Getting started with the STEVAL-STRKT01 LoRa® IoT tracker

Introduction

The STEVAL-STRKT01 LoRa® IoT tracker is designed and optimized to implement the latest technologies in IoT tracker applications such as asset, people and animal tracking as well as fleet management.

The evaluation board simplifies prototyping, evaluation and development of tracker innovative solutions. It comes with comprehensive software, firmware libraries, tools, battery, cables and plastic case.

Thanks to the STM32L072CZ embedded in the CMWX1ZZABZ-091 LoRa® module (by Murata), the STEVAL-STRKT01 allows acquiring position, managing geofence and data logging from Teseo-LIV3F GNSS module and monitoring motion (LIS2DW12) and environmental (HTS221 and LPS22HB) sensors.

The board also transmits and receives data, configurations and events to and from the cloud over a LoRaWAN™ network, or stores data locally in the M95M02-DR EEPROM.

The STEVAL-STRKT01 is a LiPo battery operated solution and implements low power strategies thanks to an enhanced power/battery management design, based on the STBC02 battery charger and the ST1PS01 step-down converter, to ensure long battery autonomy. The STUSB1600A addresses 5 V USB Type-C port management and offers high voltage protection pins.

Figure 1. STEVAL-STRKT01 evaluation board

For further information contact your local STMicroelectronics sales office.

1 Getting started

1.1 Overview

The STEVAL-STRKT01 evaluation board key features are:

- Optimized IoT tracker solution over LoRaWAN™ network with simultaneous multi-constellation GNSS positioning and geofencing support
- Battery operated solution with smart power management architecture
- First IoT ST reference embedding a USB Type-C connector and a port controller
- Environmental and motion sensors
- Data logging
- STM32Cube function pack (FP-ATR-LORA1)
- High flexibility to cover different application profiles:
  - asset tracker
  - people and animal tracker
  - fleet management
- WEEE and RoHS compliant
- 2006/66/EC Directive compliant
- Contains trasmitter module FCC ID: VPYCMABZ and IC ID: 772C-CMABZ
- CE certified

1.2 STEVAL-STRKT01 package

The STEVAL-STRKT01 package includes:

- an evaluation board;
- a plastic case;
- a USB Type-C cable;
- a Type-A to Type-C USB adapter;
- a programming cable;
- a battery;
- an antenna;
- a plastic band and plastic support.

Figure 2. STEVAL-STRKT01 package

Figure 3. STEVAL-STRKT01 components

1.3 How to use and configure the board

1.3.1 Hardware setup

To start up the system and run the demo:

Step 1. Set up the hardware, as shown below.
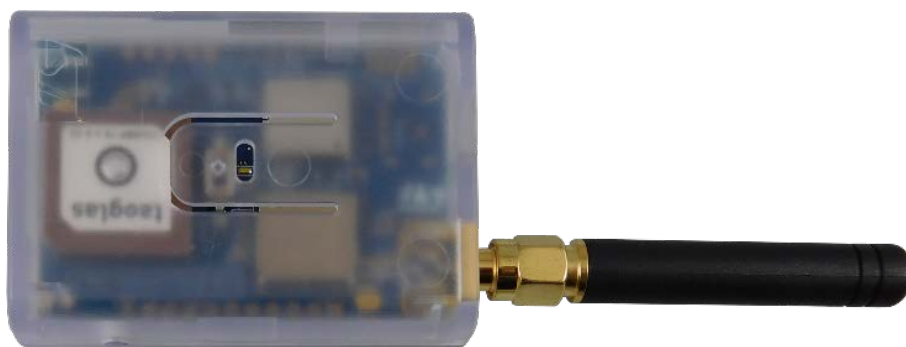
Step 1a.

Figure 4. STEVAL-STRKT01 setup (1 of 4)

Step 1b.

Figure 5. STEVAL-STRKT01 setup (2 of 4)

Step 1c.

Figure 6. STEVAL-STRKT01 setup (3 of 4)

Step 1d.

Figure 7. STEVAL-STRKT01 setup (4 of 4)

Step 2.   Connect the LoRa antenna to connector J101.

Step 3.   Press switch SW400 to power on (for 1.250 s at least)
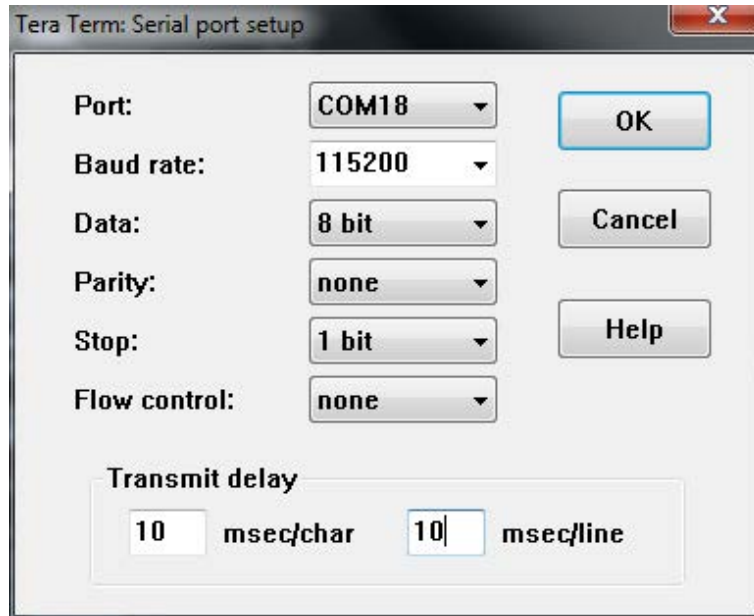
1.3.2   Serial port configuration

To access the network, you have to customize a few board parameters by connecting a USB type-C cable to connector CN500 and to a host PC.

A virtual com port and specific commands allow accessing the board settings.

Step 1. Configure the virtual com port as shown below.

Figure 8. Virtual com port configuration

Step 2. Open the serial connection.

Step 3. On the first run, take note of the DevEUI string necessary to identify the device.

Step 4. For further steps of device registration and configuration, and gateway setup, refer to UM2487, freely available at www.st.com.

2 Command list

The STEVAL-STRKT01 supports a set of commands to get information from the system.

Most commands do not need customization, except the ones to set the LoRa device EUI, the LoRa join EUI, the application key and the network key, the LoRa sending interval and data rate, as well as the RTC date and time.

Table 1. STEVAL-STRKT01 command list

ASCII command[1]	Label	Get/Set	Description
?	help	G	It shows this command list.
?fwversion	View fw info	G	It shows information about firmware version.
?mcuid	View MCU ID	G	It shows information about microcontroller ID (96-bit unique ID).
!sysreset	System reset	S	It resets the system. Disconnect the VCP and wait for system restart.
!shutdown	System shutdown	S	It switches the system in shutdown mode. Disconnect the USB cable and wait for system shutdown.
?welcomemsg	Welcome message	G	It displays a welcome message, useful to test whether the USB connection has been established and VCP is open.
?platformstatus	Get the platform settings	G	It gets the platform settings.
!defaultsettings	Restore EEPROM default settings	S	It restores EEPROM default settings and has to be followed by System reset command.
!lpsensorevent-x	Set Low P on sensor event on/off	S	It enables or disables the system to go in low power mode after a sensor event (accelerometer inactivity). Replace x with 1 to activate the low power mode at sensor event, otherwise replace x with 0 to disable this feature.
!lpsleeptimer-x	Set Low P on sleep timer on/off	S	It enables or disables the system to go in low power mode after a timer event. Replace x with 1 to activate the low power mode at timer event, otherwise replace x with 0 to disable this feature.
!sendonwake-x	Send data on sensor wakeup (on/off)	S	It enables or disables sending sensor data after the accelerometer wake-up event. Replace x with 1 to activate this feature, otherwise replace x with 0 to disable it.
!sendonthreshold-x	Send data on sensor threshold (on/off)	S	It enables or disables sending data after a sensor overshoots the threshold event (low or high humidity, temperature or pressure). Replace x with 1 to activate this feature, otherwise replace x with 0 to disable it.
!loraadronoff-x	Set LoRa ADR on/off	S	The adaptive data rate (ADR) is a mechanism for optimizing network data rates, airtime and energy consumption. This command allows enabling or disabling this feature. Replace x with 1 to activate it, otherwise replace x with 0 to disable it.
!loradr-x	Set LoRa Data Rate	S	It sets the LoRa data rate (values should be between 0 and 5).

ASCII command[1]	Label	Get/Set	Description
!lorainterval-xxxxx	Set LoRa send interval	S	It sets the LoRa sending interval (xxxxx is the interval expressed in ms). The syntax of the ASCII command which sets the LoRa sending interval is: ! lorainterval-xxxxx<CR><LF>. You have to change the xxxxxx digts with the chosen interval.
?loraack	Get LoRa ack variable status	G	It gets the LoRa ack variable status.
!loraack-x	Set LoRa ack variable status	S	It sets the LoRa ack variable status. Replace x with 1 to activate this feature, otherwise replace x with 0 to disable it.
!txtimerintv-xxx	Set tx timer interval	S	Set the system setting for tx timer interval. Replace xxx with the tx timer interval in ms.
!format	Format EEPROM. It loses data	S	Format EEPROM to use with log manager. The EEPROM is prepared to be used with log manager. This command is mandatory before the very first activation of the log manager.
!pushlog	Push current data to EEPROM	S	It stores current data to EEPROM (activity/inactivity of the accelerometer, T, P, H, latitude, longitude, altitude, battery level).
?getsingleitem	Get 1 item from EEPROM	G	It gets one single item from EEPROM.
?getlogs	Get all items from EEPROM	G	It gets all items from EEPROM.
?getunsentlogs	Get items not sent from EEPROM		
?logmanager	Get EEPROM datalog status	G	Get EEPROM log manager status and can be running or not. It also returns the amount of log manager events per type.
!logmanager	Set EEPROM datalog ON/OFF	S	It enables or disables log manager in EEPROM. Replace x with 1 to activate this feature, otherwise replace x with 0 to disable it.
?gnssappconf	GNSS get app config data	G	It gets GNSS application configuration status.
!gnssappconf-x-y	GNSS set app config data	S	It configures the GNSS application layer: x is the activation for WAIT FOR FIX when sending data and y is the activation for WAIT FOR FIX when polling data from GNSS.
!powergnssp-x	GNSS VDD is switched on or off	S	This command has effect on the GNSS feeding line (refer to GNSS_POWER net in Section 4 Schematic diagrams) managed by STBC02 SW1_OA load switch. Replace x with 1 to activate the GNSS power line, otherwise replace x with 0 to break the feeding.[2]
!powereeprom-x	EEPROM VDD is switched on or off	S	This command has effect on the EEPROM feeding line (refer to EEPROM_POWER net in Section 4 Schematic diagrams) managed by STBC02 SW1_OB load switch. Replace x with 1 to activate the EEPROM power line, otherwise replace x with 0 to break the feeding.[2]

ASCII command[1]	Label	Get/Set	Description
!powertcctrl-x	Type-C controller VDD is switched on or off	S	This command has effect on the feeding line (refer to 1600_POWER net in Section 4 Schematic diagrams) that enables the I²C communication with the USB Type-C port controller as well as its status management. It is managed by STBC02 SW2_OA load switch. Replace x with 1 to activate the Type-C controller power line, otherwise replace x with 0 to break the feeding.[2]
!powersens-x	Sensors VDD is switched on or off	S	This command has effect on the sensors (humidity, temperature and pressure) feeding line (refer to SENS_VDD net in Section 4 Schematic diagrams) managed by STBC02 SW2_OB load switch. Replace x with 1 to activate the sensor power line, otherwise replace x with 0 to break the feeding.[2]
?debugmode	Get the debug mode	G	It gets debug over USB mode status.
!debugmodeSs	Set the debug mode	S	It sets debug mode status. Replace last s character with e or E to activate the debug mode, otherwise replace it with d or D to disable this functionality.
?devicejoinstatus	Get the LoRa device join status	G	It gets the LoRa device join status.
?devicejoinparam	Get the LoRa join parameters	G	It gets the LoRa join parameters.
!deviceeui-xxxxxxxxxxxxxxxx	Set the LoRa device EUI	S	It sets the device EUI. In the command syntax, replace each x character with one of the 16 nibbles composing the LoRa device EUI.
!joineui-xxxxxxxxxxxxxxxx	Set the LoRa join EUI	S	It sets the join EUI. In the command syntax, replace each x character with one of the 16 nibbles composing the LoRa join EUI.
!appkey-xxxxxxxxxxxxxxxx	Set the application key	S	It sets the application key. In the command syntax, replace each x character with one of the 32 nibbles composing the application key.
!ntwkkey-xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	Set the network key	S	It sets the network key. In the command syntax, replace each x character with one of the 32 nibbles composing the network key.
!eraselorakeys	Erase LoRa keys in EEPROM	S	It erases LoRa keys.
!triggerlora	Trigger a LoRa sending	S	It forces a LoRa data sending.
?includeepochtime	Get 'Include Epoch time' variable status	G	It gets the 'Include Epoch time' variable status.
!includeepochtime-x	Set 'Include Epoch time' variable status	S	It Sets the 'Include Epoch time' variable status. Replace x with 1 to include Epoch time, otherwise replace x with 0 to not include it.
?joinreqintvshort	Get 'Shorten join req intv' variable status	G	It gets the shorten join request interval variable status.
!joinreqintvshort-x	Set 'Shorten join req intv' variable status	S	It sets the shorten join request interval variable status. Replace x with 1 to enable shorten join request interval, otherwise replace x with 0 to not disable it.
!sysrun	Set system state to run	S	It sets system state in run mode.

ASCII command[1]	Label	Get/Set	Description
`!syslp`	Set system state to low power	S	It forces the system state to low power.
`!sysulp`	Set system state to ultra low power	S	It forces the system state to ultra low power.
`!gpscoldstart`	GPS cold start	S	It performs a GPS cold start initialization.
`?gpsgetposition`	Get GPS position	G	It gets the GPS position.
`!geofence-p-rrrrr`	Config geofence	S	The command manages the geofence functionality. You have to replace p with: • H if the geofence is centered on current GPS coordinates • L if the geofence is centered on ST Catania site coordinates • C if the geofence is centered on ST Lecce site coordinates • X to disable geofence functionality Moreover if H, L or C is selected, the command must be completed with the '-' character, replacing rrrrr with the radius expressed in meters.
`?geofence`	Get geofence status	G	It gets the GPS geofence status.
`?sensordata`	Get sensors data	G	It gets the sensors data.

1.   All ASCII commands must end with the <CR> <LF> characters (where <CR> is the 0x0D carriage return byte and <LF> is the 0x0A line feed byte).

2.   For further details refer to Section 3.2 Power management.

3 Hardware description

The STEVAL-STRKT01 evaluation board includes the following devices:

- STM32L072CZ- ultra-low-power ARM Cortex-M0+ MCU with 192 Kbytes Flash, 32 MHz CPU, USB
- Teseo-LIV3F - tiny GNSS module
- STBC02 - Li-Ion linear battery charger with LDO, load switches and reset generator
- STUSB1600A - USB Type-C controller (with short-to-VBUS protection)
- M95M02-DR - 2 Mbit serial SPI bus EEPROM

The main components are described in the following sections.

3.1 LoRa module

The STEVAL-STRKT01 embeds the CMWX1ZZABZ-091 LoRa®/Sigfox™ module (by Murata) that allows easily developing applications with the STM32L072CZ and the LoRa®/Sigfox™ RF connectivity in one single module.

The CMWX1ZZABZ-091 has the full set of features available in the STM32L0 series and offers ultra-low-power and LoRa® RF features:

- Embedded ultra-low-power STM32L072CZ Series MCUs, based on ARM® Cortex®-M0+ core, with 192 Kbytes of Flash memory, 20 Kbytes of RAM, 20 Kbytes of EEPROM
- RF frequency range: 860 - 930 MHz
- USB 2.0 FS
- 4-channel,12-bit ADC, 2xDAC
- 6-bit timers, LP-UART, I2C and SPI
- Embedded SX1276 transceiver
- LoRa®, FSK, GFSK, MSK, GMSK and OOK modulations
- +14 or +20 dBm selectable output power
- 157 dB maximum link budget
- Programmable bit rate up to 300 kbit/s
- High sensitivity: down to -137 dBm
- Bullet-proof front end: IIP3 = -12.5 dBm
- 89 dB blocking immunity
- Low RX current of 10 mA, 200 nA register retention
- Fully integrated synthesizer with a resolution of 61 Hz
- Built-in bit synchronizer for clock recovery
- Sync word recognition
- Preamble detection
- 127 dB+ dynamic range RSSI

The Murata LoRa® module embeds its own TCXO running at 32 MHz when enabled.

The TCXO is controlled by the STM32 PA12 pin (R106 mounted – R107 not mounted) or by default always enabled (R106 not mounted – R107 mounted).

When an accurate external-high-speed clock is needed by the STM32, the TCXO_OUT clock pin can feed the module PH0_OSC_IN pin by mounting R105.

The STEVAL-STRKT01 can be equipped, if needed, with an external crystal oscillator: a 24 MHz oscillator with 20 pF capacitors can be added to the board (Y100, C108 and C109 are not fitted by default).

Figure 9. STEVAL-STRKT01 LoRa module and components (top view)

Figure 10. STEVAL-STRKT01 LoRa module and components (bottom view)

Figure 11. STEVAL-STRKT01 LoRa module schematic diagram
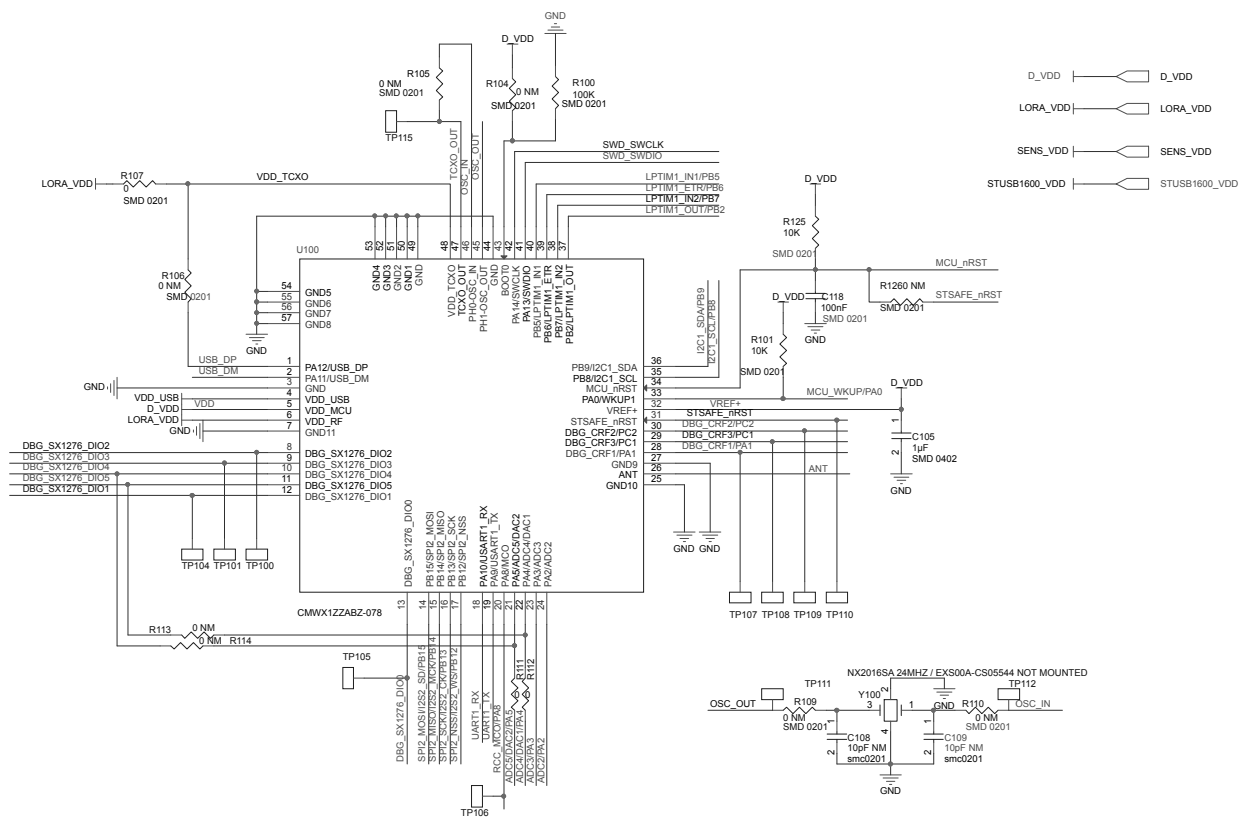
The STEVAL-STRKT01 has an SMA antenna connector J101, that can be replaced by a U.FL connector by assembling J100.

The PI greek filter on the RF path allows improving RF performance by tuning C110, C110, L103, L104.
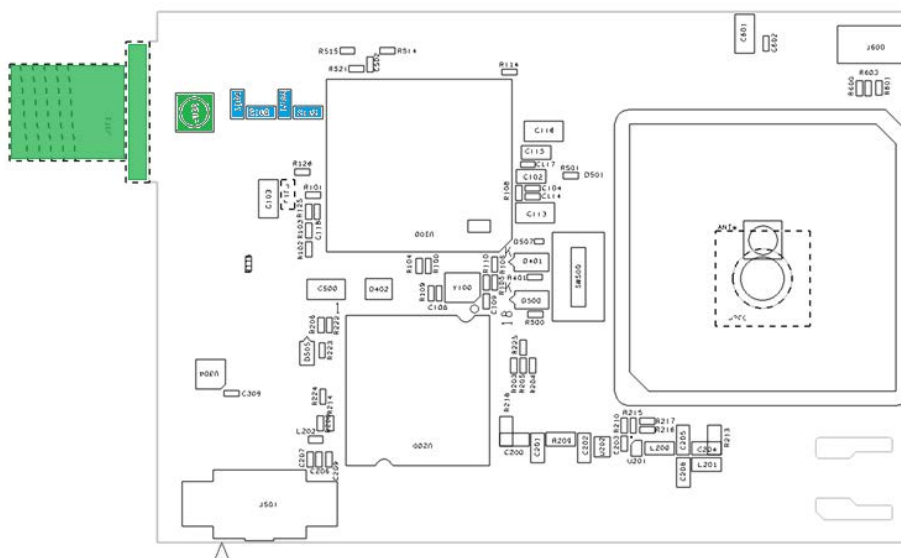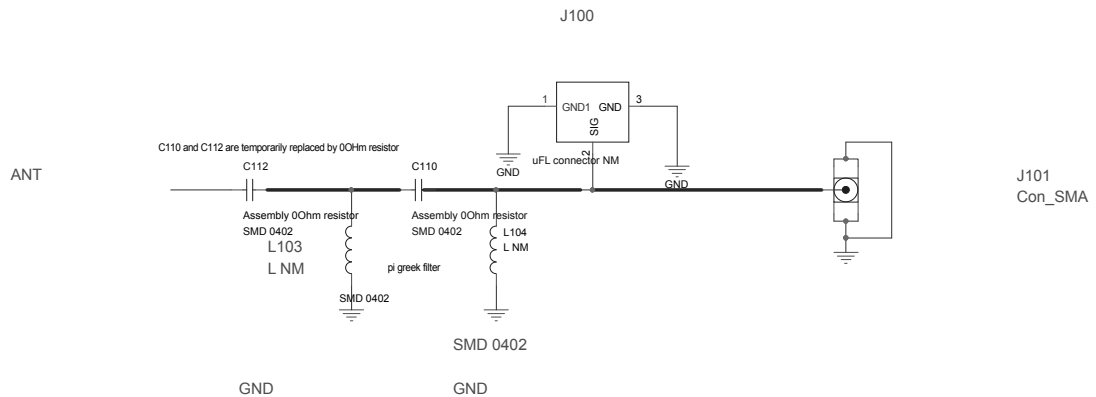
Figure 12. STEVAL-STRKT01 LoRa antenna and components (top view)

Figure 13. STEVAL-STRKT01 LoRa antenna schematic diagram

3.2 Power management

The STEVAL-STRKT01 targets very low power consumption and high energy efficiency. An accurate analysis and definition of the system operation and energy management strategies cannot by achieved by just selecting energy-efficient components.

The energy subsystem has been integrated by the following main devices:

- STBC02
- ST1PS01EJR
- rechargeable 480 mAh LiPo battery

The STBC02 is a highly integrated power management device, embedding a linear battery charger, a 150 mA LDO, 2 SPDT load switches, a smart reset/watchdog block and a protection circuit module (PCM) to prevent the battery from being damaged under faulty conditions.

The STBC02 implements CC/CV algorithms to charge the battery as well as fast charge and pre-charge modes whose currents can be both independently programmed by using dedicated resistors.

The termination current is set by default, being 5% of the programmed fast charge current, but it can also be fixed to different values. Likewise, the battery floating voltage value is programmable and can be set to a value up to 4.45 V. Moreover, it implements battery under/over temperature checks.

The STBC02 is automatically powered off from the connected battery when the IN pin is not connected to a valid power source (battery mode) and also features a charger enable input to stop the charging process anytime.

Figure 14. STBC02 schematic diagram
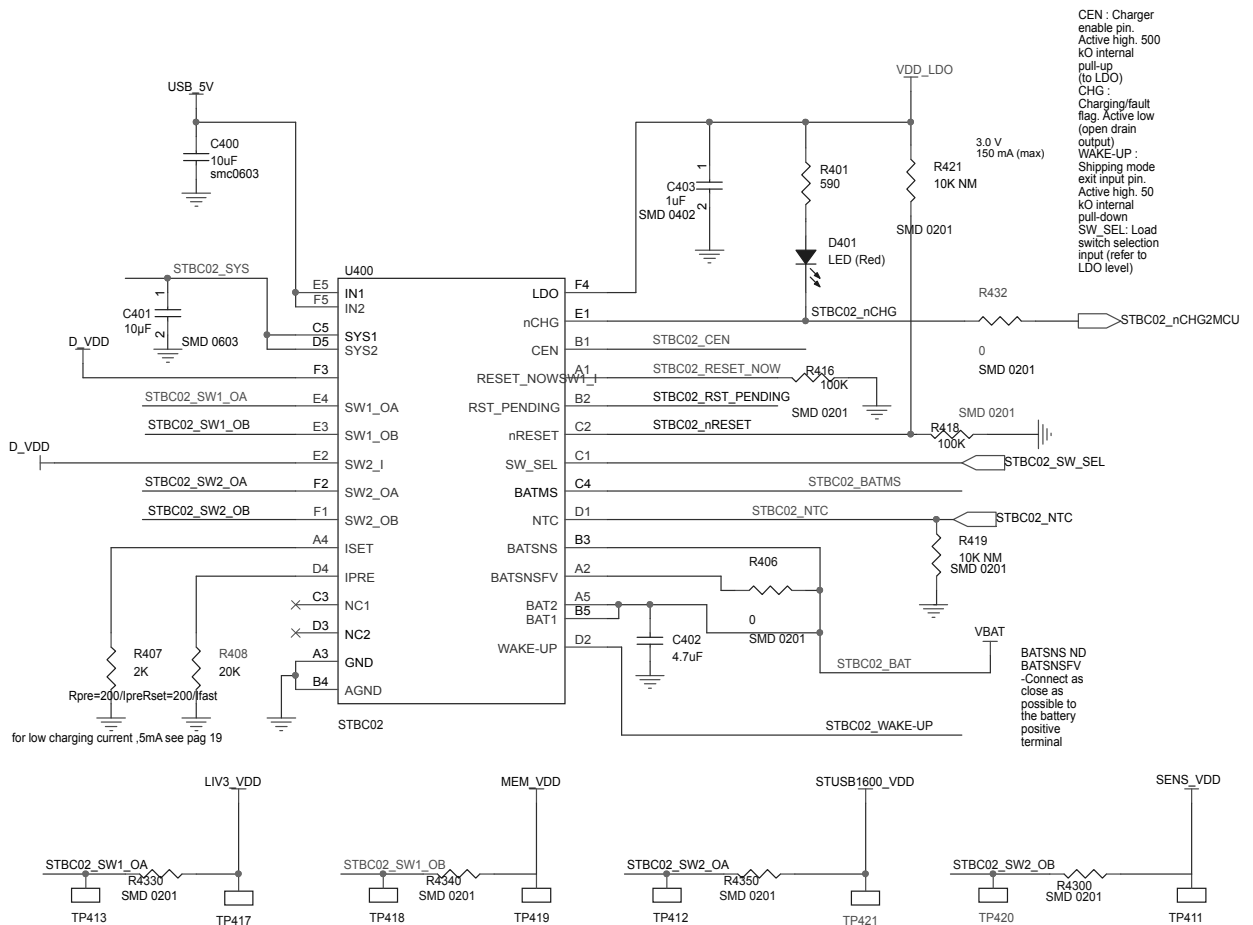
The SPDT load switches are controlled by an internal register, using the SWIRE interface available on SW_SEL pin.

Inputs of both SPDT SW1 switches are connected to digital VDD (D_VDD) from the ST1PS01 device, which is a nano-quiescent miniaturized synchronous step-down converter able to provide up to 400 mA output current.

The output voltage can be set by using two digital control inputs (D0 and D1) in the range from 1.8 to 3.3 V.

For this application, the supply voltage downstreaming the step-down converter is set to 3.3 V (the same feeding voltage for the Murata module).

Figure 15. ST1PS01 schematic diagram
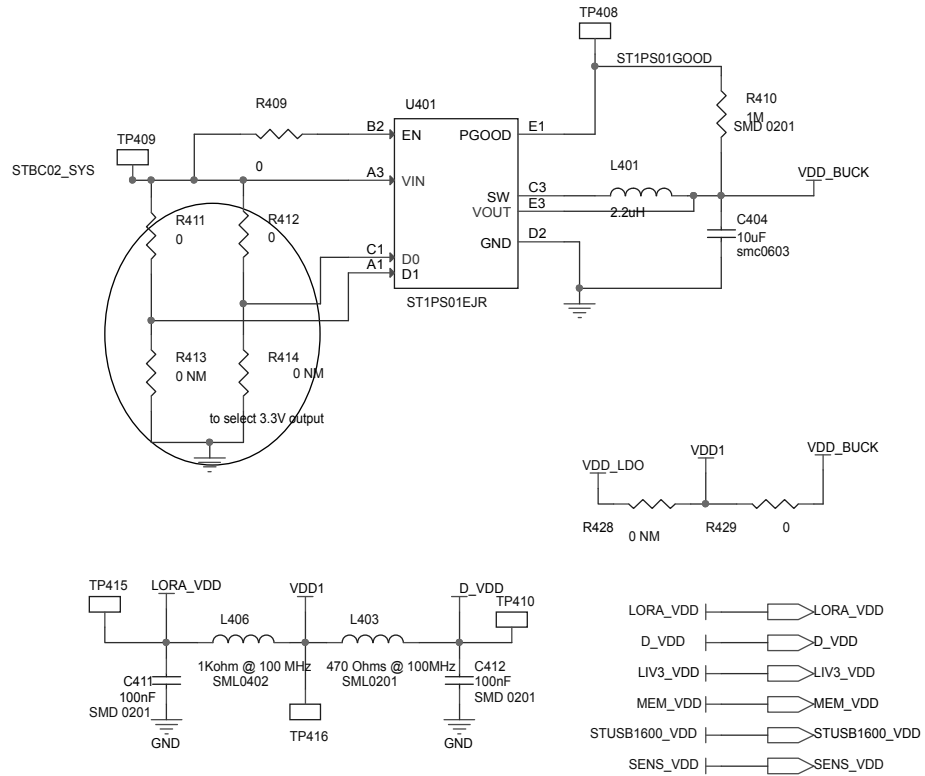
The microcontroller plays a key role at power management stage. Acting on the STBC02 device SW_SEL pin, it allows switching on and off the SPDT switches feeding downstream sub-circuits as requested by the application.

Figure 16. STEVAL-STRKT01 block diagram
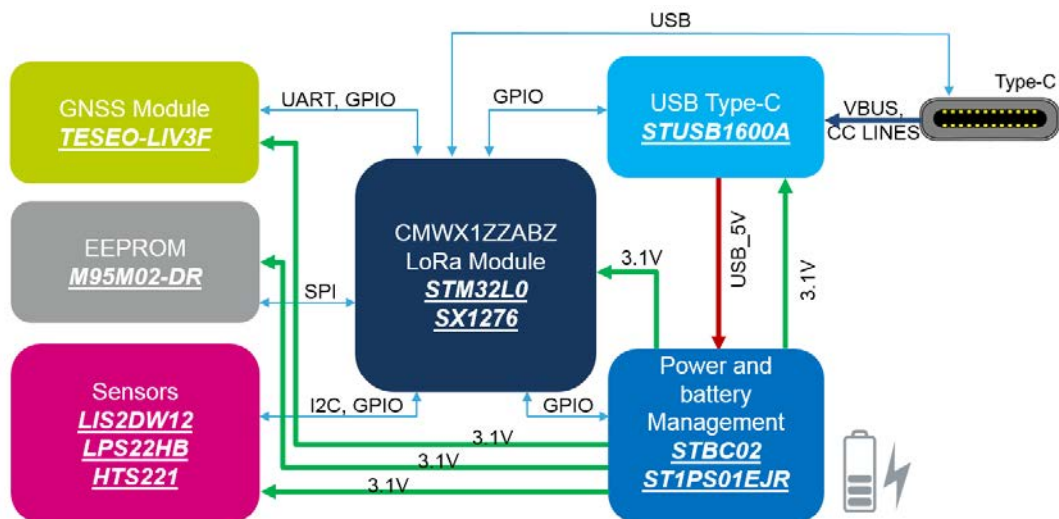
The sub-circuits that can be activated according to the application programmed tasks are:

- GNSS TESEO-LIV3F sub-circuit
- EEPROM sub-circuit
- USB Type-C controller sub-circuit
- Sensor sub-circuit

3.3 Memory

The M95M02 devices are electrically erasable programmable memories (EEPROMs) organized as 262144 x 8 bits, accessed through the SPI bus.

The M95M02 can operate with a supply range from 1.8 to 5.5 V. These devices are guaranteed over the –40/+85 °C temperature range.

The M95M02-DR offers an additional page, named the Identification Page (256 bytes) that can be used to store sensitive application parameters to be (later) permanently locked in read-only mode.

The M95M02-DR module is powered by the MEM_VDD domain through one of the switches embedded in the STBC02 (SW1_OB). It is interfaced with the LoRa module via SPI (LoRa module pins PB12:PB15, that is SPI2).

Figure 17. M95M02-DR schematic diagram
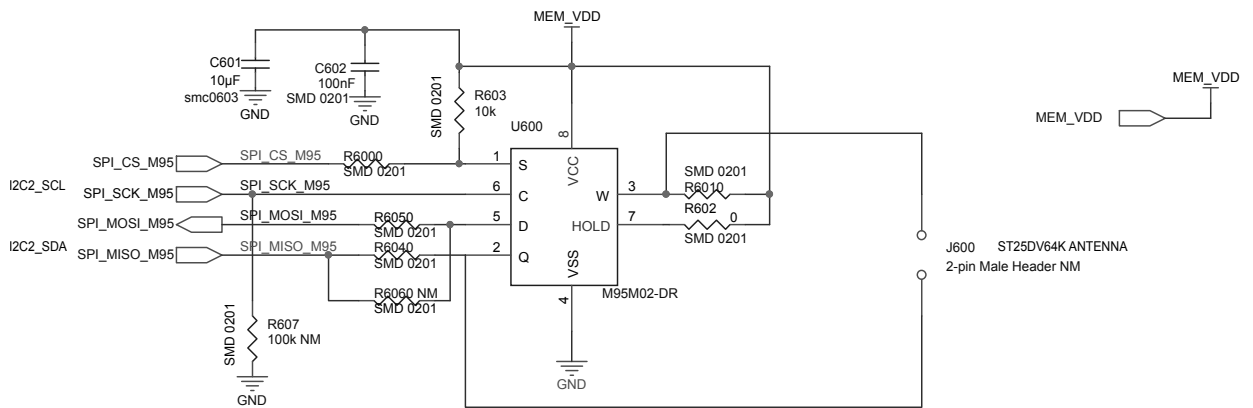
The sensor data can be stored in the eeprom; this is managed by a firmware module, called "log manager" that manages formatting, saving and retrieving data.

The log manager deals with three types of data: normal, system and critical.

In the developed application, only the normal data storage is implemented.

For further information, see FP-ATR-LORA1 user manual.

The table below shows the log manager data format.

Table 2. Datalog format details

Size	Data	Units
32b	Timestamp	s from board start
16b	Temperature	°C * 100
16b	Pressure	hPa/10
16b	Humidity	percentage * 10
32b	Latitude	Sexagesimal degree converted to decimal.[1]
32b	Longitude	Sexagesimal degree converted to decimal. [1]
32b	Altitude	m

1. For details see FP-ATR-LORA1, file main.c, function convertCoord.

3.4 Interface

The available interfaces are:
- CON501: SWD connector
- CON502, CON503: expansion connectors
- J501 (not mounted): extended SWD connector

- • SW500: user button
- • SW400: power on and wake-up button
- • D500: user LED
- • CN500: USB TYPE-C connector

3.4.1 USB Type-C

The USB Type-C™ is the newest USB connector ecosystem that addresses the evolving platforms and device requirements in terms of usability and robustness.

The USB Type-C™ standard has been developed to convey, even simultaneously, data, video and audio signals, to and from the host device. Moreover, it is able to sink or source power up to 15 W or up to 100 W for those devices also supporting the USB Power Delivery specification.

It is based on a 24-pin USB plug and receptacle system with two groups of pin connections arranged to ensure the two-fold rotational symmetry.

The symmetrical connections are:

- • eight power pins: VBUS/GND
- • USB2.0 differential pairs (D+/D-)

The asymmetrical connections are:

- • two sets of Tx/Rx signal paths supporting USB3.1 data rates
- • two configuration channels (CC lines) for the discovery, configuration and management of USB Type-C power delivery features
- • two sideband use (SBU lines) signals for analog audio modes (used by the alternate mode)

Figure 18. USB Type-C™ plug configuration
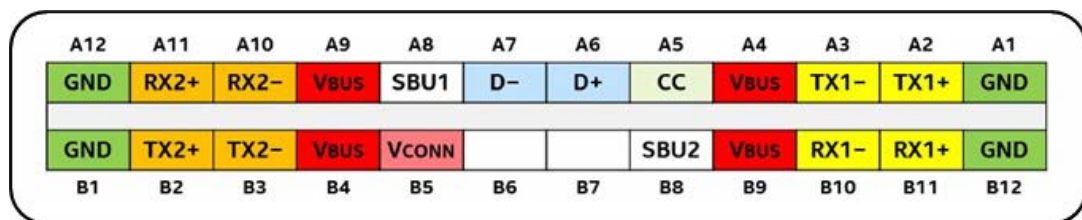
Figure 19. USB Type-C™ receptacle configuration
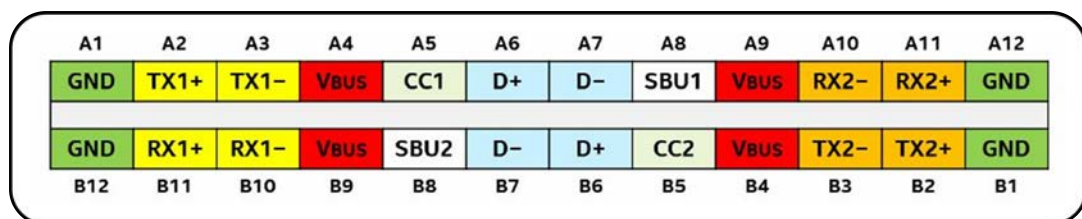
The STEVAL-STRKT01 LoRa® IoT tracker embeds a USB Type-C™ receptacle and a port controller. Both devices, according to the USB Type-C™ specification, support the following features:

- • consumer power role to recharge the on-board battery
- • USB 2.0 and communication device class (CDC)

Figure 20. USB Type-C™ sub-circuit schematic diagram
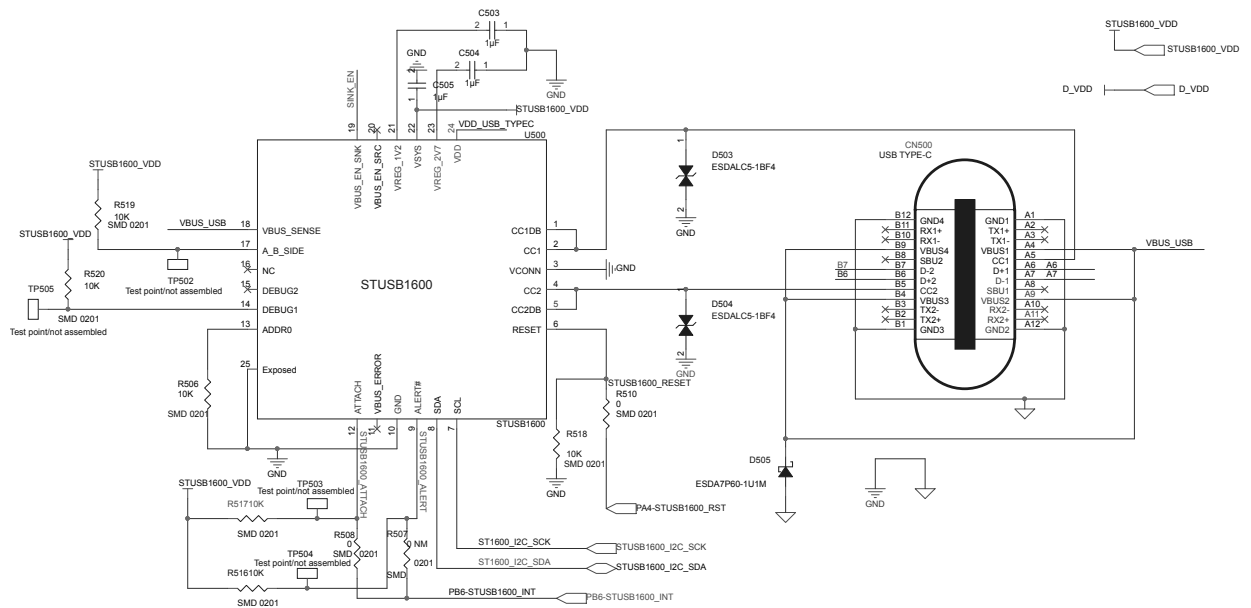
The STUSB1600A is the USB Type-C™ port controller, fully compliant with the USB Type-C specification (rev. 1.2), which addresses 5 V USB Type-C port management on the host and/or device side.

It is designed for a broad range of applications, but for this application purposes, it supports the following USB Type-C functions:

- Detect the connection between two USB Type-C ports
- Establish a valid source-to-sink connection
- Support the consumer power role
- Resolve cable orientation and twist connections to establish USB data routing
- Configure and monitor the VBUS power path, supporting the USB default power capability

The STUSB1600A also provides:

- Low power standby mode
- Dead battery mode
- I²C interface and interrupt (optional connection to the MCU)
- Startup configuration customization: static through NVM and/or dynamic through I²C
- High voltage protection

When a Type-C device, that acts the provider role, is attached to the USB Type-C™ receptacle, the port manager detects the attachment. Consequently, it enables the power path between the VBUS pins of USB receptacle and STBC02 battery charger.

Figure 21. STEVAL-STRKT01 load switch schematic diagram
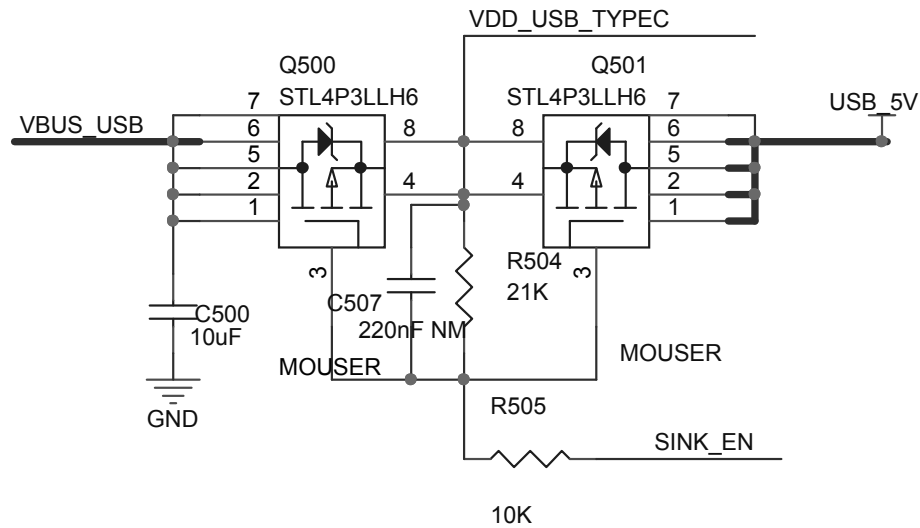
The applied input voltage allows the loads connected to SYS and LDO pins of STBC02 devices to be supplied, thus enabling proper system operations and starting the charging cycle, signaled by the CHG pin which starts toggling.

The red LED D401, driven by STBC02 CHG pin, provides status information about the battery charge and faults by toggling at different frequencies as listed in the table below.

The frequency is measured by the STM32L072CZ pin PA3, connected to the STBC02 nCHG pin through R432.

Table 3. Charging status details

Device state	CHG pin state
End-of-charge (EOC)	Toggling 4.1 Hz (until USB is disconnected)
Charging phase (pre and fast)	Toggling 6.2 Hz
Overcharge fault	Toggling 8.2 Hz
Charging timeout (pre-charge, fast charge)	Toggling 10.2 Hz
Battery voltage below VPRE after the fast charge starts	Toggling 12.8 Hz
Charging thermal limitation (thermal warning)	Toggling 14.2 Hz
Battery temperature fault (NTC warning)	Toggling 16.2 Hz

The STUSB1600A port controller notifies the attach/detach status through the ATTACH pin: when the microcontroller detects the VBUS line is supplied, it acts on the STBC02 power path to enable the STUSB1600_VDD supply line (STBC02_SW2_OA) and configure the interrupt pin (PB6 connected through R508) to detect the detach event.

When STUSB1600_VDD power line is supplied, the microcontroller is also able to query the STUSB1600A port controller acting on the I²C communication bus. It allows the microcontroller to retrieve information about the USB connection.

When the USB Type-C™ attach event is detected, the microcontroller enables the USB communication device class (CDC): the STM32 microcontroller communicates with the host (PC) through the USB interface in device mode through a virtual com port (VCP).

3.4.2 Buttons and LEDs

Figure 22. Buttons and LED schematic diagram
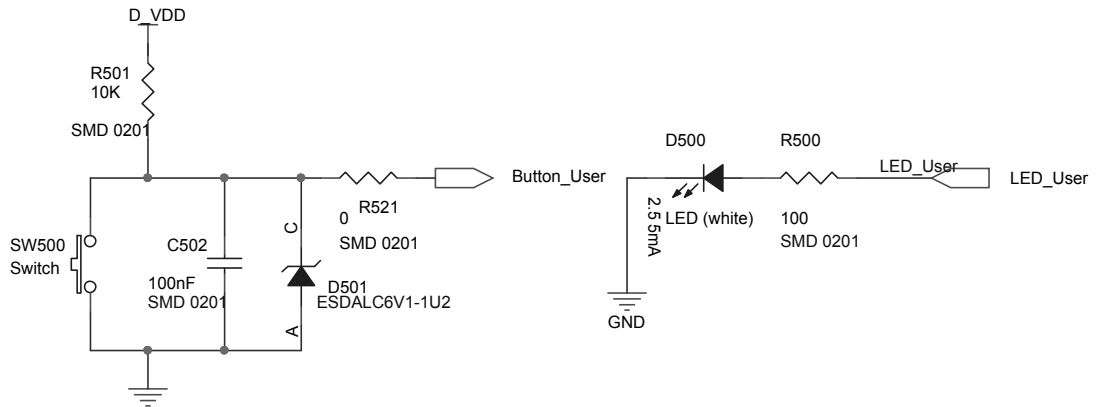
The STEVAL-STRKT01 has two buttons:

- SW500 (user button) placed on the board top side. The default firmware (FP-ATR-LORA1) implements:
  - short press to trigger the LoRa module
  - long press to power off
- SW400 to turn the board on when it is supplied only by the battery (keep the button pressed for 1.250 s). After the power on, SW400 becomes a generic user button. FP-ATR-LORA1 uses it to reset the system.

Figure 23. STEVAL-STRKT01 buttons and LEDs (top view)
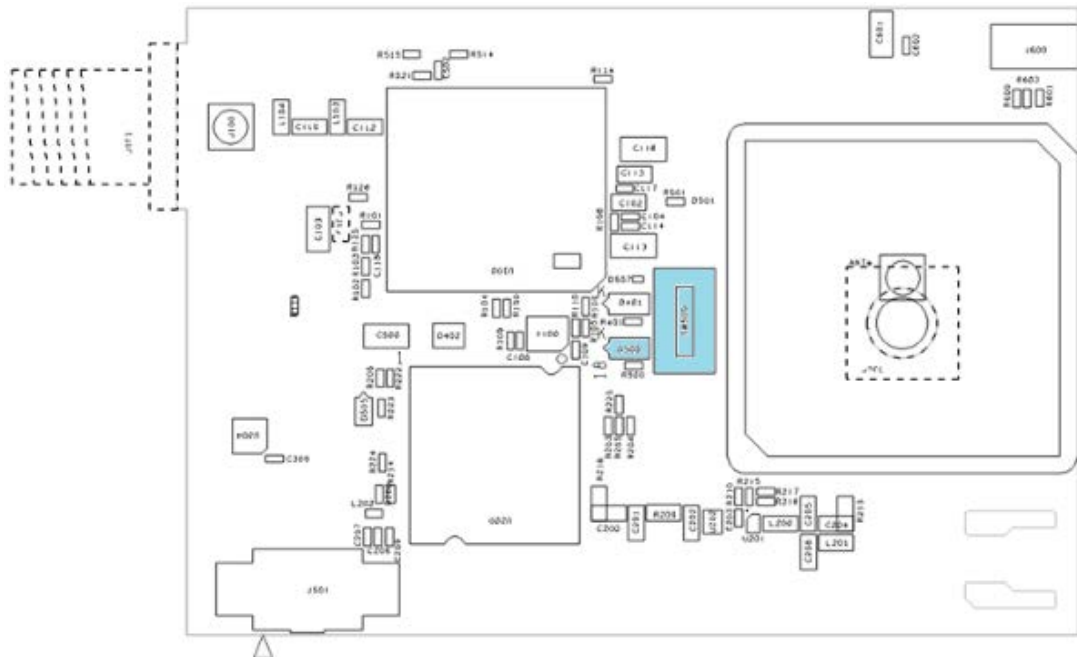
Figure 24. **STEVAL-STRKT01 buttons and LEDs (bottom view)**
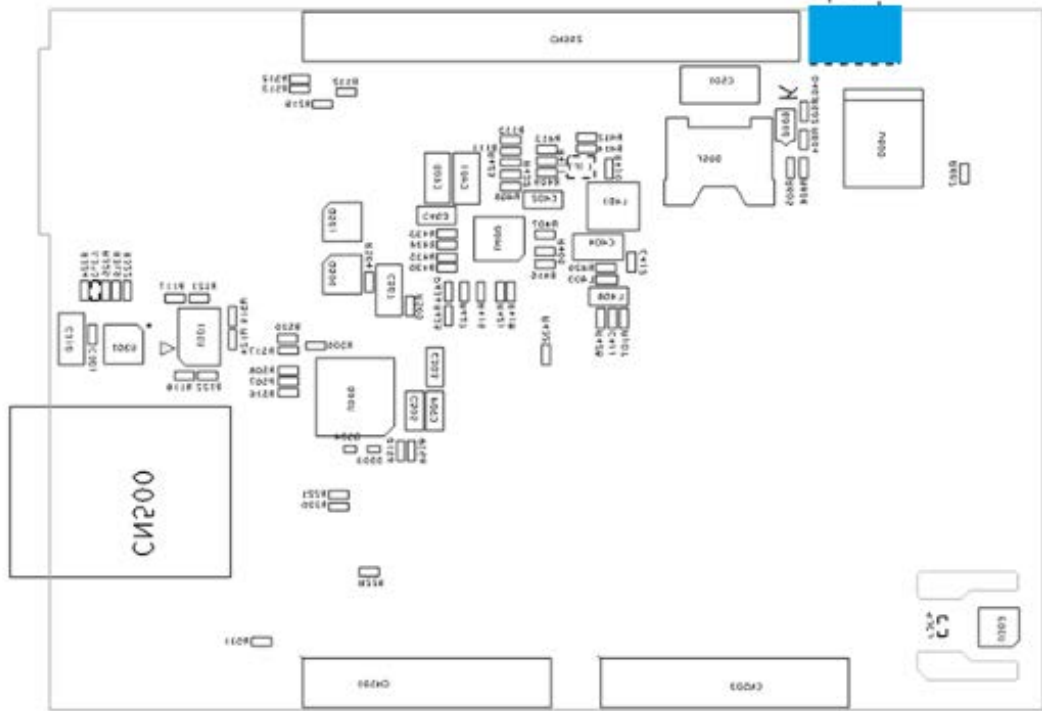
LED D500 is the white user LED used by FP-ATR-LORA1 to provide indication of LoRa transmission status:

- Slow blinking (2 seconds) = not joined
- Fast blinking (0.5 seconds) = joined
- Very fast blinking (200 ms) lasting about 5/10 seconds = transmission on going

LED D401 is the red LED connected to the battery charger. When the USB is connected to a valid power supply, it blinks at 4.1- 6.2 - 8.2 - 10.2 - 12.8 - 14.2 - 16.2 Hz (for further details, refer to Table 3. Charging status details). For the different flashing rate refer to the debug messages.

3.4.3 SWD and expansion connectors

Figure 25. **SWD and expansion connector schematic diagram**
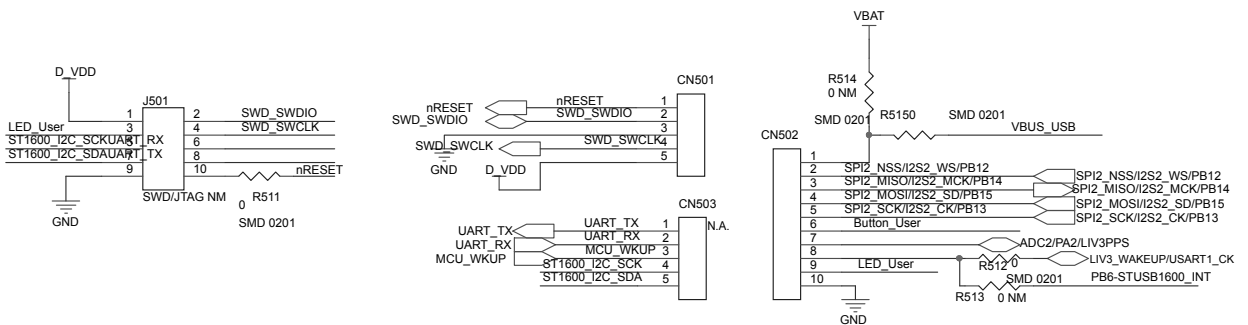
Figure 26. STEVAL-STRKT01 connectors (top view)
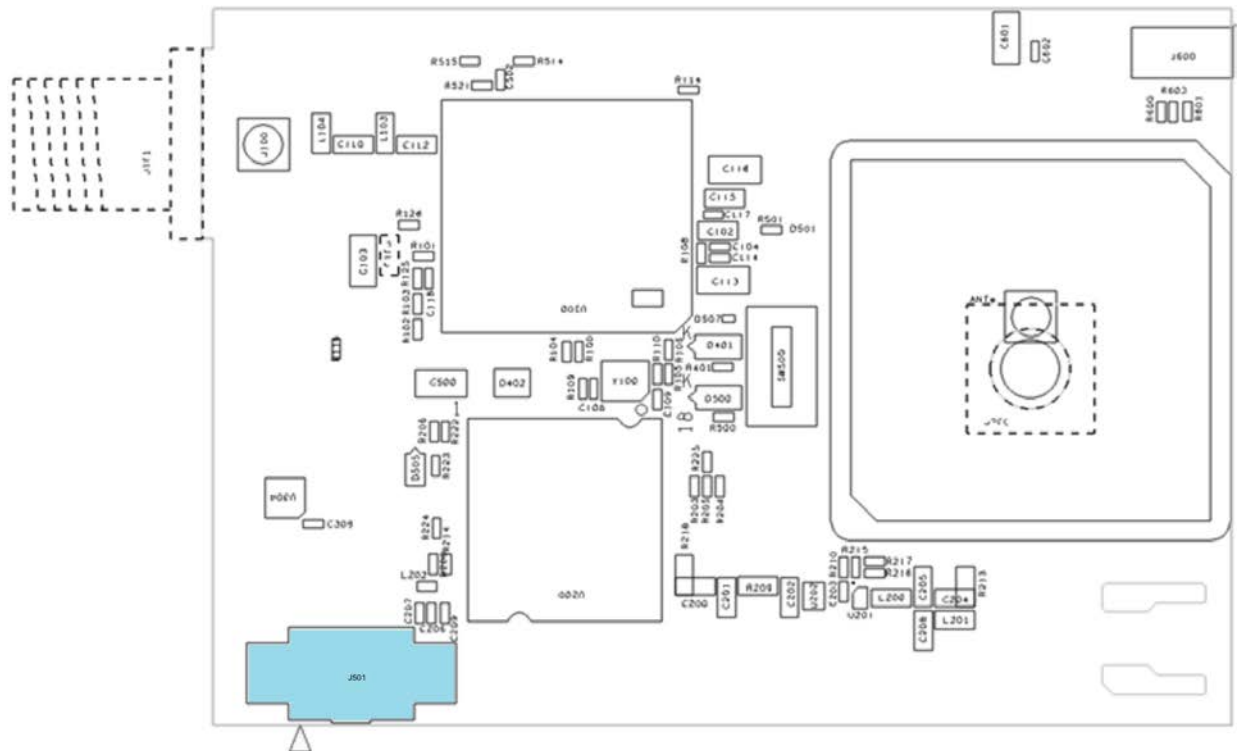
Figure 27. STEVAL-STRKT01 connectors (bottom view)
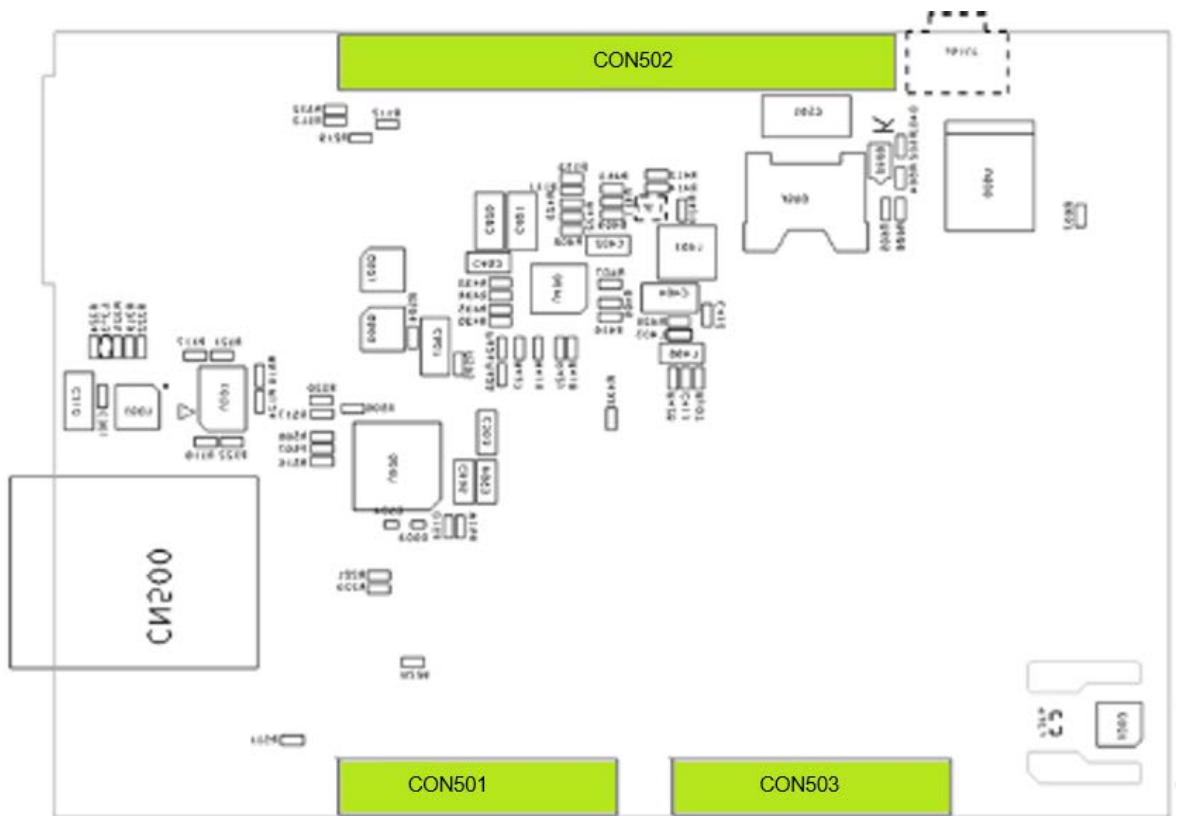
CON501 enables SWD connection to program and debug STM32L072CZ.

Figure 28. STEVAL-STRKT01 connector

To program the STEVAL-STRKT01, connect an ST-LINK/V2/STLINK-V3SET in-circuit debugger/programmer.

Connectors CON502 and CON503 (not mounted) provide some MCU peripheral (SPI, I²C, GPIO, etc.) and VDD/GND pins to allow expansion capabilities.

J501 (not mounted) has a 1.27 mm pitch, 10-contact, 2-row board-to-board connector that can be used:

- to program the microcontroller via a dedicated adapter (STEVAL-UKI001V1 – not included in the kit) connected to the programming tool (for example, ST-LINK/V2 or STLINK-V3SET).
- as an expansion connector that routes the UART pins to connect to a PC COM port. An IO for USER_LED is also routed.

3.4.4 Update via ST-LINK/V2 in-circuit debugger/programmer

Step 1. Connect the 5-pin flat cable (male side) to STEVAL-STRKT01 CN501 connector as per Table 4

Step 2. Connect the 5-pin flat cable (female side) to ST-LINK/V2 pins 1-5 as per Table 4
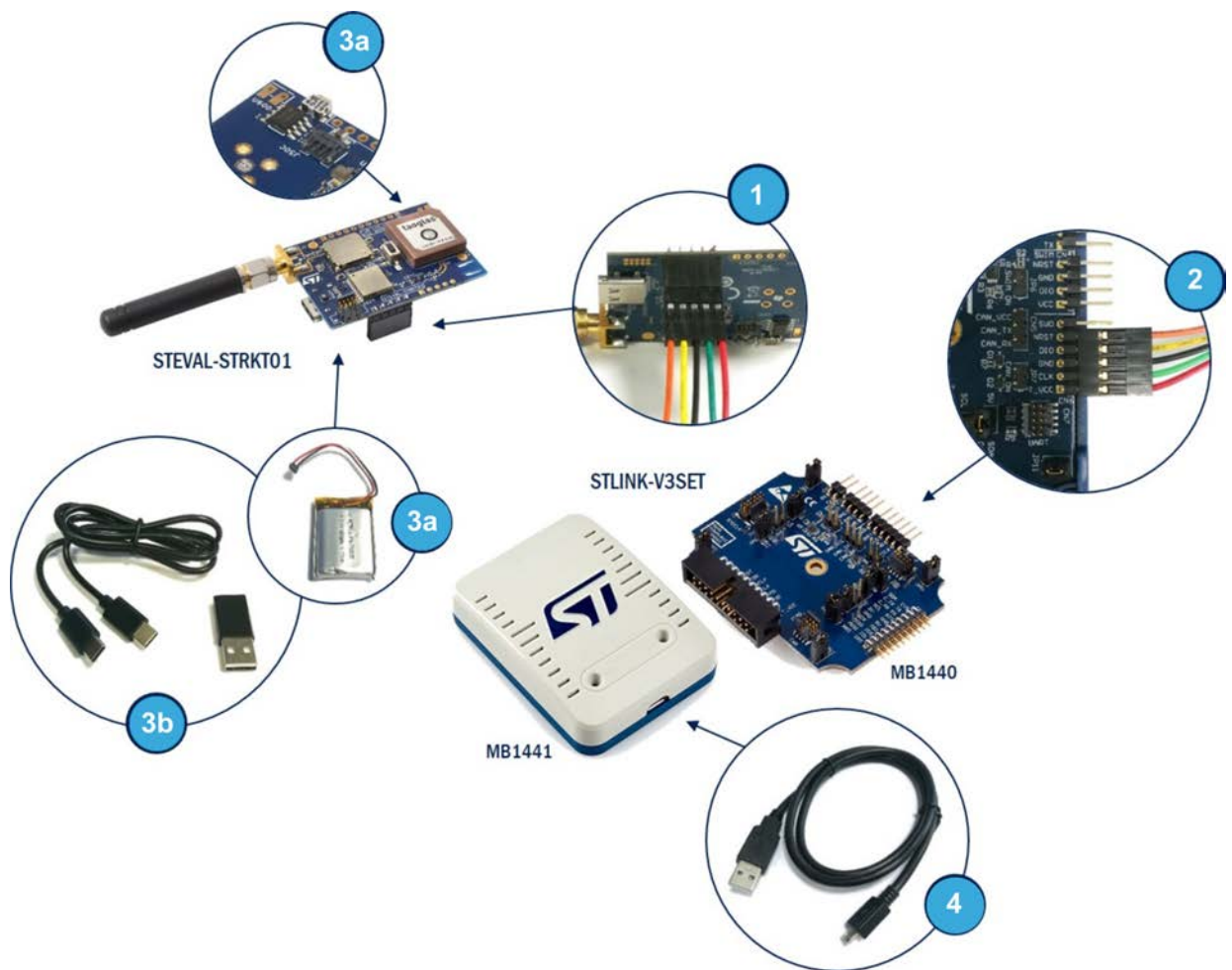
Step 3.

Step 3a. Connect the battery and press SW400 button to power the board on (for 1.250 s at least)

or

Step 3b. Supply the STEVAL-STRKT01 via a Type-C USB cable (and a Type-C to Type-A adapter if needed)

Step 4. Connect the ST-LINK/V2 to a PC via a Type-A/mini B cable

Figure 29. Hardware configuration for STEVAL-STRKT01 firmware update using an ST-LINK/V2 programmer
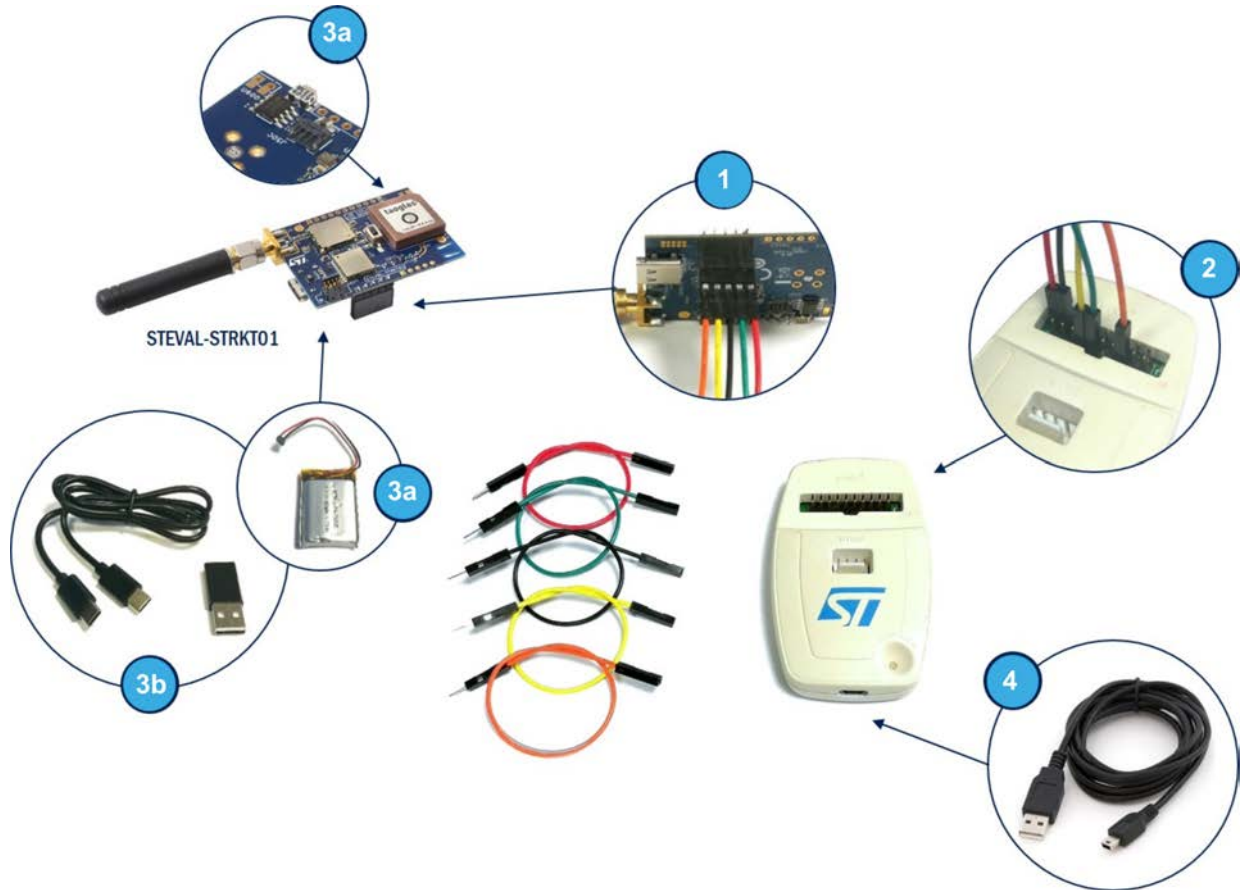
Table 4. ST-LINK/V2 programmer and STEVAL-STRKT01 pinout

ST-LINK/V2 connector (pin and label)		STEVAL-STRKT01 CN501 (pin and label)
	2, VAPP	5, D_VDD
	4, GND	3, GND
	7, TMS_SWDIO	2, SWD_SWDIO
	9, TCK_SWCLK	4, SWD_SWCLK
	15, NRST	1, nRESET

3.4.5 Update via ST-LINK/V3 in-circuit debugger/programmer

To perform the update via ST-LINK/V3 you first have to combine it with the adapter (MB1441 plus MB1440, shown in Figure 30. Hardware configuration for STEVAL-STRKT01 firmware update using an ST-LINK/V3 programmer).

Step 1. Connect the 5-pin flat cable (male side) to STEVAL-STRKT01 CN501 connector

Step 2. Connect the 5-pin flat cable (female side) to MB1440 CN6 connector pins 1-5 and leave pin 6 unconnected

Step 3.

    Step 3a. Connect the battery and press SW400 button to power the board on (for 1.250 s at least)

        or

    Step 3b. Supply the STEVAL-STRKT01 via a Type-C USB cable (and a Type-C to Type-A adapter if needed)

Step 4. Connect the ST-LINK/V3 to a PC via a Type-A/micro B cable

Figure 30. Hardware configuration for STEVAL-STRKT01 firmware update using an ST-LINK/V3 programmer

3.4.6 Update via STM32 Nucleo-64 on-board ST-LINK programmer

Step 1. Connect the 5-pin flat cable (male side) to STEVAL-STRKT01 CN501 connector

Step 2. Connect the 5-pin flat cable (female side) to the STM32 Nucleo SWD connector pins 1-5, leave pin 6 unconnected and remove CN2 jumpers

Step 3.

    Step 3a. Connect the battery and press SW400 button to power the board on (for 1.250 s at least)

        or

    Step 3b. Supply the STEVAL-STRKT01 via a Type-C USB cable (and a Type-C to Type-A adapter if needed)

Step 4. Connect the STM32 Nucleo to a PC via a Type-A/mini B cable

Figure 31. Hardware configuration for STEVAL-STRKT01 firmware update using STM32 Nucleo-64 on-board ST-LINK programmer
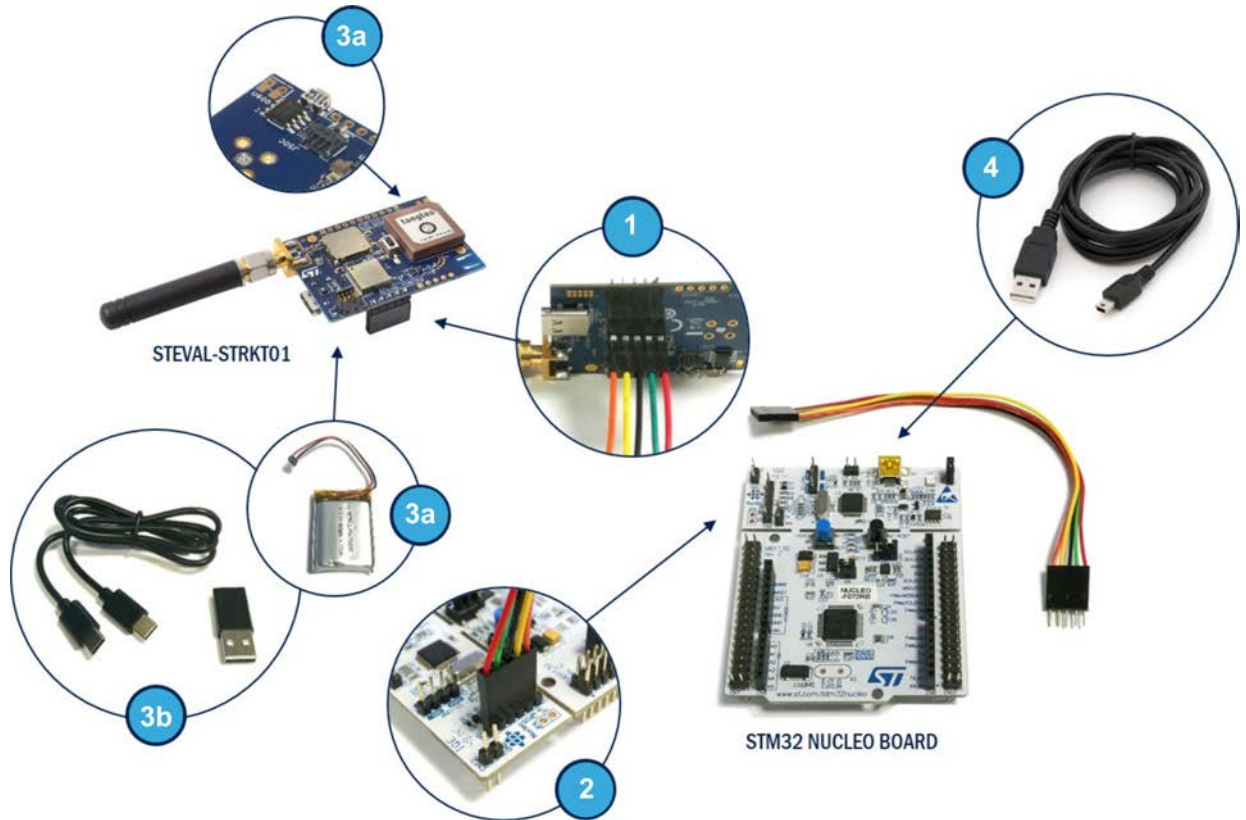
3.5 GNSS

The Teseo-LIV3F tiny GNSS module represents an affordable, easy-to-use, global navigation satellite system (GNSS) module, embedding a TeseoIII single die standalone positioning receiver IC.

It is a compact (9.7x10.1 mm) module that provides superior accuracy thanks to the on-board 26 MHz temperature compensated crystal oscillator (TCXO) and a reduced time-to-first fix (TTFF) with its dedicated 32 KHz real-time clock (RTC) oscillator.

Teseo-LIV3F key features:

- Simultaneously multiconstellation
- -163 dBm navigation sensitivity
- 1.5 m CEP accuracy positioning
- 16 Mbit embedded Flash for data logging and firmware upgrade
- 2.1 to 4.3 V supply voltage range
- Tiny LCC 18 pin package (9.7x10.1)
- Operating temperature (-40°, 85°C)
- Free firmware configuration
- 17 µW standby current and 75 mW tracking power consumption

The Teseo-LIV3F module comes with a pre-programmed firmware to perform all GNSS operations including acquisition, tracking, navigation, geofence and data output without external memory support. For more information on geofence configuration, see Table 1. STEVAL-STRKT01 command list, "!geofence" command

As shown in the following picture, the STEVAL-STRKT01 embeds a Teseo-LIV3F module, the related RF signal conditioning electronics (in green) and the option of adding an external antenna (in blue).
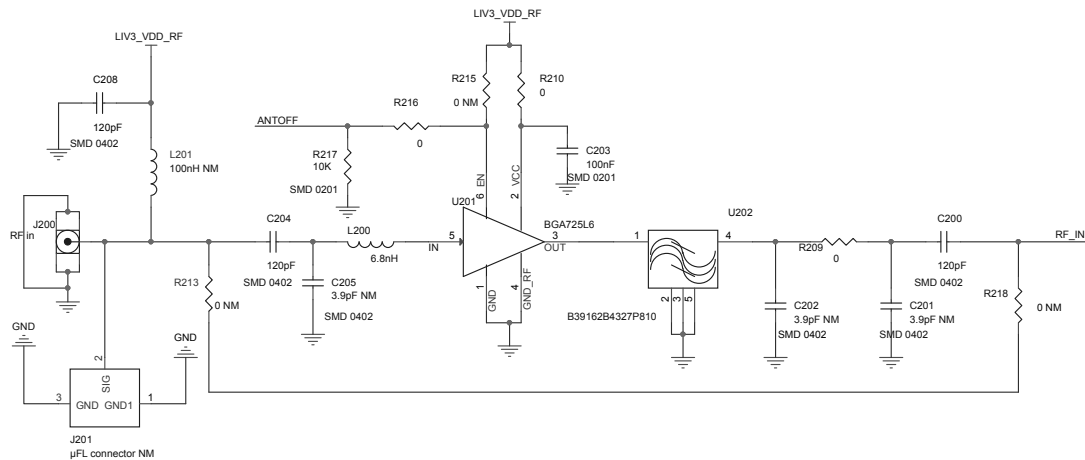
The module is powered by the VDD_BUCK domain (3.3 V output from ST1PS01) through one of the switches embedded in the STBC02 (STBC02_SW1_OA). This enables the low power strategies implemented in the firmware that permit the complete shutdown of the Teseo-LIV3F module.

Figure 33. STEVAL-STRKT01 Teseo-LIV3F module schematic diagram
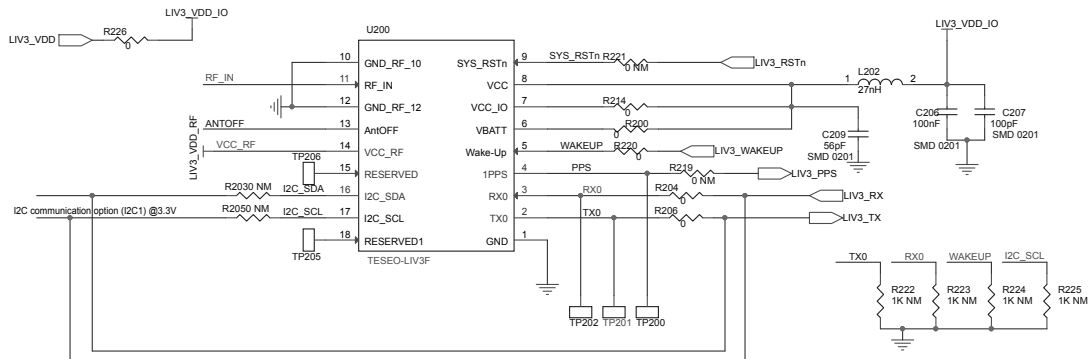
The interface with the main microcontroller is a UART (PA9 and PA10 for USART1) for communication (NMEA strings, proprietary strings and commands): this is the board default configuration, with R204 and R206 mounted.

To interface the module through I²C, mount R203 and R205 and remove R204 and R206, disabling UART communication.

The wakeup pin is connected to PA8 through R220, whereas the reset and PPS pins are not controlled by MCU and can be optionally connected through 0-Ohm resistors by resetting pin to PA4 (remove R510, mount R221, STUSB1600_RESET control is lost) and PPS pin to PA2 (remove R521, mount R219, Button_User input is lost).

The RF path is made up of a ceramic patch antenna (18x18x 4 mm, Beidou, GLONASS, GPS constellations, 1.56 - 1.575 - 1.602 - 1.548 ~ 1.615 GHz) soldered in J200, an LNA (U201) and a SAW RF filter (U202).

The PCB can host an SMA connector for GPS RF input, suitable for an external antenna (remove J200 and mount J201 connector whose footprint is compatible with the U.FL and SMA connectors).

If the external antenna needs to be powered, L201 100 nH inductor has to be mounted.

3.6 Sensors

The integrated environmental and motion sensors feature extremely low power capabilities and advanced performance in terms of accuracy and embedded digital features.

The following sensors are mounted on the STEVAL-STRKT01 evaluation board:

- U301: LIS2DW12 – 3-axis accelerometer
- U303: HTS221 – humidity and temperature sensor
- U304: LPS22HB – pressure sensor

3.6.1 LIS2DW12

The LIS2DW12 is an ultra-low-power high-performance three-axis linear accelerometer belonging to the "femto" family which leverages on the robust and mature manufacturing processes already used for the production of micromachined accelerometers.

It has user-selectable full scales of ±2g/±4g/±8g/±16g and is capable of measuring accelerations (with output data rates from 1.6 to 1600 Hz) and an integrated 32-level first-in, first-out (FIFO) buffer allowing the user to store data to limit intervention by the host processor.

The embedded self-test capability also allows checking the sensor functioning in the final application.

The LIS2DW12 has a dedicated internal engine to process motion and acceleration detection including free-fall, wakeup, highly configurable single/double-tap recognition, activity/inactivity, stationary/motion detection, portrait/landscape detection and 6D/4D orientation.

The accelerometer is available in a small thin plastic land grid array package (LGA) and it is guaranteed to operate over an extended temperature range from -40 to +85 °C.

It is supplied by D_VDD (same feeding line as the STM32L072CZ), being R324 mounted; it can be supplied also by the SENS_VDD power domain, mounting R323 and removing R324.

The acceleration data are accessed through I²C interface, being its slave address set to 0x30 (SA0 set to gnd).

Accelerometer interrupt is configured to recognize activity/inactivity, switching through different power states.

As shown in Figure 35. LIS2DW12 schematic diagram, by default INT1 pin is not connected (R322 unfit) while INT2 pin interrupt is used (R325 fit) and connected to LoRa module wakeup pin.

I²C bus and LIS2DW12_INT2 pin are connected to LoRa module pins PB8, PB9 and PA0, respectively (see Figure 38. STEVAL-STRKT01 circuit schematic (1 of 7)).

Alternatively, in case you need to use accelerometer INT1 interrupt too, LIS2DW12_INT1 pin may be connected to LoRa module PA0 pin, by soldering resistor R322, and unsoldering resistor R325 (Figure 35. LIS2DW12 schematic diagram); INT2 can be then switched to LoRa module PB6_INT pin by soldering resistor R319. With this option, USB interrupt cannot be used.

Figure 35. LIS2DW12 schematic diagram
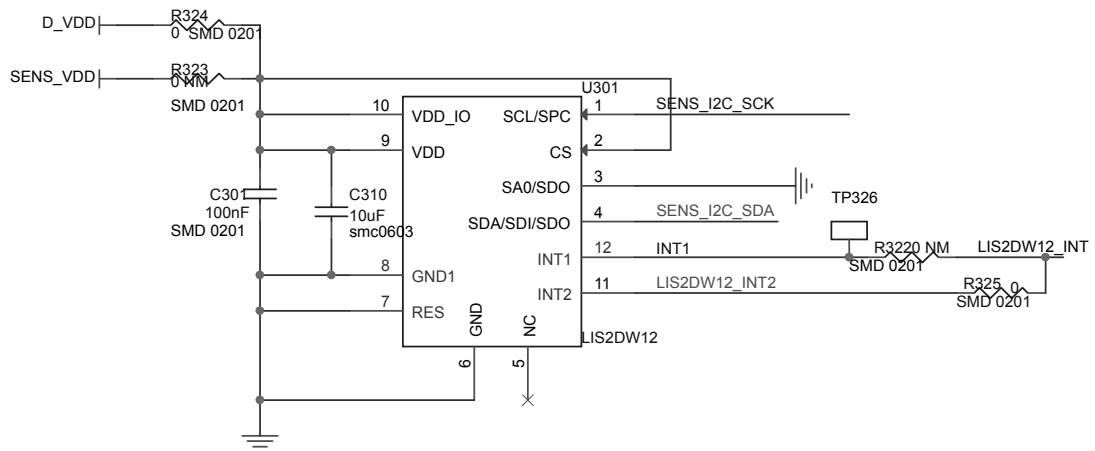
3.6.2 HTS221

The HTS221 is an ultra-compact sensor for relative humidity and temperature. It includes a sensing element and a mixed signal ASIC to provide the measurement information through digital serial interfaces.

The sensing element consists of a polymer dielectric planar capacitor structure capable of detecting relative humidity variations and is manufactured using a dedicated ST process.

The HTS221 is available in a small top-holed cap land grid array (HLGA) package guaranteed to operate over a temperature range from -40 to +120 °C.

The sensor embeds an I²C peripheral, having slave address set to 0xBE.

The HTS221 is supplied by SENS_VDD power domain, connected to the VDD_BUCK domain (3.3 V output from ST1PS01) through one of the switches embedded in the STBC02 (STBC02_SW2_OB). This enables the low power strategies implemented in the firmware, by removing the power supply of the sensors when not used.

I²C bus (SENS_I2C_SCK_SWITCH and SENS_I2C_SDA_SWITCH) pins are connected to LoRa module PB8 and PB9 pins.

Figure 36. HTS221 schematic diagram
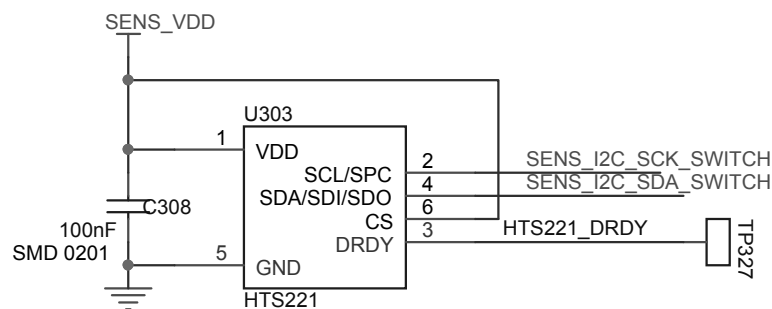
3.6.3 LPS22HB

The LPS22HB is an ultra-compact piezo resistive absolute pressure sensor which functions as a digital output barometer. The device comprises a sensing element and an IC interface which communicates through I²C or SPI from the sensing element to the application.

The sensing element, which detects absolute pressure, consists of a suspended membrane manufactured using a dedicated process developed by ST.

The LPS22HB is available in a full-mold, holed LGA package (HLGA). It is guaranteed to operate over a temperature range extending from -40 to +85 °C. The package is holed to allow external pressure to reach the sensing element.

Even for this last described sensor, data outputs are accessible through the I²C/SPI interface.

In the described application, the I²C is the preferred peripheral, thus the CS pin is tied to Vdd. The slave address associated for this device is set to 0xB8 (SA0 set to GND).

The LPS22HB is supplied by SENS_VDD power domain, connected to the VDD_BUCK domain (3.3 V output from ST1PS01) through one of the switches embedded in the STBC02 (STBC02_SW2_OB). This enables the low power strategies implemented in the firmware, by cutting the power supply of the sensors when not used.

The I²C bus (SENS_I2C_SCK_SWITCH and SENS_I2C_SDA_SWITCH), shared with HTS221, is connected to LoRa module PB8 and PB9 pins.

Figure 37. LPS22HB schematic diagram
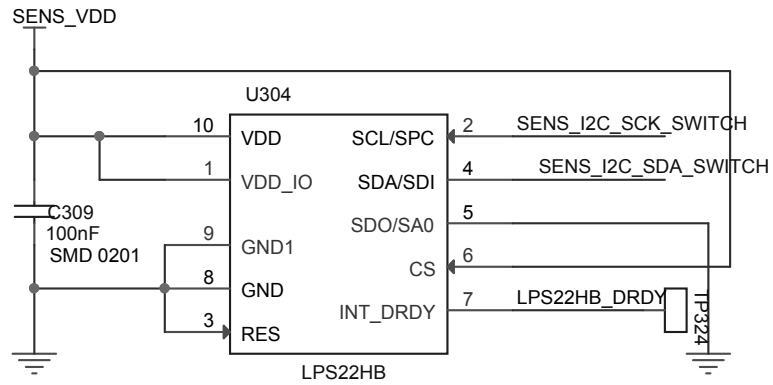
4 Schematic diagrams

Figure 38. STEVAL-STRKT01 circuit schematic (1 of 7)
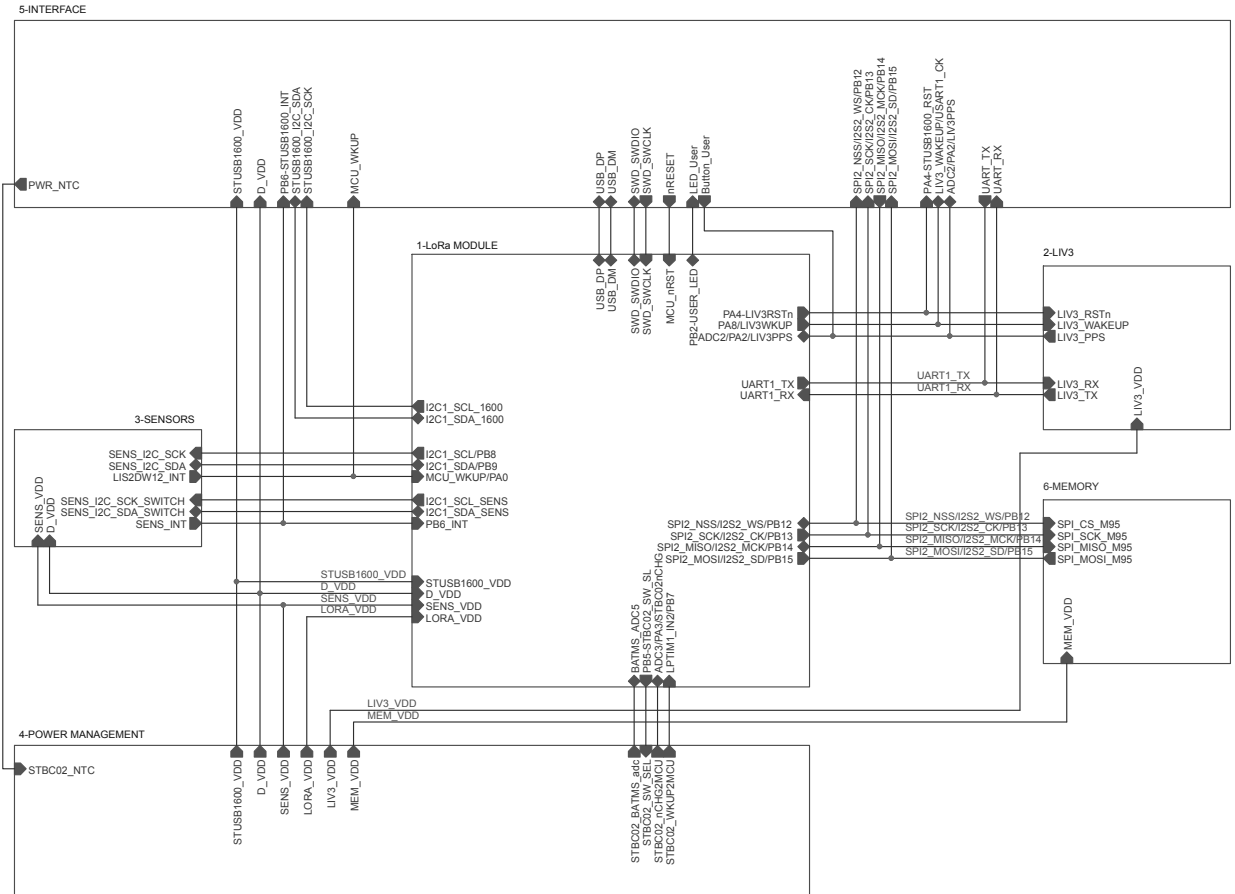
Figure 39. STEVAL-STRKT01 circuit schematic (2 of 7)
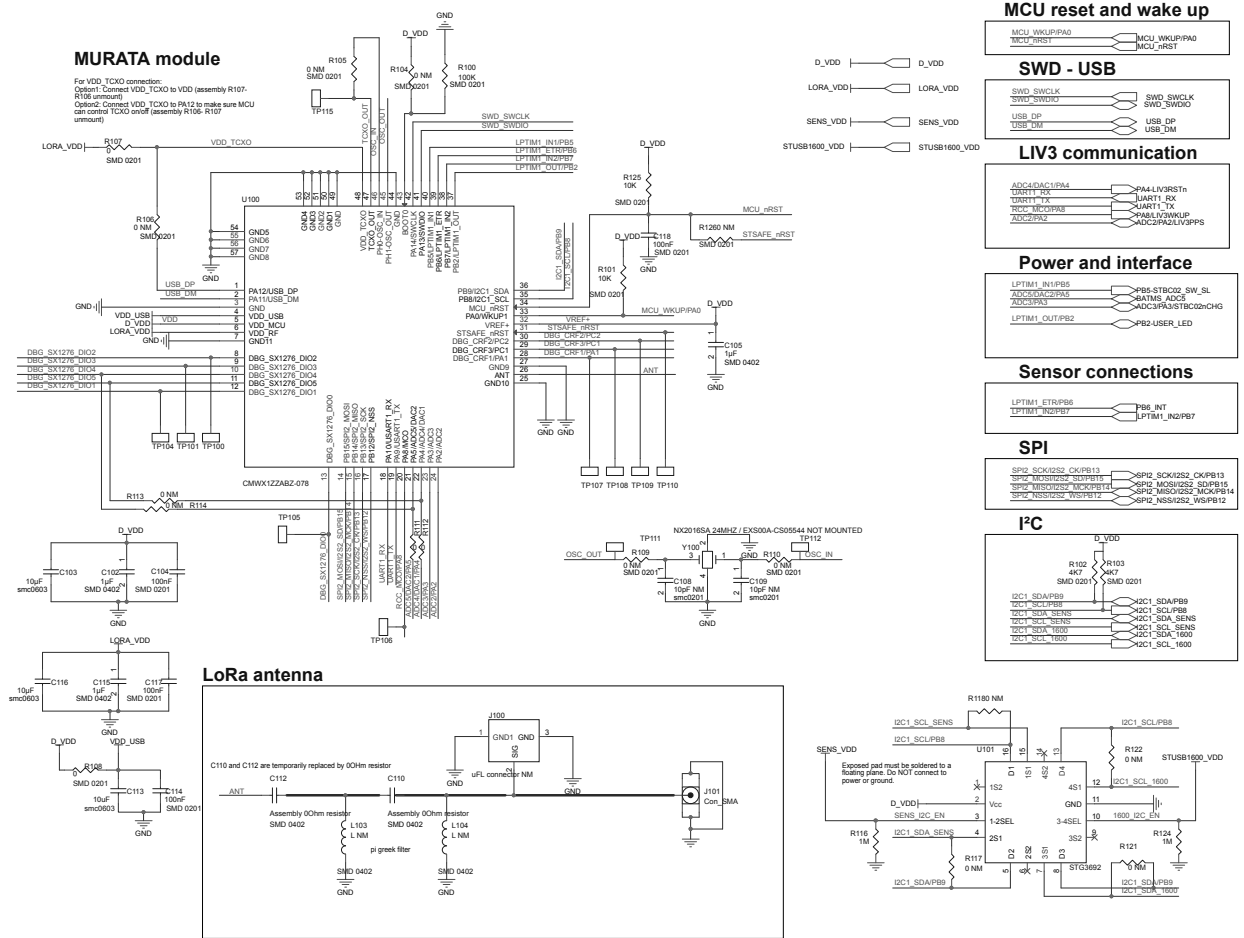
Figure 40. STEVAL-STRKT01 circuit schematic (3 of 7)
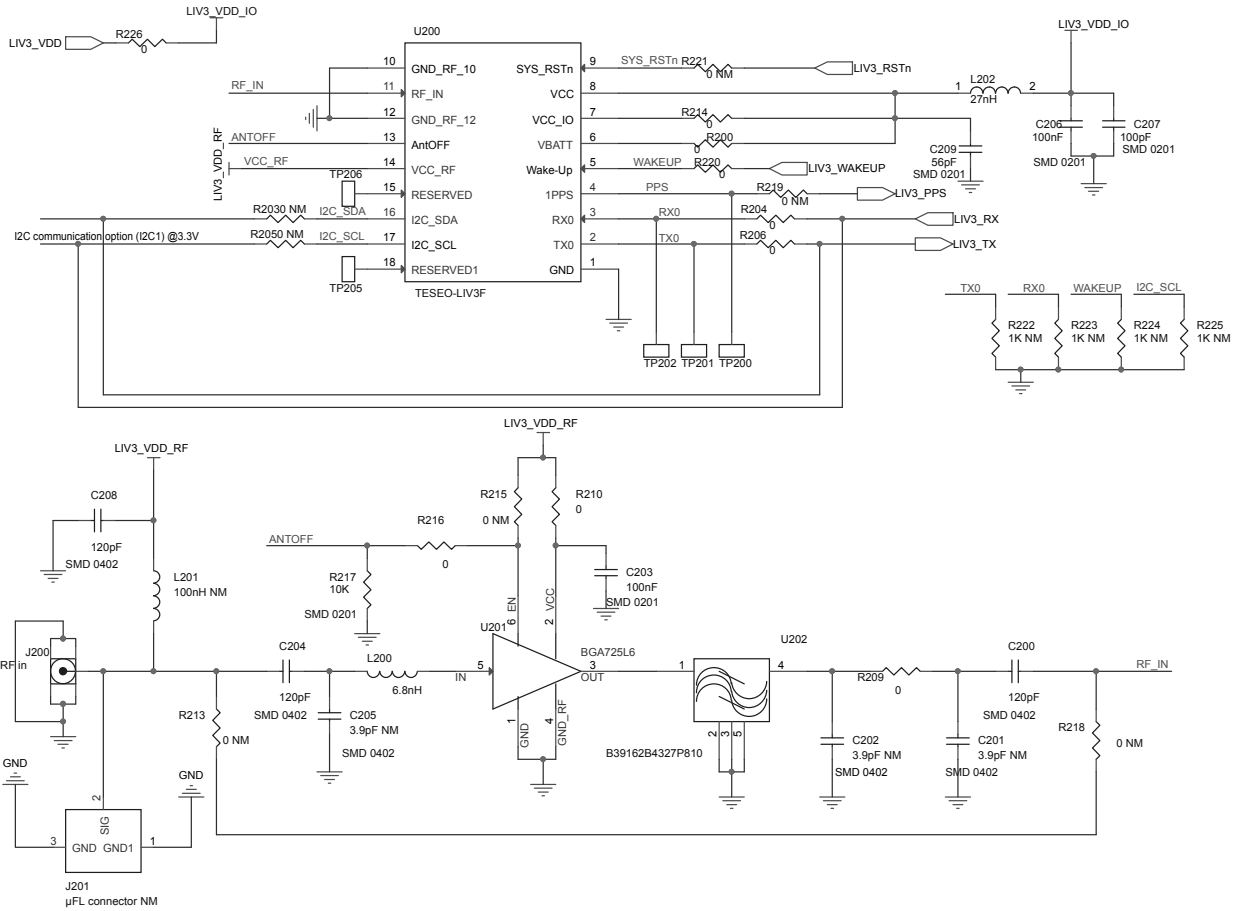
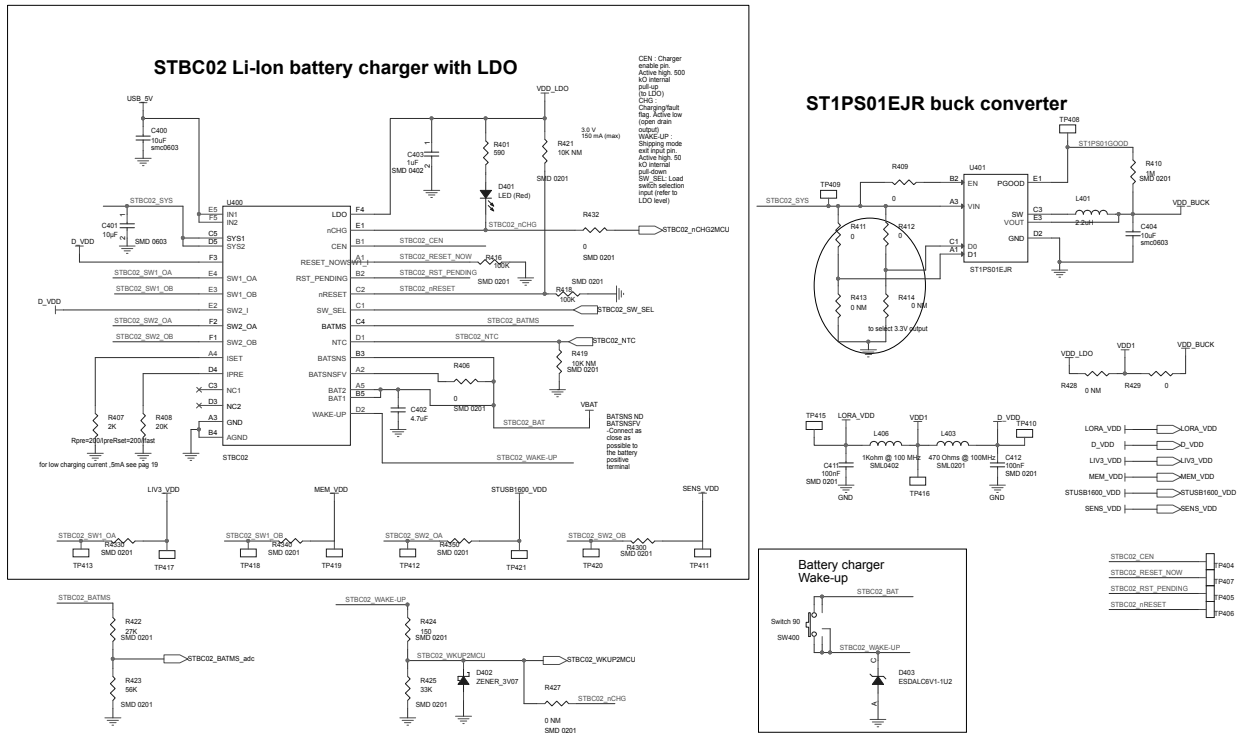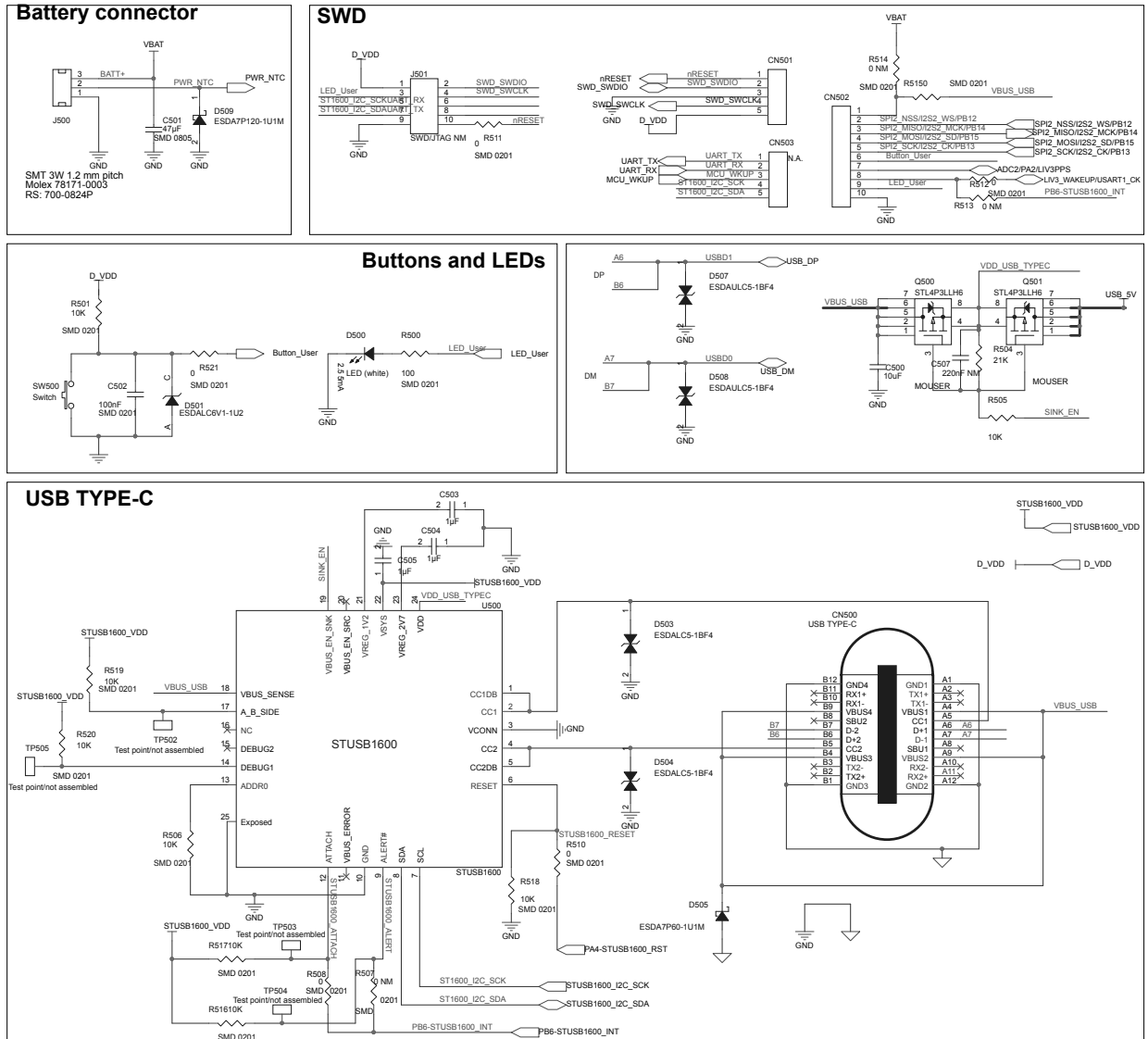**Figure 41. STEVAL-STRKT01 circuit schematic (4 of 7)**

3-axis accelerometer - LIS2DW12

I2C - address 0011000 - 0x30

Humidity and Temperature Sensor - HTS221

I2C - address 0xBE

Pressure Sensor - LPS22HB

I2C - address 0xB8
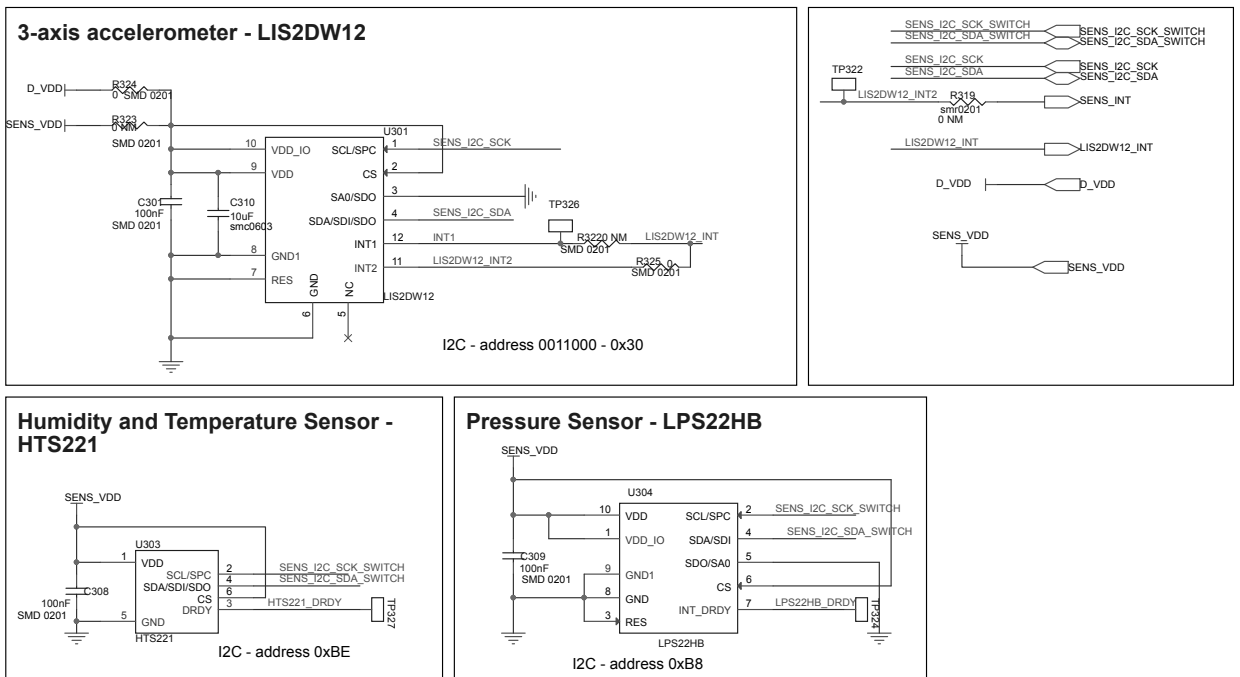
Figure 42. STEVAL-STRKT01 circuit schematic (5 of 7)

Figure 43. STEVAL-STRKT01 circuit schematic (6 of 7)

Figure 44. STEVAL-STRKT01 circuit schematic (7 of 7)
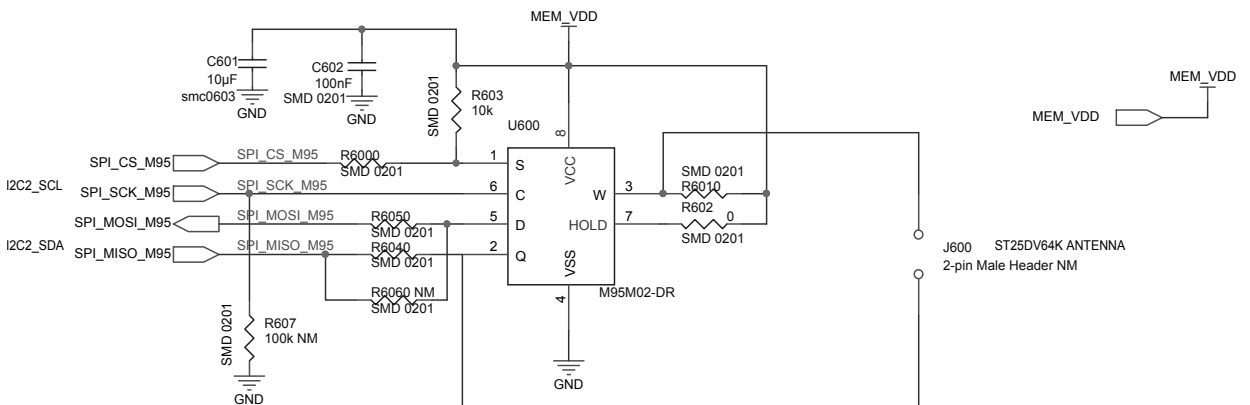
5 Bill of materials

Table 5. **STEVAL-STRKT01 bill of materials**

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
1	1	CN500		USB Type-C	Wurth Electronics	632723300011
2	1	CN501	5-pin 5x1 2.54 mm pitch	Female header	Sullins Connector Solutions	PPPC051LFBN-RC
3	1	CN502	10-pin 10x1 2.54 mm pitch	Female header (not mounted)	Sullins Connector Solutions	PPPC101LFBN-RC
4	1	CN503	5-pin 2.54 mm pitch	Female header (not mounted)	Sullins Connector Solutions	PPPC051LFBN-RC
5	7	C102, C105, C115, C403, C503, C504, C505	1 µF SMD 0402 6.3 V ±10%	Capacitors	Any	
6	7	C103, C113, C116, C310, C400, C404, C601	10 µF SMD 0603 6.3 V ±20%	Capacitors	Any	
7	13	C104, C114, C117, C118, C203, C206, C301, C308, C309, C411, C412, C502, C602	100 nF SMD 0201 16 V ±10%	Capacitors	Any	
8	2	C108, C109	10 pF SMD 0201 25 V ±0.5 pF	Not mounted	Any	
9	2	C110, C112	0 Ohm SMD 0402	Capacitors	Any	
10	3	C200, C204, C208	120 pF SMD 0402 50 V ±5% C0G, NP0	Capacitors	TDK	CGA2B2C0G1H121J050BA
11	3	C201, C202, C205	3.9 pF SMD 0402 6.3 V ±20%	Capacitors (not mounted)	Any	
12	1	C207	100 pF SMD 0201 16 V ±10%	Capacitor	Any	
13	1	C209	56 pF SMD 0201 16 V ±10%	Capacitor	Any	
14	1	C401	10 µF SMD 0603 10 V ±10%	Capacitor	Any	
15	1	C402	4.7 µF SMD 0402 6.3 V ±20%	Capacitor	Any	
16	1	C500	10 µF SMD 0603 35 V ±20%	Capacitor	Murata	GRM188R6YA106MA73D
17	1	C501	47 µF SMD 0805 10 V ±20%	Capacitor	Any	

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
18	1	C507	220 nF SMD 0603 50 V ±10%	Capacitor (not mounted)	Any	
19	1	D401	SMD 0402	Red LED	KingBright	KPHHS-1005SURCK
20	1	D402	ZENER_3V07 SOD323 0.02	Zener diode	Nexperia	BZX384-B3V0, 115
21	2	D403, D501	ESDALC6V1-1U2 0201 (0603 metric)	Single-line low capacitance Transil™ for ESD protection	ST	ESDALC6V1-1U2
22	1	D500	SMD 0402	White LED	VISHAY	VLMW1500-GS08
23	2	D503, D504	ESDALC5-1BF4 SMD 0201	Low clamping and low capacitance bidirectional single line ESD protection	ST	ESDALC5-1BF4
24	1	D505	ESDA7P60-1U1M 1610	High-power transient voltage suppressor (TVS)	ST	ESDA7P60-1U1M
25	2	D507, D508	ESDAULC5-1BF4 SMD 0201	Low clamping and ultra low capacitance bidirectional single line ESD protection	ST	ESDAULC5-1BF4
26	1	D509	ESDA7P120-1U1M QFN 1610	High-power transient voltage supressor (TVS)	ST	ESDA7P120-1U1M
27	2	J100, J201	50 Ohm 6 Ghz SMD	Coaxial connector (not mounted)	Hirose	U.FL-R-SMT-1(10)
28	1	J101	Con_SMA	CONN SMA RCPT STR 50OHM EDGE MNT	Amphenol RF Division	132414
29	1	J200	RF in	RF ANT 1.56/1.575GHZ CER PATCH	Taoglas Ltd.	CGGBP.18.4.A.02
30	1	J500	CON3 SMT 3W 1.2 mm pitch	Connector	Molex	78171-0003
31	1	J501	SWD/JTAG NM THR 1.27 mm 2x5	Not mounted	Samtec	FTSH-105-01-F-D-K
32	1	J600	2-pin strip line, 2 poles, 2.54 mm pitch	Male header (not mounted)	Any	
33	2	L103, L104	L NM SMD 0402 ±0.1 nH	Not mounted	Any	
34	1	L200	6.8 nH SMD 0402 ±0.2 nH		Murata	LQW15AN6N8G00D
35	1	L201	100 nH SMD 0402 ±5 nH	Not mounted	Murata	LQG15HNR10J02

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
36	1	L202	27 nH SMD 0402 0.05		Murata Electronics North America	LQG15HS27NJ02D
37	1	L401	2.2 µH SMD 1008 1.3 A 0.2		Wurth Electronics/ TDK	74438323022 / VLS252010HBX-2R2M
38	1	L403	470 Ohms @ 100MHz SMD 0201		Murata	BLM03BD471SN1D
39	1	L406	1 Kohm 100 MHz SMD 0402 250 mA 0.25		Wurth Electronics Inc / Murata	782422102/ BLM15HG102SN1D
40	2	Q500, Q501	STL4P3LLH6 PowerFlat (2x2)	P-Channel 30 V, 0.048 Ohm typ., 4 A STripFET H6 Power MOSFET in PowerFLAT(TM) 2x2 package	ST	STL4P3LLH6
41	3	R100, R416, R418	100K SMD 0201 ±1%	Film resistors	Any	
42	12	R101, R125, R217, R501, R505, R506, R516, R517, R518, R519, R520, R603	10k SMD 0201 ±1%	Film resistors	Any	
43	2	R102, R103	4K7 SMD 0201 ±1%	Film resistors	Any	
44	28	R104, R105, R106, R109, R110, R113, R114, R117, R118, R121, R122, R126, R203, R205, R215, R219, R221, R319, R322, R323, R413, R414, R427, R428, R507, R513, R514, R606	0 NM SMD 0201 ±1%	Film resistors (not mounted)	Any	
45	35	R107, R108, R111, R112, R200, R204, R206, R210, R214, R216, R220, R226, R324, R325, R406, R409, R411, R412, R429, R430, R432, R433, R434, R435, R508, R510, R511, R512, R515, R521, R600, R601, R602, R604, R605	0 SMD 0201 ±1%	Film resistors	Any	

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
46	3	R116, R124, R410	1M SMD 0201 ±1%	Film resistors	Any	
47	1	R209	0 SMD 0402 ±1%	Film resistor	Any	
48	2	R213, R218	0 NM SMD 0402 ±1%	Film resistors (not mounted)	Any	
49	4	R222, R223, R224, R225	1K NM SMD 0201 ±1%	Film resistors (not mounted)	Any	
50	1	R401	590 SMD 0201 ±1%	Film resistor	Any	
51	1	R407	2K SMD 0201 ±1%	Film resistor	Any	
52	1	R408	20K SMD 0201 ±1%	Film resistor	Any	
53	2	R419, R421	10K NM SMD 0201 ±1%	Film resistors (not mounted)	Any	
54	1	R422	27K SMD 0201 ±1%	Film resistor	Any	
55	1	R423	56K SMD 0201 ±1%	Film resistor	Any	
56	1	R424	150 SMD 0201 ±1%	Film resistor	Any	
57	1	R425	33K SMD 0201 ±1%	Film resistor	Any	
58	1	R500	100 SMD 0201 ±1%	Film resistor	Any	
59	1	R504	21K SMD 0201 ±1%	Film resistor	Any	
60	1	R607	100k NM SMD 0201 ±1%	Film resistor (not mounted)	Any	
61	1	SW400	SMD4, 7x3, 5 mm	Switch	C&K Components	KMS233GLFG
62	1	SW500	FSM5M	Switch	TE Connectivity	1437566-3
63	42	TP100, TP101, TP104, TP105, TP106, TP107, TP108, TP109, TP110, TP111, TP112, TP115, TP200, TP201, TP202, TP205, TP206, TP322, TP324, TP326, TP327, TP404, TP405, TP406, TP407, TP408, TP409, TP410, TP411, TP412, TP413, TP415, TP416, TP417, TP418, TP419, TP420, TP421, TP502, TP503, TP504, TP505		Test points (not mounted)	Any	

Item	Q.ty	Ref.	Part/Value	Description	Manufacturer	Order code
64	1	U100	CMWX1ZZABZ-078 LoRA42X125X116X017	LoRa module	Murata	CMWX1ZZABZ-078
65	1	U101	STG3692 QFN16L (2.6mm x 1.8mm)	Low voltage quad SPDT switch	ST	STG3692QTR
66	1	U200	TESEO-LIV3F LCC 18 pin package (9.7x10.1)	Tiny GNSS module	ST	TESEO-LIV3F
67	1	U201	BGA725L6 TSLP-6-2	Low Noise Amplifier for GPS, GLONASS, Galileo and COMPASS	Infineon	BGA725L6
68	1	U202	B39162B4327P810 QCS5P 1.4 x1.1 x 0.4 mm	Automotive SAW RF filter for GPS, COMPASS and GLONASS	EPCOS	B39162B4327P810
69	1	U301	LIS2DW12 LGA-12	MEMS digital output motion sensor	ST	LIS2DW12
70	1	U303	HTS221 HLGA-6L (2 x 2 x 0.9 mm)	Humidity and temperature sensor	ST	HTS221TR
71	1	U304	LPS22HB HLGA-10L	MEMS nano pressure sensor	ST	LPS22HBTR
72	1	U400	STBC02 Flipchip30 (2.25 x 2.59 x 0.57 mm) 400um pitch	Li-Ion battery charger with LDO	ST	STBC02JR
73	1	U401	ST1PS01EJR Flip-chip8 1.11x1.41mm	400 mA synchronous step-down converter	ST	ST1PS01EJR
74	1	U500	STUSB1600 QFN24 EP 4x4 mm	USB Type-C controller	ST	STUSB1600AQTR
75	1	U600	M95M02-DR SO8	2-Mbit serial SPI bus EEPROM	ST	M95M02-DRMN6TP
76	1	Y100	NX2016SA 24 MHZ / EXS00A-CS05544 SMD	Crystal (not mounted)	NDK	NX2016SA 24MHZ / EXS00A-CS05544

Revision history

Table 6. Document revision history

Date	Version	Changes
15-Feb-2019	1	Initial release.
09-Dec-2019	2	Updated Table 1. STEVAL-STRKT01 command list and Section 3.4.3 SWD and expansion connectors. Added Section 3.4.4 Update via ST-LINK/V2 in-circuit debugger/programmer, Section 3.4.5 Update via ST-LINK/V3 in-circuit debugger/programmer and Section 3.4.6 Update via STM32 Nucleo-64 on-board ST-LINK programmer.

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