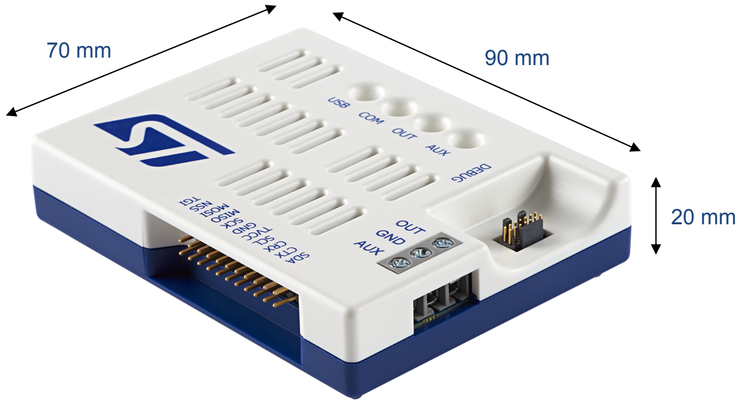
USB host port	Port identification	STLINK-V3PWR compatibility	USB LED color
	Standard USB Type-A port (500 mA)	OUT and AUX disabled	orange
	Charging USB Type-A port (1.5 A)	OK	green
	USB Type-C®[(1)] port (1.5 or 3 A)	OK	green
	Charging USB Type-C® port (3 A)	OK	green

1. *Some USB Type-C® ports without the "spark" logo might be advertised as 500 mA ports. In that case, STLINK-V3PWR works with the OUT and AUX disabled and the USB LED lights in orange color.*

Note: Connection to a USB charger is not a functional use case for STLINK-V3PWR. In that case, USB LED lights in green color (valid power source) and COM LED blinks in red color (waiting for USB enumeration). Refer to Section 7.6: LEDs management.

5.4 Mechanical information

Figure 3. **Product dimensions**



5.5 Thermal recommendation

STLINK-V3PWR is recommended to operate at the temperature range specified in Table 11.

STLINK-V3PWR uses precision components that are affected by temperature changes. It is recommended to use it at a place where the thermal gradient or airflow is minimal. A typical laboratory bench or table might be an optimal location.

Accordingly, airflow cooling holes on the top and the bottom of STLINK-V3PWR must be kept free to ease air cooling.

Hence, it is recommended to start the measurement after waiting for a few minutes after the product is plugged into the USB port and a connection is established. This ensures the entire product self-heating to reach thermal equilibrium and avoid triggering a self-calibration sequence during measurement acquisition (refer to Section 7.2.3: Self-calibration management).

5.6 Known limitations

The STLINK-V3PWR internal acquisition circuitry is sensitive to vibration and shock. If vibration or shock occurs during acquisition, STLINK-V3PWR sends acquisition data containing an erroneous peak current.

STLINK-V3PWR is damaged if a DC voltage is applied onto OUT or AUX from an external source and STLINK-V3PWR is not connected to a host PC. Refer to Section 8.1: Absolute maximum rating

6 Quick start

This section describes how to start with STLINK-V3PWR to make power measurements:

1. Check that the bundle is complete (STLINK-V3PWR with three flat cables and a bundle of four wire jumpers).
2. Install or update the power measurement software (for example STM32CubeMonitor-Power).
3. Connect a USB Type-C® to USB Type-C® cable (recommended) or USB Type-A to USB Type-C® cable between STLINK-V3PWR and the PC (refer to Section 5.3: USB connection with a host PC).
4. Check the LED status:
   – The USB LED must turn green: STLINK-V3PWR is supplied by a valid power source from the PC.
   – The COM LED must turn red: STLINK-V3PWR debugger is ready.
5. Hardware configuration for power measurement: Connect the STLINK-V3PWR's SMU (OUT and GND) to the power supply input of the target application using wire jumpers. Refer to Section 6.1: Typical application.
6. Software configuration for power measurement: Refer to Section 6.2: Software configuration.

6.1 Typical application

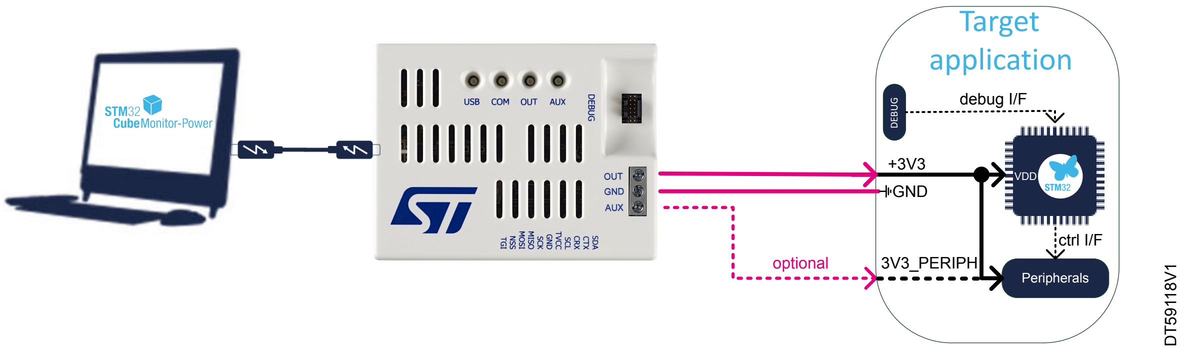
6.1.1 Connection with a target application for power measurements

STLINK-V3PWR provides two voltage-regulated power sources: OUT and AUX:

- OUT is a programmable voltage-regulated power source including current measurement: Refer to Section 7.2: SMU output (OUT).
- AUX is a programmable voltage-regulated power source only: Refer to Section 7.3: Auxiliary power source output (AUX).

Figure 4 provides a basic connection example of STLINK-V3PWR with a target application.

Figure 4. STLINK-V3PWR connection



- Connect OUT to the target application power supply input to be measured (for example pin +3V3 of an STM32 Nucleo board) using a wire jumper provided in the kit.
- Connect GND to the target application ground (for example pin GND of an STM32 Nucleo board) using a wire jumper provided in the kit.
- (Optional) Connect the AUX power source to the target application input power supply that does not require to be measured.

6.1.2 Recommendations for power measurements

The use of wire jumpers provided in the kit must be limited to target applications not consuming more than 100 mA to avoid voltage drop through wire jumper cables.

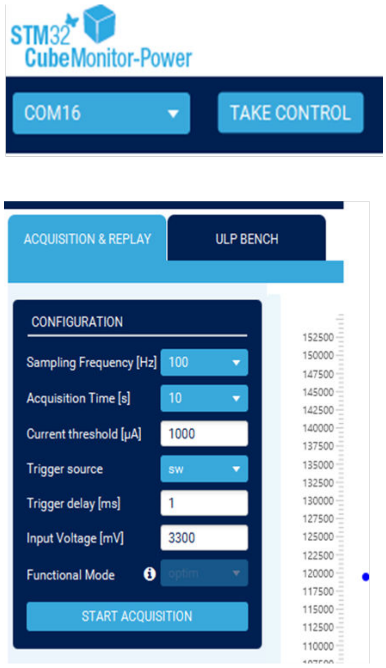
For target applications having significant current consumption, it is recommended to use cables with adapted conductor diameter to limit voltage drop through the cable due to wire resistance and current consumption of the target application.

In addition, it is recommended not to use wires longer than ~30 cm and twist them (OUT and GND wires) to reduce parasitic inductance.

6.2 Software configuration

1. Launch the STM32CubeMonitor-Power application.
2. Select the COM port of the device.

Figure 5. STM32CubeMonitor-Power setting



3. Click on the "TAKE CONTROL" button to handle the STLINK-V3PWR probe.
   – ACQUISITION & REPLAY:
   – Set "Sampling Frequency" to 20000 Hz [recommended value]
   – Set "Acquisition Time" to 10 s
   – Set "Current Threshold" to 1000 µA
   – Set "Trigger Source" to "sw" (software)
   – Set "Trigger Delay" to 1 ms
   – Set the desired "Input Voltage" of the target application inside the range 1600 mV/3600 mV
4. Click on the "START ACQUISITION" button
5. The STLINK-V3PWR's SMU turns on and current measurement acquisition starts:
   – VOUT and VAUX LEDs turn on green (output voltage turned on)
   – Current measurement is displayed in real time in the STM32CubeMonitor-Power main window.

Note: Refer to the user manual *STM32CubeMonitor-Power software tool for power and ultra-low-power measurements* (UM2202).

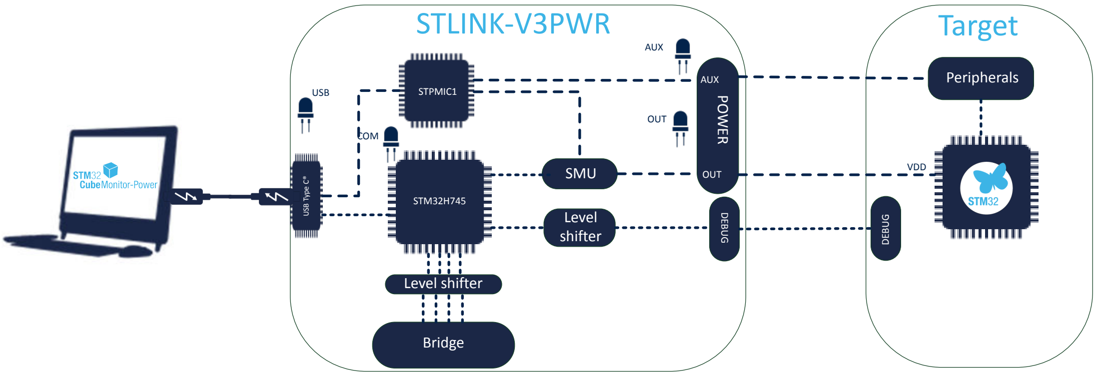
7 STLINK-V3PWR functional description

7.1 STLINK-V3PWR overview

The following sections provide a functional description of the STLINK-V3PWR features.

Figure 6 provides a high-level block diagram of the STLINK-V3PWR internal circuitry that illustrates a typical connection of STLINK-V3PWR with a host PC and with a target application.

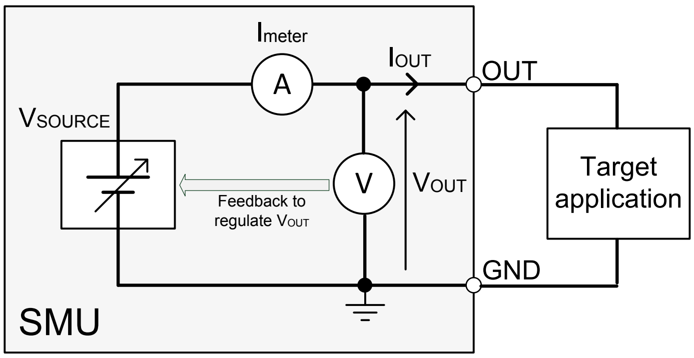
Figure 6. STLINK-V3PWR block diagram



7.2 SMU output (OUT)

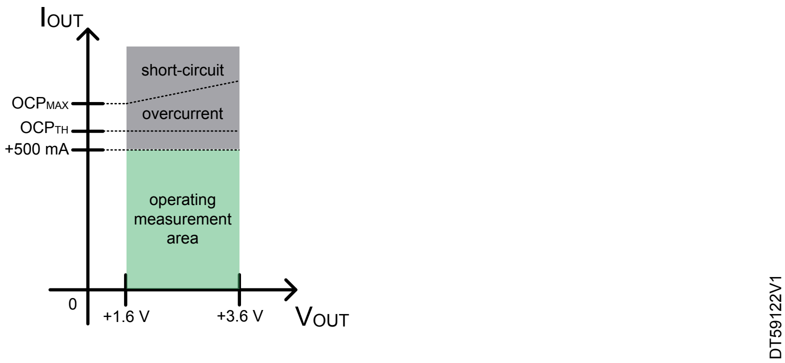
The STLINK-V3PWR's SMU output is accessible on the POWER's 3-pin screw connector between the OUT pin (positive node) and GND pin (negative node). Figure 7 provides a block diagram of the SMU.

Figure 7. STLINK-V3PWR SMU block diagram



The STLINK-V3PWR's SMU operates as a 1-quadrant voltage source and current meter. The SMU operating area is illustrated in Figure 8.

Figure 8. STLINK-V3PWR SMU operating area



7.2.1 Voltage source

The SMU output voltage is programmable from +1.6 to +3.6 V by 100 mV step.

The SMU output voltage remains stable and accurate over the operating measurement area (refer to Figure 8), even with a large capacitive load (order of 100 µF) that usually causes SMU oscillating.

It has an excellent load transient response, even for a transient starting from a very low current to a high current with a fast current rise time (refer to V_{OUT_LO} in Table 12). This is especially suitable for supplying an STM32 microcontroller operating from the Standby mode (very low current) to the Run mode (high current) without impacting its power supply voltage.

The SMU can source a 500 mA continuous output current.

Above 500 mA and up to OCP_{TH} (550 mA) output current, the SMU output starts entering the Self-protection mode. Output voltage decreases slowly as output current increases.

It can safely tolerate overcurrent and short circuits (refer to Section 7.2.4: Overcurrent and short circuit management).

Voltage source power ON/power OFF management

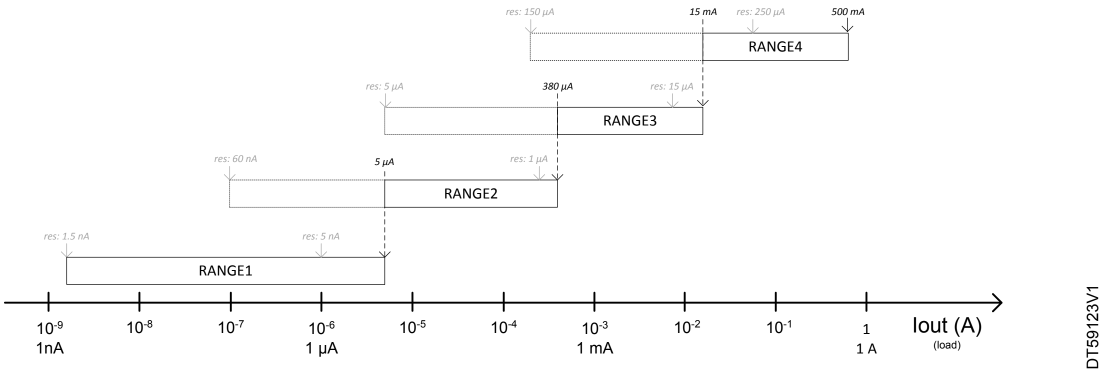
- The voltage source is OFF after STLINK-V3PWR powers up (USB cable insertion).
- The default output voltage is 3.3 V. Any voltage change must be performed before turning on the voltage source.
- By default, the voltage source is automatically turned ON when a current measurement acquisition is started.
- By default, the voltage source stays ON after a current measurement acquisition ends or stops.

7.2.2 Current measurement

The STLINK-V3PWR SMU is composed of four analog current measurement paths having 50 kHz analog bandwidth. Current sample acquisitions of the four measurement paths are performed by an STM32H745 using two 12-bit ADCs working in parallel, each at a 1.6 MHz sampling frequency. The embedded postprocessing algorithms aim to manage current range selection and to perform noise reduction. SMU provides a sampling rate of up to 100 kilosamples per second and down to 1 SPS to the host PC via a USB interface.

The four measurement paths have a fixed current range (refer to Figure 9). Range selections are fully automated at runtime by postprocessing algorithms allowing a continuous current acquisition from a few nA to 500 mA.

Figure 9. SMU current measurement ranges



Impact of noise on sampling rate selection

The sampling rate selection has a significant impact on measurements.

Using the maximum sampling rate allows the user to catch fast current transient activities but it intrinsically increases the noise level making small current variations hidden in the noise level.

Reciprocally, using the minimum sampling rate allows the user to measure small current variations and average the noise but it smooths fast current transient activities.

Note: Sampling rate selection does not impact the current measurement DC accuracy.

7.2.3 Self-calibration management

STLINK-V3PWR has built-in self-calibration circuitry to compensate for the current measurements offset due to temperature variation.

A self-calibration is automatically performed during current measurements acquisition every +/- 5°C temperature change inside STLINK-V3PWR.

During the self-calibration sequence, STLINK-V3PWR keeps the SMU output voltage (OUT) enabled but STLINK-V3PWR stops sending measurement data to the host PC. Once the self-calibration sequence ends, STLINK-V3PWR restarts sending measurement data to the host PC.

A self-calibration sequence duration is approximately 1 s max and does not require user intervention.

Each time a self-calibration occurs:

- A popup is displayed on the STM32CubeMonitor-Power windows to inform the user that acquisition data is stopped for self-calibration sequence duration.
- The OUT LED turns in an orange color (refer to Table 8. OUT LED).

7.2.4 Overcurrent and short circuit management

The SMU output is protected against overcurrent higher than OCP_{TH} (refer to Table 12) and short circuits.

It can safely tolerate a short overcurrent or peak current before triggering an OCP (overcurrent protection). This is suitable to keep the target application operating without crashing during peak transient activities where the current consumption is higher than OCP_{TH}.

When $OCP_{TH} < I_{OUT} < OCP_{MAX}$, the output voltage decreases as the output current increases:

$V_{OUT} \approx V_{OUTnom} - 0.3 \times I_{OUT}$

Short overcurrent

A short overcurrent is a current consumption within $OCP_{TH} < I_{OUT} < OCP_{MAX}$ having a duration less than $t_{\_short\_ocp}$ (refer to Table 12).

Nevertheless, the SMU returns erroneous current measurement values to the host PC as the current consumption is above the operating measurement area.

If the overcurrent disappears before $t_{\_short\_ocp}$ duration, then the OUT LED blinks red/green for 2 s duration (refer to Table 8. OUT LED) and a warning popup message is displayed on the STM32CubeMonitor-Power windows.

An overcurrent longer than $t_{\_short\_ocp}$ duration is considered a long overcurrent.

Long overcurrent

A long overcurrent is a current consumption within OCP_{th} < IOUT < OCP_{max} having a duration longer than $t_{\_short\_ocp}$.

Once a long overcurrent condition occurs:

- SMU output is turned OFF.
- Current measurement is stopped.
- OUT LED turns red.
- Error popup message is displayed on the STM32CubeMonitor-Power windows.

Short circuit

A short circuit is detected when the SMU output voltage drops below 10% of the programmed voltage due to I_{OUT} > OCP_{MAX}.

A short circuit is managed as a long overcurrent by STLINK-V3PWR (refer to Long overcurrent).

Note: Long overcurrent and short circuits are considered fatal errors. Accordingly, the user must disconnect and reconnect STLINK-V3PWR from the host PC to restart STLINK-V3PWR.

Warning: *As mentioned, STLINK-V3PWR tolerates overcurrent and short circuits. Consequently, as STLINK-V3PWR is supplied from a host PC USB port, the host PC USB port must support the equivalent amount of power consumed during the overcurrent or the short circuit. Else, the host PC USB port OCP might trigger; making STLINK-V3PWR turn OFF. Accordingly, it is recommended to connect STLINK-V3PWR to a 5 V/3 A USB Type-C® port for a target application running peak activities above STLINK-V3PWR's operating measurement area.*

7.3 Auxiliary power source output (AUX)

The auxiliary power source output is a regulated voltage source programmable from +1.6 to +3.6 V by 100 mV step.

Note: When STLINK-V3PWR is managed by STM32CubeMonitor-Power, the auxiliary power source output voltage is a mirror of the SMU output voltage.

The auxiliary power source output is generated by a programmable SMPS step-down converter allowing a high power-efficiency conversion from the host PC USB port.

The auxiliary power source can supply a 2000 mA continuous output current with excellent load transient response.

It has a built-in OCP. It can safely tolerate overcurrent and short circuits up to the OCP_{TH_AUX} threshold (refer to Table 15).

Warning: *As STLINK-V3PWR is supplied from a host PC USB port, the host PC USB port should be able to support the equivalent amount of power consumed on the AUX output. Else, the host PC USB port OCP might trigger; making STLINK-V3PWR turn OFF. Accordingly, it is recommended to connect STLINK-V3PWR to a 5 V/3 A USB Type-C® port.*

7.4 Debugger interfaces (SWD/JTAG/VCP)

The STLINK-V3PWR debugger functionalities are detailed in this section. These functionalities are split on the following STLINK-V3PWR USB interfaces:

- Debug: for SWD, JTAG, and SWV protocols
- Virtual COM port (VCP): for UART protocol
- Bridge: for SPI, I^2C, CAN, and GPIOs protocols

Level shifters are integrated with STLINK-V3PWR to adapt debug, bridge, and VCP interface voltage to target application I/Os voltage from 1.6 to 3.6 V.

7.4.1 Target voltage connection (T_VCC)

The target voltage (T_VCC) must always be provided from the target application (I/Os voltage reference) to STLINK-V3PWR when the debug interface and bridge functionalities are used.

When connecting the DEBUG connector (using the STDC14 ribbon) to the target application, it must be provided to pin 3 of the DEBUG connector (refer to Section 9.3: DEBUG (STM32 JTAG/SWD and VCP)). When using the BRIDGE functionality only, without connecting the DEBUG connector to the target, the target voltage must be provided through the TVCC pin of the BRIDGE connector (refer to Section 9.4: BRIDGE (I^2C, CAN, SPI, UART, and GPIO)).

Warning: *If the target voltage is not provided, the VCP interface, debug interface, trigger, and bridge functionalities do not work.*

Note: The T_VCC signal on the DEBUG connector and the TVCC signal on the BRIDGE connector are internally interconnected.

7.4.2 SWD with SWV

SWD protocol is a debug/program protocol used for STM32 microcontrollers with SWV as a trace. This function is available on the DEBUG connector.

For details regarding performance and baud rate, refer to Section 8.5: Debug and bridge performance.

7.4.3 JTAG

The JTAG protocol is a debug/program protocol used for STM32 microcontrollers. This function is available on the DEBUG connector.

For details regarding performance, refer to Section 8.5: Debug and bridge performance.

7.4.4 Virtual COM port (VCP)

The serial interface VCP (UART) is directly available as a Virtual COM port of the PC, connected to the STLINK-V3PWR USB connector. This function is available on both DEBUG and BRIDGE connectors and must be used exclusively on one connector (UART signals are internally connected).

On the DEBUG connector, the functionality is available without flow control, T_VCP_RX (or RX) signal is the Rx for the target (Tx for STLINK-V3PWR), T_VCP_TX (or TX) signal is the Tx for the target (Rx for STLINK-V3PWR).

On the BRIDGE connector, the functionality is available with or without hardware flow control (CTS/RTS). On the BRIDGE connector, the TXD signal is the Rx for the target (Tx for STLINK-V3PWR), the RXD signal is the Tx for the target (Rx for STLINK-V3PWR), the CTS signal is the RTS for the target (CTS for STLINK-V3PWR) and the RTS signal is the CTS for the target (RTS for STLINK-V3PWR). The hardware flow control might be activated by physically connecting UART_RTS and/or UART_CTS signals to the target. If not connected, the virtual COM port works without hardware flow control. Note that the hardware flow control activation/deactivation cannot be configured by software from the host side on a Virtual COM port. Consequently, configuring a parameter related to that on the host application does not affect the system behavior.

To reach a high UART frequency, it is recommended to use a flat ribbon on the DEBUG connector with all unused signals tied to the ground on the target side.

For details regarding baud rate and performance, refer to Section 8.5: Debug and bridge performance.

7.4.5 Baud rate computing

Some interfaces (VCP and SWV) are using the UART protocol. In that case, the baud rate of STLINK-V3PWR must be aligned as much as possible with the target one.

Below is a rule allowing the computation of the baud rate achievable by the STLINK-V3PWR probe:

192 MHz/prescaler with prescaler = [24 to 31] then 96 MHz/prescaler with prescaler = [16 to 65535]

Note: The UART protocol does not guarantee data delivery (all the more without hardware flow control). Consequently, at high frequencies, the baud rate is not the only parameter impacting the data integrity. The line load rate and the capability of the receiver to process all the data also affect communication.

7.5 Bridge functions

STLINK-V3PWR implements a USB interface dedicated to bridging functions from USB to SPI/I^{2}C/CAN/GPIOs of the STM32 microcontroller target. This interface is mainly used by the STM32CubeProgrammer to allow target programming through the SPI/I^{2}C/CAN bootloader. An API host software, STLINK-V3-BRIDGE, is provided to extend the use cases and be used for customized needs.

For details regarding performance, refer to Section 8.5: Debug and bridge performance.

7.5.1 Bridge SPI

SPI signals (SCK, MISO, MOSI, NSS, TVCC, GND) are available on the bridge connector. To reach a high SPI frequency, it is recommended to use a flat ribbon (or short wires), with all unused signals tied to the ground on the target side.

7.5.2 Bridge I^{2}C

I^{2}C signals (SDA, SCL, TVCC, and GND) are available on the bridge connector. 560 Ω pull-ups are included in STLINK-V3PWR.

7.5.3 Bridge CAN

CAN signals (CRX, CTX, TVCC, and GND) are available on the bridge connector and can be used as input for an external CAN transceiver.

7.5.4 Bridge GPIOs

Four GPIO signals (IO0, IO1, IO2, IO3, TVCC, and GND) are available on the bridge connector. The I/O direction is internally managed according to the I/O software configuration through the public ST bridge software interface.

7.6 LEDs management

STLINK-V3PWR has four bicolor LEDs that allow the user to know the status of the product at any time. The assigned function of each LED is noticed on the housing.

Table 5. LEDs overview

LED reference	Label purpose	Description
USB LED	USB power status	The USB LED indicates the power budget provided by the host PC.
COM LED	ST-LINK communication	This LED shows the ST-LINK status (refer to the technical note *Overview of ST-LINK derivatives* (TN1235))
OUT LED	SMU voltage output	The OUT LED indicates the SMU output state.
AUX LED	Auxiliary voltage	The AUX LED indicates the AUX output state.

7.6.1 LED management

Table 6. USB LED

LED status/color	Description
Green	Host PC can provide enough energy for SMU and AUX features.
Orange	Host PC cannot provide enough energy for SMU and AUX features. SMU and AUX features are disabled.
Red	Transitional state after USB cable plug and before identification of host port by STLINK-V3PWR
Slow blinking red	USB enumeration in progress
Fast blinking red	Undervoltage detected on VBUS or fatal error during USB enumeration or host port identification. Check the electrical context, restart STLINK-V3PWR (do a USB cable removal), and try another USB port.

LED status/color	Description
OFF	No USB connection

Table 7. COM LED

LED status/color	Description
Green	The last communication with the target has been successful
Orange	The last communication with the target has failed
Red	STLINK-V3PWR is in the idle state (the USB enumeration with the PC is finished and the STLINK-V3PWR is waiting for an application to connect).
Blinking red	The first enumeration with the PC is taking place. If an STLinkUpgrade application is running, the firmware is being programmed.
Blinking green/red	Data is being exchanged between the target and the PC
OFF	Fatal error: USB removal cable is required

Table 8. OUT LED

LED status/color	Description
Green	OUT is turned ON and no power measurement is ongoing.
Slow blinking green	OUT is turned ON and the current measurement is ongoing.
Fast blinking green	OUT is turned ON and trigger IN is armed.
Orange	Calibration ongoing
Red	Overcurrent detected on OUT (refer to Section 7.2.4: Overcurrent and short circuit management). OUT and AUX automatically turned OFF
Slow blinking red	Overheating protection. OUT and AUX automatically turned OFF
Fast blinking red	Fatal error during initialization
Slow blinking green/red	Short overcurrent detected on OUT (not fatal, blinking during 2 s)
OFF	OUT is turned OFF.

Table 9. VAUX LED

LED color	Description
Red	Overcurrent is detected (refer to Section 7.3. OUT and AUX are automatically turned OFF
Green	AUX is ON.
OFF	AUX is OFF.

8 Electrical and performance parameters

In this section, all parameters are not guaranteed: They are extracted from the design phase and the product validation on a few STLINK-V3PWR samples. They are not issued from characterization or a calibration process.

8.1 Absolute maximum rating

Table 10. **Absolute maximum rating**

Parameter	Condition	Min	Max	Unit
USB-C® supply voltage (VBUS)	OVP from 6.5 V	-0.3	20	V
Voltage applied on any port	Unpowered	-0.3	0.7	V
Voltage applied on OUT or AUX port	Powered, outputs OFF	-0.3	5	V
Voltage applied on T_VCC	powered	-0.3	4.2	V
Voltage applied on any DEBUG or BRIDGE input	powered, T_VCC ≤ 3.6 V	-0.3	T_VCC + 0.6	V
Storage temperature	-	-20	80	°C
Operating temperature	-	0	50	°C
Relative humidity (noncondensing)	-	0	95	%

All voltages are relative to GND with GND internally connected to USB GND.

8.2 Recommended operating conditions

Table 11. **Recommended operating conditions**

Symbol	Parameter	Min	Typ	Max	Unit
V_{BUS_IN}	USB-C® supply voltage	4.5	5	5.5	V
I_{SUP_USB}	USB host port supply current capability (charging port)	1.5	-	-	A
H_{REL}	Relative humidity (noncondensing)	20	-	80	%
T_{OP}	Operating temperature	15	23	35	°C

8.3 SMU output (OUT) characteristics

8.3.1 SMU voltage source characteristics

All parameters are provided at V_{BUS_IN} = 5 V, T_{OP} = 23 °C, and V_{OUT} = 3.3 V unless otherwise specified.

Table 12. **SMU voltage source characteristics**

Symbol	Parameter	Conditions	Typical values	Unit
VOUT	Output voltage	Programmable range	1.6 to 3.6	V
		Programming step	100	mV
VOUT_ACC	Output voltage DC accuracy	10 nA < I_{OUT} < 500 mA V_{OUT} = { 1.6 V; 1.8 V; 2.5 V; 3.3 V; 3.6 V}	+0.1/-1.4	%

Symbol	Parameter	Conditions	Typical values	Unit
I_{OUT}	Maximum continuous output current	1.6 V < V_{OUT} < 3.6 V	500	mA
OCP_{TH}	Overcurrent protection threshold	1.6 V < V_{OUT} < 3.6 V	550	mA
OCP_{MAX}	Short circuit protection threshold	V_{OUT} = 3.6 V	900	mA
		V_{OUT} = 1.6 V	700	mA
$t_{\_SHORT\_OCP}$	OCP blanking delay	1.6 V < V_{OUT} < 3.6 V	1	ms
V_{OUT_LO}	Load transient regulation	IOUT = 60 µA to 140 mA in 200 ns rising edge IOUT = 140 mA to 60 µA in 500 ns falling edge	-68 +43	mV
t_{SS}	Output voltage rise duration OFF to ON	Load on OUT: R = 7.5 Ω // C = 10 µF VOUT from 0 to 95% with VOUT set at 3.6 V	40	µs
		Load on OUT: R = 7.5 Ω // C = 100 µF VOUT from 0 to 95% with VOUT set at 3.6 V	350	µs

8.3.2 SMU current measurement characteristics

All parameters are provided at V_{BUS_IN} = 5 V, T_{OP} = 23 °C, and V_{OUT} = { 1.6 V; 1.8 V; 2.5 V; 3.3 V; 3.6 V}, unless otherwise specified.

Table 13. SMU's current measurement characteristics

Symbol	Range	Measurement resolution	Typical measurement accuracy
RANGE1	5 µA	1.5 nA (Iout ≤ 1 µA) 5 nA (Iout > 1 µA)	±0.4% ± 8 nA
RANGE2	380 µA	100 nA (Iout ≤ 250 µA) 1 µA (Iout > 250 µA)	±0.2% ±100 nA
RANGE3	15 mA	5 µA (Iout ≤ 4 mA) 15 µA (Iout > 4 mA)	±0.5% ±30 µA
RANGE4	500 mA	150 µA (Iout ≤ 60 mA) 250 µA (Iout > 60 mA)	±0.3% ±200 µA

Table 14. SMU's current measurement supplemental characteristics

Symbol	Parameter	Conditions	Typical values	Unit
Sr	Sampling rate	Programmable range: {1;2;5;10;20;50;100;200;500;1000;2000;5000; 10000;20000;50000;100000} SPS	1 to 100000	SPS
eN_R1	measured system noise on RANGE1[1]	I_{OUT} < 5 µA[2]	3.7	nAp-p
		I_{OUT} < 5 µA[3]	140	nAp-p
eN_R2	measured system noise on RANGE2[1]	5 µA < I_{OUT} < 250 µA[2] 250 µA < I_{OUT} < 380 µA[2][4]	60 950	nAp-p
		5 µA < I_{OUT} < 250 µA[3] 250 µA < I_{OUT} < 380 µA[3][4]	300 950	nAp-p

Symbol	Parameter	Conditions	Typical values	Unit
eN_R3	measured system noise on RANGE3[1]	380 µA < I_{OUT} < 4 mA[2] 4 mA < I_{OUT} < 15 mA[2][4]	10 15	µAp-p
		380 µA < I_{OUT} < 4 mA[3] 4 mA < I_{OUT} < 15 mA[3][4]	34 46	µAp-p
eN_R4	measured system noise on RANGE4[1]	15 mA < I_{OUT} < 60 mA[2] 60 mA < I_{OUT} < 500 mA[2][4]	50 250	µAp-p
		15 mA < I_{OUT} < 60 mA[3] 60 mA < I_{OUT} < 500 mA[3][4]	120 500	µAp-p

1. *Measured system noise includes the additional noise generated by the electronic load equipment (Keithley 2400 SourceMeter®)*
2. *Sampling rate = 10 samples per second*
3. *Sampling rate = 10000 samples per second*
4. *Quantification effect*

8.4 AUX output (AUX) voltage source characteristics

All parameters are provided at V_{BUS_IN} = 5 V, T_{OP} = 23 °C, and V_{AUX} = 3.3 V unless otherwise specified.

Table 15. Auxiliary output (AUX) voltage source characteristics

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
VAUX	output voltage	Programmable range	1.6	-	3.6	V
		Programming step	-	100	-	mV
VAUX_ACC	output voltage accuracy	10 nA < I_{AUX} < 2.0 A 1.6 V < V_{AUX} = < 3.6 V	-	±3	-	%
I_{AUX}	Max continuous output current	1.6 V < V_{AUX} < 3.6 V	-	-	2[1]	A
OCP_{AUX}	Overcurrent and short circuit protection threshold	1.6 V < V_{AUX} < 3.6 V	-	2.5	-	A
V_{AUX_LO}	Load transient regulation	I_{AUX} = 0 to 1 A in 1 µs rising duration	-	-30	-	mV
t_{SS}	Output voltage rise duration OFF to ON	Load on AUX: R = 7.5 Ω // C = 10 µF V_{AUX} from 0 to 95% with V_{AUX} set at 3.6 V	-	700	-	µs
η_{AUX}	Power efficiency (P_{AUX}/P_{USB})	I_{AUX} = 250 mA	-	90	-	%
		I_{AUX} = 1.3 A	-	85	-	%
		I_{AUX} = 2 A	-	79	-	%

1. *Recommended to use a USB Type-C® host port supporting the Charging mode (up to 5 V/1.5 A minimum)*

8.5 Debug and bridge performance

Table 16 gives an overview of the achievable maximal performances with STLINK-V3PWR on different communication channels. Those performances are also depending on the overall system context (target included), so they are not guaranteed to be always reachable. For instance, a noisy environment or connection quality can impact system performance.

Table 16. Debug and bridge performances

Target voltage (T_VCC)	Data interface maximum frequency (in MHz)						
	SWD	JTAG	SWV	VCP	SPI	I^2C	CAN
3.3 V	10	20	12	12	24	1	1
1.8 V	10	12.5	10	10	12	1	1

9 Board connectors description

9.1 Conventions

Per conventions, refer to Table 17 for the I/O type definition:

Table 17. **I/O type definition**

Type	Definition
I	The signal is an input for STLINK-V3PWR and an output for the target application
O	The signal is an output for STLINK-V3PWR and an input for the target application
I/O	A bidirectional signal that can be configured as input or output (default input)
S	Supply pin

9.2 POWER (OUT/AUX)

The POWER connector (Figure 10) is a 3-pin screw terminal block with a 5.00 mm pitch. It is used to supply a target application using cables.

Figure 10. **POWER connector (front view)**

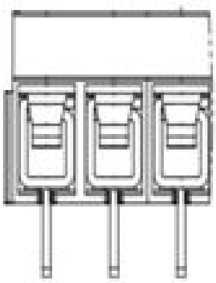


Table 18. **Power connector pinout**

Name	Type	Description
OUT	S	SMU output (refer to Section 7.2)
GND	S	Ground
AUX	S	Auxiliary power source output (refer to Section 7.3)

9.3 DEBUG (STM32 JTAG/SWD and VCP)

The DEBUG (STDC14) connector in Figure 11 is a 2x7-pin with a 1.27 mm pitch. It allows connection to an STM32 target using the JTAG or SWD protocol, respecting (from pin 3 to pin 12) the MIPI10/ARM10 pinout (Arm® Cortex® debug connector).

It also provides two UART signals for the Virtual COM port. The related pinout for the DEBUG connector is listed in Table 19.

Figure 11. **DEBUG STDC14 connector (top view)**

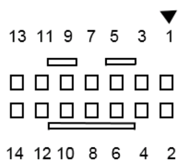


Table 19. DEBUG STDC14 connector pinout

Pin No.	Type	Description	Pin No.	Type	Description
1	-	NC(1)	2	-	NC
3	I	T_VCC(2)	4	I/O	T_JTMS/T_SWDIO
5	S	GND	6	O	T_JCLK/T_SWCLK
7	S	GND	8	I	T_JTDO/T_SWO(3)
9	-	NC	10	O	T_JTDI/NC
11	O	GNDDetect(4)	12	O	T_NRST
13	O	T_VCP_RX	14	I	T_VCP_TX

1. *NC means not connected.*
2. *Input reference voltage for debug interface level shifters (it must be connected to the target application onto the VDDIO domain)*
3. *T_SWO: SWO is optional, and required only for Serial Wire Viewer (SWV) trace.*
4. *Tied to GND by the STLINK-V3PWR firmware after its initialization. This might be used by the target for the detection of the tool.*

Note: The T_VCC signal on the DEBUG connector is internally connected with the T_VCC signal of the BRIDGE connector (refer to Section 9.4: BRIDGE (I^2C, CAN, SPI, UART, and GPIO)).

Note: Debug and bridge interfaces share the same UART interface. T_VCP_RX is internally connected with UART_TXD of the BRIDGE connector. T_VCP_TX is internally connected with the UART_RXD pin of the BRIDGE connector (Section 9.4: BRIDGE (I^2C, CAN, SPI, UART, and GPIO)).

9.4 BRIDGE (I^{2}C, CAN, SPI, UART, and GPIO)

All the bridge functions are provided on a 2x11-pin connector with a 2.54 mm pitch. The related pinout is listed below:

Table 20. BRIDGE connector pinout

-	Pin name	Type	Description	Features	-	Pin name	Type	Description	Features
Bottom	TGO	O	TRIG_OUT	SMU trigger	Top	TGI	I	TRIG_IN	SMU trigger
	IO0	I/O	Bridge_GPIO0	GPIO bridge		NSS	O	SPI_NSS	SPI bridge
	IO1	I/O	Bridge_GPIO1			MOSI	O	SPI_MOSI	
	IO2	I/O	Bridge_GPIO2			MISO	I	SPI_MISO	
	IO3	I/O	Bridge_GPIO3			SCK	O	SPI_SCK	
	+5V	S	+5V[1]	-		GND	S	GND	-
	GND	S	GND	-		TVCC	I	T_VCC[2]	-
	RTS	O	UART_RTS	UART VCP		SCL	O	I2C_SCL	I^{2}C bridge
	RXD	I	UART_RXD			CRX	I	CAN_RX	CAN bridge
	TXD	O	UART_TXD			CTX	O	CAN_TX	
	CTS	I	UART_CTS			SDA	I/O	I2C_SDA	I^{2}C bridge

1. *Supply output (100 mA max) powered from USB-C® voltage. Reserved to power supply a daughterboard to be connected onto the BRIDGE connector.*
2. *Input reference voltage for bridge interface level shifters (must be connected to the target application onto the VDDIO domain)*

Note: The T_VCC signal on the BRIDGE connector is internally connected with the T_VCC signal of the DEBUG connector (refer to Section 9.3: DEBUG (STM32 JTAG/SWD and VCP)).

Note: Debug and bridge interfaces share the same UART interface. T_VCP_RX is internally connected with UART_TXD of the BRIDGE connector. T_VCP_TX is internally connected with the UART_RXD pin of the BRIDGE connector (refer to Section 9.3: DEBUG (STM32 JTAG/SWD and VCP)).

10 Flat ribbons

STLINK-V3PWR provides three flat cables allowing the connection from the DEBUG (STDC14) connector output to:

- STDC14 connector (1.27 mm pitch) on target application: pinout detailed in Table 19. Reference Samtec FFSD-07-D-05.90-01-N.
- ARM10-compatible connector (1.27 mm pitch) on target application: pinout detailed in Reference Samtec ASP-203799-04 (Like Part: FFSD-05/07-D-05.90-01-N).
- ARM20-compatible connector (1.27 mm pitch) on target application: pinout detailed in Reference Samtec ASP-203800-04 (Like Part: FFSD-10/07-D-05.90-01-N).

Table 21. ARM10/MIPI10-compatible connector pinout (target side)

Pin No.	Description	Pin No.	Description
1	T_VCC(1)	2	T_JTMS/T_SWDIO
3	GND	4	T_JCLK/T_SWCLK
5	GND	6	T_JTDO/T_SWO(2)
7	T_JRCLK(3)/NC(4)	8	T_JTDI/NC
9	GNDDetect(5)	10	T_NRST

1. *Input reference voltage for debug interface level shifters (must be connected to target application onto VDDIO domain).*
2. *SWO is optional, required only for Serial Wire Viewer (SWV) trace*
3. *Optional loopback of T_JCLK on the target application side. Not connected on the STLINK-V3PWR side.*
4. *NC means not connected.*
5. *Tied to GND by the STLINK-V3PWR firmware after its initialization. Might be used by the target application to detect the STLINK-V3PWR connection or might be connected to GND.*

Table 22. ARM20/MIPI20-compatible connector pinout (target side)

Pin No.	Description	Pin No.	Description
1	T_VCC(1)	2	T_JTMS/T_SWDIO
3	GND	4	T_JCLK/T_SWCLK
5	GND	6	T_JTDO/T_SWO(2)
7	T_JRCLK(3)/NC(4)	8	T_JTDI/NC
9	GNDDetect(5)	10	T_NRST
11	NC	12	NC
13	NC	14	NC
15	NC	16	NC
17	NC	18	NC
19	NC	20	NC

1. *Input reference voltage for debug interface level shifters (must be connected to target application onto VDDIO domain).*
2. *SWO is optional, required only for Serial Wire Viewer (SWV) trace.*
3. *Optional loopback of T_JCLK on the target application side. Not connected on the STLINK-V3PWR side.*
4. *NC means not connected.*
5. *Tied to GND by the STLINK-V3PWR firmware after its initialization. Might be used by the target application to detect the STLINK-V3PWR connection or might be connected to GND.*

11 Federal Communications Commission (FCC) and ISED Canada Compliance Statements

11.1 FCC Compliance Statement

Part 15.19

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Part 15.21

Any changes or modifications to this equipment not expressly approved by STMicroelectronics may cause harmful interference and void the user's authority to operate this equipment.

Part 15.105

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception which can be determined by turning the equipment off and on, the user is encouraged to try to correct interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Note: *Use only shielded cables.*

Responsible party (in the USA)

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11.2 ISED Compliance Statement

This device complies with FCC and ISED Canada RF radiation exposure limits set forth for general population for mobile application (uncontrolled exposure). This device must not be collocated or operating in conjunction with any other antenna or transmitter.

Compliance Statement

Notice: This device complies with ISED Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

ISED Canada ICES-003 Compliance Label: CAN ICES-3 (B) / NMB-3 (B).

Déclaration de conformité

Avis: Le présent appareil est conforme aux CNR d'ISDE Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Étiquette de conformité à la NMB-003 d'ISDE Canada : CAN ICES-3 (B) / NMB-3 (B).

Revision history

Table 23. **Document revision history**

Date	Revision	Changes
16-Mar-2023	1	Initial release.
30-Jan-2024	2	Updated electrical characteristics in Features, Table 12, and Table 15. Added Section 8.3.2: SMU current measurement characteristics with new Table 13 and Table 14.

Contents

List of tables

List of figures