

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

Introduction

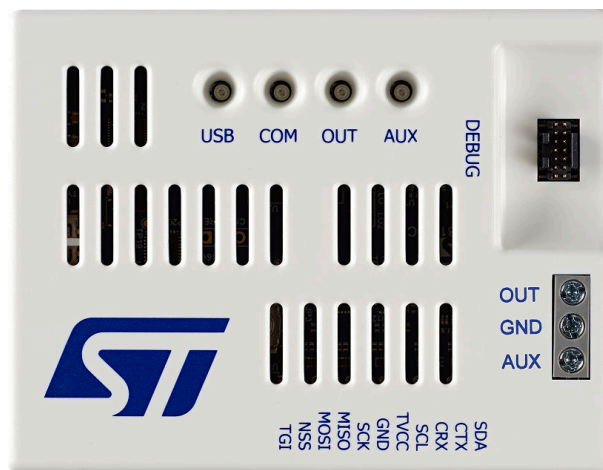
STLINK-V3PWR is a two-in-one standalone debugger probe and a source measurement unit (SMU) designed to synchronize code execution with a power consumption of STM32 applications in real time. This tool is specifically adapted for power consumption optimization (patent pending).

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 fast current transient from very low current to high current.

STLINK-V3PWR is also a standalone debugging and programming probe for STM32 microcontrollers. The product embeds a multi-path 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.

Figure 1. STLINK-V3PWR top, bottom, and cable views



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:
 - 100 nA to 500 mA current / 160 nW to 1.65 W power measurements
 - 50 kHz bandwidth / 1.6 MHz acquisition / 2% 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
 - Multi-path bridge USB to SPI/I²C/CAN/GPIOs
 - Integrated level shifter I/O voltage 1.6 to 3.6V adaptable
- Four bi-color 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 details 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 details 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 |
| SMPS | Switched-mode power supply |
| 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”)

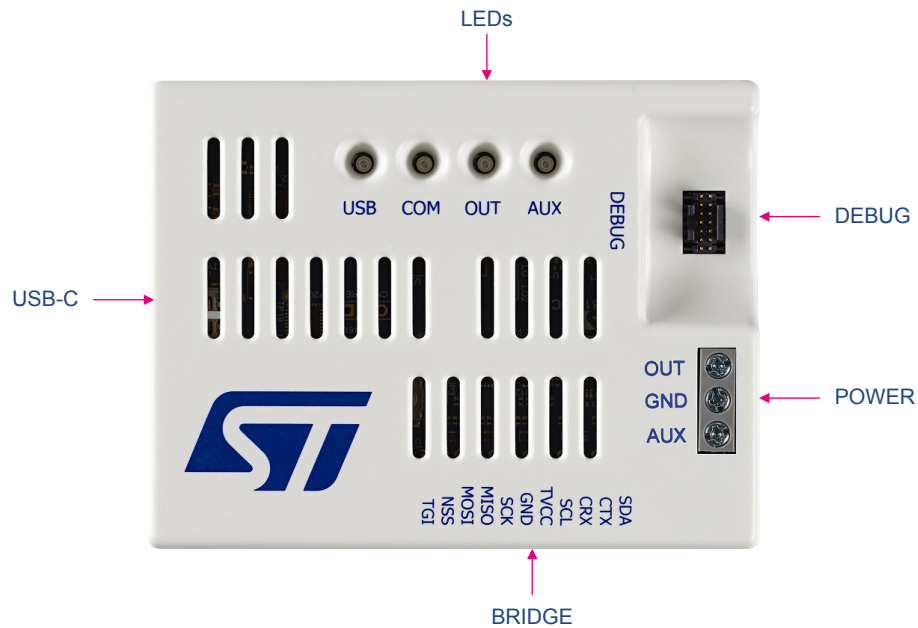
5.2 STLINK-V3PWR connectors and LEDs identification

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 \(I²C, CAN, SPI, UART, and GPIO\)](#).
- **POWER:** 3-pin screw connector with a 5 mm pitch allows supplying the target application via two independent programmable power source: OUT (refer to [Section 7.2 SMU output \(OUT\)](#)) and AUX (refer to [Section 7.3 Auxiliary power source output \(AUX\)](#)).
- **LEDs:** 4x3-colors LED to indicate the state of the product. Refer to [Section 7.6 LEDs management](#).

Figure 2. STLINK-V3PWR connections



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

5.3 USB connection with a host PC

5.3.1 Pre-requisite

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 bridges 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 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 to supply 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

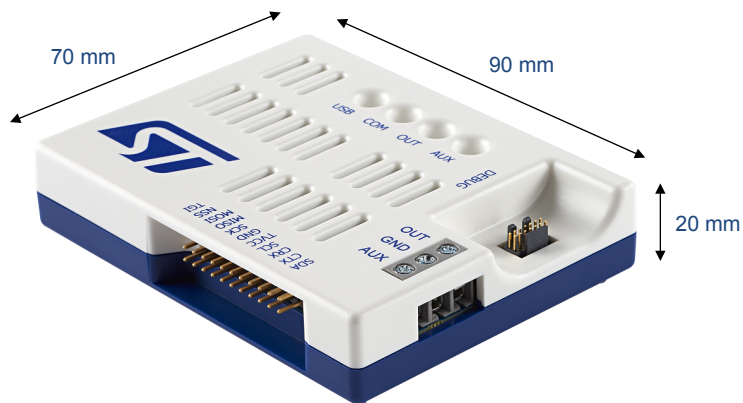
| USB host port | Port identification | STLINK-V3PWR compatibility | USB LED color |
|---------------|---|----------------------------|---------------|
| | Standard USB Type-A port (500 mA) | OUT and AUX disabled | orange |
| | Charging USB Type-A port (1.5 A) | OK | green |
| | USB Type-C [®] (1) port (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 red color (waiting for USB enumeration). Refer to Section 7.6 LEDs management.

5.4 Mechanical information

Figure 3. Product dimensions



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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 minimum. 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 limitation

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 erroneous peak current.

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 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) onto 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

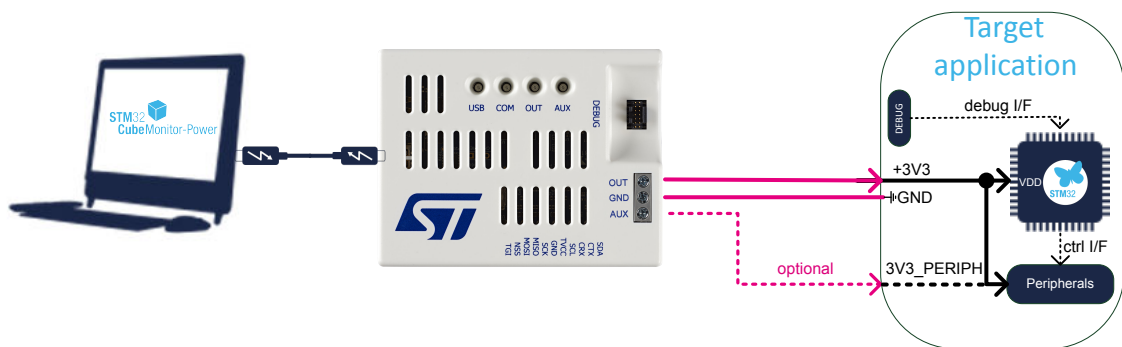
6.1.1 Connection with a target application for power measurements

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



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- 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 the 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.

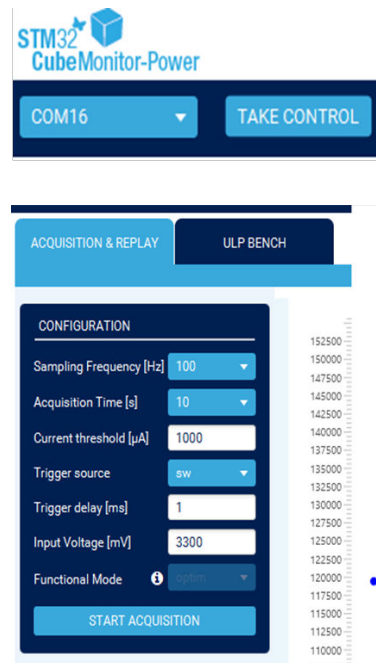
For target applications having significant current consumption, it is recommended to use cables with adapted conductor diameter to limit voltage drop through the cable due to wire resistance and current consumption of the target application.

In addition, it is recommended to not 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 μ A
 - Set "Trigger Source" to "sw" (software)
 - Set "Trigger Delay" to 1ms
 - 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:
 - OUT and AUX 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)*.

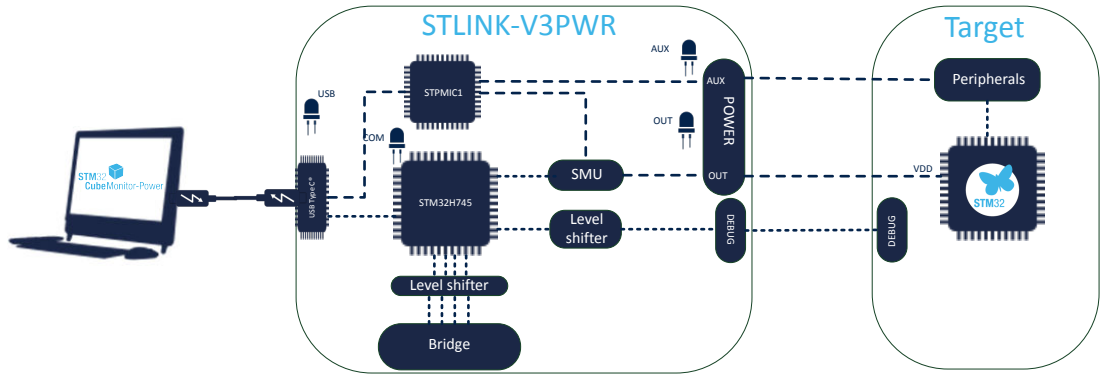
7 STLINK-V3PWR functional description

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

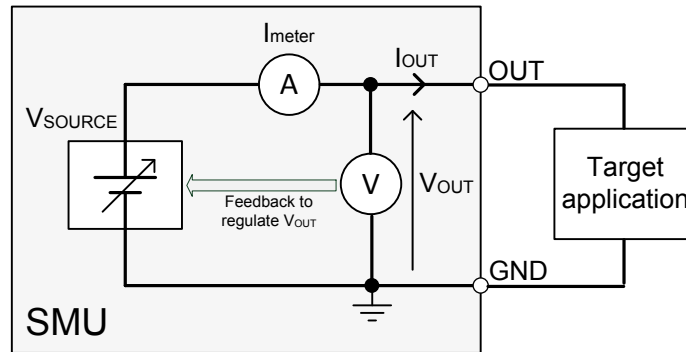


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7.2 SMU output (OUT)

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.

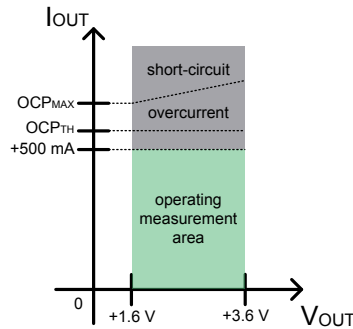
Figure 7. STLINK-V3PWR SMU block diagram



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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



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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 keeps stable and accurate over the operating measurement area (refer to Figure 8), even with a large capacitive load (order of 100 μ F) that usually causes SMU oscillating.

It has excellent load transient response, even for a transient starting from very low current to high current with fast current rise time (refer to V_{OUT_LO} in Table 12). This is especially suitable to supply an STM32 microcontroller operating from STANDBY mode (very low current) to 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 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

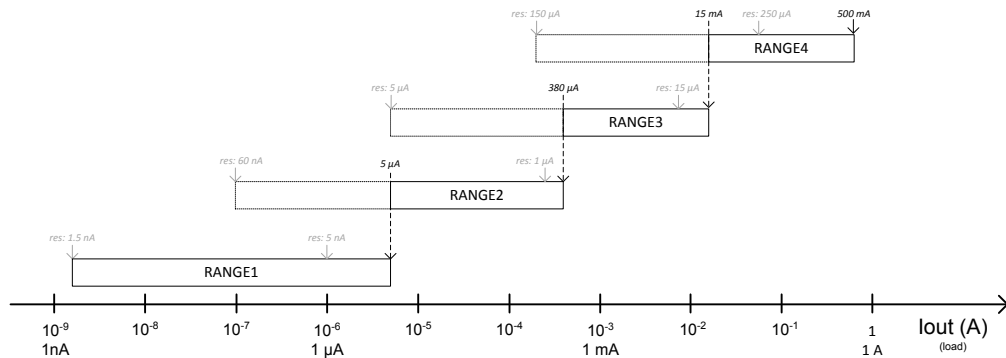
- The voltage source is OFF after STLINK-V3PWR powers up (USB cable insertion).
- The default output voltage is 3.3 V. Any voltage change must be performed before turning on the voltage source.
- By default, the voltage source is automatically turned ON when a current measurement acquisition is started.
- 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 post-processing algorithms aim to manage current range selection and to perform noise reduction. SMU provides a sampling rate of up to 100 kSPS (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 run time by post-processing algorithms allowing a continuous current acquisition from a few nA to 500 mA.

Figure 9. SMU current measurement ranges



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Impact of noise on sampling rate selection

The sampling rate selection has significant impacts 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 15 ms 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 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 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 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 $t_{\text{short_ocp}}$ duration, then the OUT LED blinks red/green for 2s duration (refer to [Table 8. OUT LED](#)) and a warning popup message is displayed on the STM32CubeMonitor-Power windows. An overcurrent longer than $t_{\text{short_ocp}}$ duration is considered a long overcurrent.

Long overcurrent

A long overcurrent is a current consumption within $OCP_{\text{th}} < I_{\text{OUT}} < OCP_{\text{max}}$ having a duration longer than $t_{\text{short_ocp}}$.

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 $I_{\text{OUT}} > OCP_{\text{MAX}}$.

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 $OCP_{\text{TH_AUX}}$ threshold (refer to [Table 13](#)).

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, I²C, 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 functionalities 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 \(I²C, CAN, SPI, UART, and GPIO\)](#)).

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

Note: 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 rates, refer to [Section 8.5 Debug and bridge performance](#).

7.4.3 JTAG

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 or the other 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 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 rates 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 rates 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/I²C/CAN/GPIOs of the STM32 microcontroller target. This interface is mainly used by STM32CubeProgrammer to allow target programming through SPI/I²C/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 I²C

I²C 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 bi-color LEDs which 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 <i>Overview of ST-LINK derivatives (TN1235)</i>) |
| OUT LED | SMU voltage output | OUT LED indicates the SMU output state. |
| AUX LED | Auxiliary voltage | 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 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 detected (refer to Section 7.3 . OUT and AUX 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 ≤ 3.6V | -0.3 | T_VCC + 0.6 | V |
| Storage temperature | - | -20 | 80 | °C |
| Operating temperature | - | 0 | 50 | °C |
| Relative humidity (non-condensing) | - | 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 (non-condensing) | 20 | - | 80 | % |
| T _{OP} | Operating temperature | 15 | 23 | 35 | °C |

8.3 SMU output (OUT) characteristics

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

8.3.1 SMU voltage source characteristics

Table 12. SMU voltage source characteristics

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|----------------------|-----------------------------------|---|------|------|------|------|
| V _{OUT} | Output voltage | Programmable range | 1.6 | - | 3.6 | V |
| | | Programming step | - | 100 | - | mV |
| V _{OUT_ACC} | Output voltage accuracy | 10 nA < I _{OUT} < 500 mA V _{OUT} = {1.8 V ; 3.3 V} | - | ±2 | - | % |
| I _{OUT} | Maximum continuous output current | 1.6 V < V _{OUT} < 3.6 V | - | - | 500 | mA |

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|------------------------|---|---|------|------|------|------|
| 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 |
| t _{SS} | Output voltage rise duration OFF to ON | Load on OUT: R = 7.5 Ω // C = 10 μF V _{OUT} from 0 to 95% with V _{OUT} set at 3.6 V | - | 40 | - | μs |
| | | Load on OUT: R = 7.5 Ω // C = 100 μF V _{OUT} from 0 to 95% with V _{OUT} set at 3.6 V | - | 350 | - | μs |

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 13. Auxiliary output (AUX) voltage source characteristics

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

1. Recommended to use a USB Type-C[®] host port supporting charging mode (up to 5 V/3 A)

8.5 Debug and bridge performance

Table 14 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 14. Debug and bridge performances

| Target voltage (T_VCC) | Data interface maximum frequency (in MHz) | | | | | | |
|------------------------|---|------|-----|-----|-----|------------------|-----|
| | SWD | JTAG | SWV | VCP | SPI | I ² C | 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 15](#) for the I/O type definition:

Table 15. I/O type definition

| Type | Definition |
|------|--|
| I | Signal is an input for STLINK-V3PWR and an output for the target application |
| O | Signal is an output for STLINK-V3PWR and an input for the target application |
| I/O | Bidirectional signal or 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)

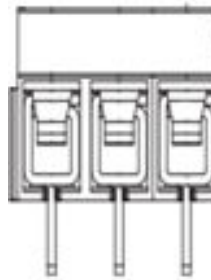


Table 16. Power connector pinout

| 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 17](#).

Figure 11. DEBUG STDC14 connector (top view)

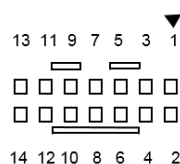


Table 17. DEBUG STDC14 connector pinout

| 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 (must be connected into target application onto 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. Might be used by the target for the detection of the tool.

Note: 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 (I²C, 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 UART_RXD of the BRIDGE connector (Section 9.4 BRIDGE (I²C, CAN, SPI, UART, and GPIO)).

9.4 BRIDGE (I²C, 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 18. 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 into target application onto VDDIO domain)

Note: 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 UART_RXD 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 17](#). 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 19. ARM10/MIP10-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 20. ARM20/MIP20-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.

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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 21. Document revision history

| Date | Revision | Changes |
|-------------|----------|------------------|
| 16-Mar-2023 | 1 | Initial release. |

Contents

| | | |
|----------|---|-----------|
| 1 | Features | 2 |
| 2 | Ordering information | 3 |
| 3 | Development environment | 4 |
| 3.1 | System requirements | 4 |
| 3.2 | Development toolchains | 4 |
| 3.3 | Toolchain versions | 4 |
| 3.4 | Drivers and firmware upgrade | 4 |
| 4 | Glossary | 5 |
| 5 | Product information | 6 |
| 5.1 | Product content | 6 |
| 5.2 | STLINK-V3PWR connectors and LEDs identification | 6 |
| 5.3 | USB connection with a host PC | 7 |
| 5.3.1 | Pre-requisite | 7 |
| 5.3.2 | Detailed description | 7 |
| 5.4 | Mechanical information | 8 |
| 5.5 | Thermal recommendation | 8 |
| 5.6 | Known limitation | 8 |
| 6 | Quick start | 9 |
| 6.1 | Typical application | 9 |
| 6.1.1 | Connection with a target application for power measurements | 9 |
| 6.1.2 | Recommendations for power measurements | 9 |
| 6.2 | Software configuration | 10 |
| 7 | STLINK-V3PWR functional description | 11 |
| 7.1 | STLINK-V3PWR overview | 11 |
| 7.2 | SMU output (OUT) | 11 |
| 7.2.1 | Voltage source | 12 |
| 7.2.2 | Current measurement | 12 |
| 7.2.3 | Self-calibration management | 13 |
| 7.2.4 | Overcurrent and short circuit management | 13 |
| 7.3 | Auxiliary power source output (AUX) | 14 |
| 7.4 | Debugger interfaces (SWD/JTAG/VCP) | 14 |
| 7.4.1 | Target voltage connection (T_VCC) | 15 |
| 7.4.2 | SWD with SWV | 15 |
| 7.4.3 | JTAG | 15 |
| 7.4.4 | Virtual COM port (VCP) | 15 |

| | | |
|------------|--|-----------|
| 7.4.5 | Baud rate computing | 15 |
| 7.5 | Bridge functions | 16 |
| 7.5.1 | Bridge SPI | 16 |
| 7.5.2 | Bridge I ² C | 16 |
| 7.5.3 | Bridge CAN | 16 |
| 7.5.4 | Bridge GPIOs | 16 |
| 7.6 | LEDs management | 16 |
| 7.6.1 | LED management | 16 |
| 8 | Electrical and performance parameters | 18 |
| 8.1 | Absolute maximum rating | 18 |
| 8.2 | Recommended operating conditions | 18 |
| 8.3 | SMU output (OUT) characteristics | 18 |
| 8.3.1 | SMU voltage source characteristics | 18 |
| 8.4 | AUX output (AUX) voltage source characteristics | 19 |
| 8.5 | Debug and bridge performance | 20 |
| 9 | Board connectors description | 21 |
| 9.1 | Conventions | 21 |
| 9.2 | POWER (OUT/AUX) | 21 |
| 9.3 | DEBUG (STM32 JTAG/SWD and VCP) | 21 |
| 9.4 | BRIDGE (I ² C, CAN, SPI, UART, and GPIO) | 22 |
| 10 | Flat ribbons | 23 |
| 11 | Federal Communications Commission (FCC) and ISED Canada Compliance Statements | 24 |
| 11.1 | FCC Compliance Statement | 24 |
| 11.2 | ISED Compliance Statement | 24 |
| | Revision history | 25 |
| | List of tables | 28 |
| | List of figures | 29 |

List of tables

| | | |
|------------------|--|----|
| Table 1. | Ordering information. | 3 |
| Table 2. | Glossary | 4 |
| Table 3. | Glossary | 5 |
| Table 4. | USB host PC or hub port identification | 8 |
| Table 5. | LEDs overview | 16 |
| Table 6. | USB LED | 16 |
| Table 7. | COM LED | 17 |
| Table 8. | OUT LED | 17 |
| Table 9. | VAUX LED | 17 |
| Table 10. | Absolute maximum rating | 18 |
| Table 11. | Recommended operating conditions. | 18 |
| Table 12. | SMU voltage source characteristics | 18 |
| Table 13. | Auxiliary output (AUX) voltage source characteristics | 19 |
| Table 14. | Debug and bridge performances | 20 |
| Table 15. | I/O type definition. | 21 |
| Table 16. | Power connector pinout | 21 |
| Table 17. | DEBUG STDC14 connector pinout. | 22 |
| Table 18. | BRIDGE connector pinout. | 22 |
| Table 19. | ARM10/MIPI10-compatible connector pinout (target side) | 23 |
| Table 20. | ARM20/MIPI20-compatible connector pinout (target side) | 23 |
| Table 21. | Document revision history | 25 |

List of figures

| | | |
|-------------------|---|----|
| Figure 1. | STLINK-V3PWR top, bottom, and cable views | 1 |
| Figure 2. | STLINK-V3PWR connections | 7 |
| Figure 3. | Product dimensions. | 8 |
| Figure 4. | STLINK-V3PWR connection. | 9 |
| Figure 5. | STM32CubeMonitor-Power setting | 10 |
| Figure 6. | STLINK-V3PWR block diagram | 11 |
| Figure 7. | STLINK-V3PWR SMU block diagram | 11 |
| Figure 8. | STLINK-V3PWR SMU operating area | 12 |
| Figure 9. | SMU current measurement ranges | 13 |
| Figure 10. | POWER connector (front view) | 21 |
| Figure 11. | DEBUG STDC14 connector (top view). | 21 |

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