UM3034

User manual

Getting started with the STEVAL-SMARTAG2 NFC dynamic tag sensor and processing node evaluation board

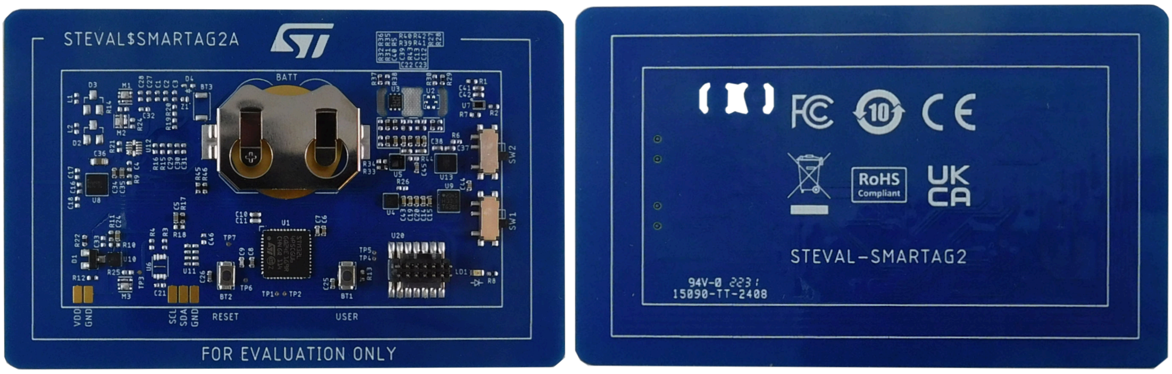
Introduction

The STEVAL-SMARTAG2 is an NFC-enabled sensor node, which embeds inertial MEMS sensors and environmental sensors, an STM32 microcontroller, and a dynamic NFC tag for communication with NFC readers, such as tablets and smartphones.

The STEVAL-SMARTAG2 can optionally be equipped with a battery charger fed through a full-wave rectifier for NFC energy harvesting (to be put on top of the energy harvester already embedded in the dynamic NFC tag) and a real-time clock (RTC) with an embedded crystal oscillator to enable an accurate timekeeping and time stamping.

The board has a small and thin form factor, comparable to the size of a credit card. This makes it particularly fit for deployment in the field and data collection.

Figure 1. STEVAL-SMARTAG2 evaluation board (top and bottom views)



1 Getting started

1.1 Safety operating use and conditions

Any use of this device not specified by the manufacturer might compromise the protection mechanisms that come with the device.

- All components, with few exceptions, have an operating temperature range from -40 to +85°C. Some components, such as the STM32L4P5CG microcontroller and the ST25DV64KC NFC EEPROM, have options with an operating range up to +125°C (but the RF interface only works up to +105°C).
- Operating ambient pressure ranges from 260 to 1260 hPa. All sensors might be sensitive to extreme changes in the ambient pressure.
- Operating ambient relative humidity ranges from 0 to 100%. The board is not protected against water condensation. A suitable water-resistant coating should be applied to the board and its components. Any difference in the thermal expansion coefficient creates a mechanical stress between the PCB and the plastic package of the components. This might affect all on-board sensors. When a coating is applied, the venting hole in the package of LPS22DF should be covered to avoid contaminating the sensing element.

Note: The battery limits the temperature, humidity, and ambient pressure operating range. Depending on their chemistry, typical batteries have a very limited or no functionality at or below 0°C. Moreover, rechargeable batteries cannot operate above +45°C. Select a suitable energy source for the operation at low and high temperatures, ambient pressure, or relative humidity.

Operating conditions for normal operation

- Temperature between -40 and +85°C. Take care to ensure the battery performance below 0°C and above 45°C.
- Ambient pressure between 260 and 1260 hPa. Extreme values or fast variations might cause mechanical stress in the sensor packages and affect measurement accuracy.
- Relative humidity between 0 and 100%. The board is not protected against condensation of water.
- FCC part 15 subpart C verification conditions: indoor environment, temperature up to 45°C, humidity range between 20% and 80%.

ST25DVKC NFC EEPROM

- Operating conditions: temperature -40 to +85°C, other packages, and device grades are available.
- Absolute maximum ratings: voltage -0.5 to 6.5V, 11V between RF input pins and -0.5 to 5.5V between RF and supply pin, storage temperature -65 to 150°C.

Note: When the harvesting is active, the RF communication is not guaranteed. The harvesting output is not used if the battery is present and if it has a higher voltage due to the diode-or configuration. A mismatch in the form factors of NFC antennas might reduce the harvester output and compromise the RF communication. For further information, refer to AN4913.

STM32L4P5CG MCU

- Operating conditions: temperature -40 to +85°C, maximum junction temperature 105°C. Other packages and device grades are available.
- Absolute maximum ratings: voltage -0.3 to 4 V, -0.3 to 1.4 V for the external SMPS pin, storage temperature -65 to 150°C, maximum junction temperature +150°C.

Inertial sensors

- LSM6DSO32X
  - Operating conditions: temperature -40 to +85°C, acceleration up to 32 g, angular velocity up to 2000 dps.
  - Absolute maximum ratings: voltage -0.3 to 4.8 V, storage temperature -40 to +125°C, acceleration 20’000 g for 0.2 ms.

- LIS2DUXS12
  - Operating conditions: temperature -40 to +85°C, acceleration up to 16 g.
  - Absolute maximum ratings: voltage -0.3 to 4.3 V, storage temperature -40 to +125°C, acceleration 10'000 g for 0.2 ms, 3000 g for 0.5 ms.
- H3LIS331DL
  - Operating conditions: temperature -40 to +85°C, acceleration up to 400 g.
  - Absolute maximum ratings: voltage -0.3 to 4.8 V, storage temperature -40 to +125°C, acceleration 10'000 g for 0.2 ms, 3000 g for 0.5 ms.

Ambient/environmental sensors

- LPS22DF
  - Operating conditions: temperature -40 to +85°C, ambient pressure 260 to 1260 hPa.
  - Absolute maximum ratings: voltage -0.3 to 4.8 V, storage temperature -40 to +125°C, ambient overpressure 2 MPa.
- STTS22H
  - Operating conditions: contact temperature -40 to +125°C.
  - Absolute maximum ratings: voltage -0.3 to 4.8 V, storage temperature -40 to +125°C.
- VD6283TX
  - Operating conditions: temperature -30 to +85°C.
  - Absolute maximum ratings: voltage -0.5 to 2.5 V, storage temperature -40 to +125°C.

STLQ020 voltage regulator

- Operating conditions: temperature -40 to +125°C, input voltage 2 to 5.5 V, short circuit current 380 mA.
- Absolute maximum ratings: voltage -0.3 to 7 V, storage temperature -55 to +150°C, maximum junction temperature 150°C.

STSAFE-A110 secure element

- Operating conditions: temperature -40 to +105°C
- Absolute maximum ratings: voltage -0.3 to 7 V, storage temperature -65 to 150°C.

M41T62LC real-time clock with embedded crystal (optional)

- Operating conditions: temperature -40 to +85°C.
- Absolute maximum ratings: voltage -0.3 to 5 V, storage temperature during soldering -55 to +125°C.

STBC15 battery charger (optional)

- Operating conditions: temperature -40 to +85°C, input voltage up to 6.5 V.
- Absolute maximum ratings: voltage -0.3 to 7 V, -0.3 to 5.5 V on battery and system output pin, storage temperature -65 to +150°C, maximum junction temperature +125°C.

CR2032 or LIR2032 coin cell battery

The battery is not included in the board package. Several device grades are available. Refer to the manufacturer datasheet.

Note: *A typical CR2032 lithium/manganese-dioxide battery has a 220 mAh nominal capacity and 3 V open-circuit voltage at room temperature. At -20°C, the open-circuit voltage is reduced from 3 V down to 2.2-2.7 V for 1 k-100 kΩ loads. The capacity is reduced from 220 mAh to 45-175 mAh for 1 k-100 kΩ loads. The inability of the battery to sustain peak currents at low temperatures might prevent the correct system operation.*

1.2 Overview

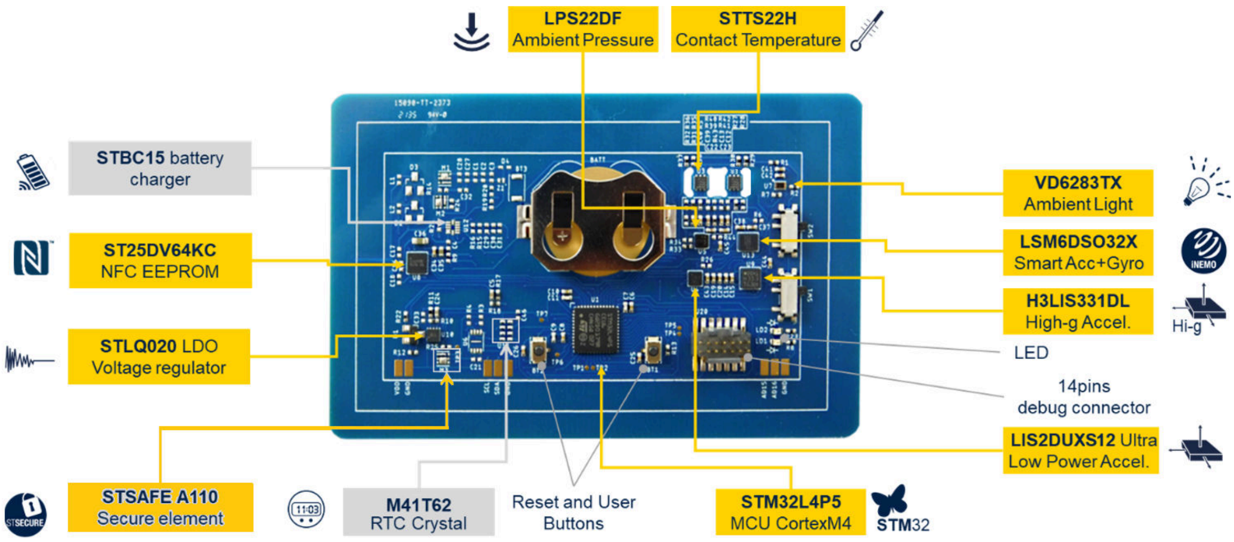


Figure 2. **STEVAL-SMARTAG2 components**

Note: Components highlighted in yellow are populated at the factory. Components highlighted in gray are optional.

STEVAL-SMARTAG2 components

- ST25DV64KC-JF6D3 dynamic NFC/RFID tag with a 64-Kbit EEPROM, fast transfer mode capability, and an operating band of 13.56 MHz (HF). It is a two-wire I²C serial interface (up to 1 MHz), with a contactless interface based on the ISO/IEC 15693 (all modulations, coding, sub-carrier modes, and data rates). It is NFC Forum Type 5 tag-certified, with fast read access (up to 53 Kbit/s), single and multiple blocks, read and write. The RF interface can be enabled/disabled from the I²C host controller. The EEPROM data retention is 40 years. The write cycle endurance is 1 M million at 25 degrees. It features fast data transfer mode between the I²C and the RF interface, half-duplex 256-byte dedicated buffer. The user memory areas (1-4) can be protected for read and/or write with three 64-bit passwords in RF and one 64-bit password in I²C. An NFC energy harvester is embedded.
  – The fast data transfer mode with dedicated buffer can be used to transfer a new binary program to the host microcontroller.
  – The energy harvester is connected in diode-OR with the battery output (or the battery charger when it is present) to power the whole system.
- STM32L4P5CGU6 microcontroller ultra-low power (110 µA/MHz in LDO mode), which belongs to the STM32L4+ series, based on the ARM Cortex-M4F 32-bit RISC core. Its operating frequency is up to 120 MHz, with a single-precision floating-point unit (FPU), support for digital signal processing (DSP) instructions, and memory protection unit (MPU). The device embeds 1 Mbyte of flash memory and 340 Kbytes of SRAM, with several protection mechanism (readout and write protection, proprietary code readout protection, and firewall).
  – Two contact pads on the board are connected to specific microcontroller pins to support the anti-tamper function.

Note: This function is available only when the the M41T62 is not populated, and the serial I²C2 bus peripheral is not needed.

- Inertial sensors:
  - LSM6DSO32X inertial module (iNEMO) with 6DoF (degrees of freedom): three-axis accelerometer (4, 8, 16, 32 g full-scale) and three-axis gyroscope (125, 250, 500, 1000, 2000 dps full scale). The peak power consumption is 0.55 mA for the accelerometer and gyroscope in the high-performance mode at 6.6 kHz output data rate (ODR) and can be reduced down to 4.4 µA for the accelerometer only in the ultra-low power mode at 1.6 Hz ODR. The sensor embeds a 3 kB FIFO and supports lossless compression (up to 3:1 compression ratio). The auxiliary SPI interface acts as a sensor hub. The sensor embeds a pedometer, a step detector, and a step counter. It can detect motion and tilt. It also features the interrupt generation logic for free fall, inertial wakeup, 6D/4D orientation detection, single and double tap detection. It embeds a dedicated core for the machine learning core (MLC) and the finite state machine (FSM).
    - The board can be configured to route the data from the environmental sensors (not the ambient light sensor) to the LSM6DSO32X that acts as a sensor hub. Data from the external sensors can be stored in the FIFO and processed by the FSM and MLC.
    - The FSM can be programmed to detect the sequence of events with a specific timing.
    - The MLC can be programmed to extract features from the data and run multiple decision trees. Therefore, it enables the detection of specific events according to their fingerprint.
    - Algorithms can be moved from the host microcontroller to this sensor with the advantage of a consistent reduction in power consumption.
  - LIS2DUXS12 ultra-low power three-axis accelerometer (2, 4, 8, 16 g full scale). It features an analog anti-alias filter available in the normal mode. Power consumption can be reduced to 0.2 µA in one-shot mode. ODR is from 1.6 to 800 Hz. It embeds FIFO for 512 samples of accelerometer and temperature data at a high resolution, or 768 samples of accelerometer data at a low resolution. It also features interrupt logic for free fall, inertial wakeup, 6D/4D orientation, single and double tap, activity/inactivity detection. A dedicated core for MLC and FSM is also embedded.
    - For further details on the MLC and FSM functionality see the previous paragraph.
  - H3LIS331DL low-power high-g three-axis accelerometer (100, 200, 400 g full scale). The output data rates from 0.5 to 1 kHz. It features ultra low-power mode (10 µA) and the automatic sleep-to-wakeup function, as well as configurable interrupt detection logic.
    - Every axis can be enabled independently. It can be compared to a threshold in the positive or negative direction. The comparison output can be combined with the AND or OR functions. The interrupt is triggered if the programmed minimum duration is exceeded.
  - A manually operated slider switch controls the energy source for all inertial sensors: VDD_ACC_MCU, a GPIO for 0-power stand-by mode, or VDD, the main supply line, for always-on mode.

Note: *When the microcontroller supplies power to other system components, observe the specific power-up and power-down sequences. Incorrect sequences can allow the power to flow from the communication bus through the protection diodes to the components, compromising their operation.*

- Ambient and environmental sensors:
  - LPS22DF low-power high-precision ambient pressure sensor. It features a 260-1260 hPa absolute pressure range, absolute pressure accuracy of 0.5 hPa, relative accuracy of 0.015 hPa, current consumption down to 1.7 µA at 1 Hz, output data rate from 1 Hz to 200 Hz. It also features an embedded FIFO and interrupt generation logic. The embedded temperature sensor is in the range of -40 to +85°C, with an absolute accuracy of 1.5°C.

Note: This sensor is designed to compensate for temperature effects in ambient pressure measurements.

  - STTS22H ultra low-power contact temperature sensor. The output data rate is 1 to 200 Hz. The power consumption is down to 1.75 µA in one-shot mode. The temperature range is from -40 to +125°C, with anc accuracy of 0.5°C from 10 to 60°C. The sensor also features the interrupt generation logic.
  - VD6283TX hybrid filter multispectral ambient light sensor (ALS) with flicker detection. ALS operation with six independent channels: red, green, blue, infrared (IR), clear, and visible (weighted by the human eye lux sensitivity) to support corrected color temperature (CCT) computation and lux measurement. The light flicker extraction is from 100 Hz to 2 kHz, sine or square wave flicker. It can run concurrently with ALS operation.
  - A manually operated slider switch controls the energy source for all ambient and environmental sensors: VDD_AMB_MCU, a GPIO for 0-power stand-by mode, or VDD, the main supply line, for always-on mode.

Note: When the microcontroller supplies power to other components in the system, observe the specific power-up and power-down sequences. Incorrect sequences can allow power to flow from the communication bus through the protection diodes to the components, compromising their operation.

- STLQ020 ultra-low quiescent current low-dropout (LDO) voltage regulator. The output current is up to 200 mA. The quiescent current is down to 300 nA with no load and 100 µA with a 200 mA load. The dropout is 160 mV at 200 mA.
- Battery holder for CR2032 (non-rechargeable) or LIR2032 (rechargeable) batteries.
- User interface components
  - Reset button
  - User button
  - LED (red)
- Flash/debug 14-pin connector to be used with an ST-LINK in-circuit debugger/programmer.
- STSAFE-A110 secure element that supports the authentication and state-of-the-art cryptographic security. It features the signature verification service to support secure boot and firmware upgrade of the host microcontroller. It embeds usage monitors with secure counters. It also features pairing and secure channel with the host microcontroller, symmetric data encryption and decryption (up to 16 keys), on-chip key pair generation, advanced asymmetric cryptography (elliptic curve, NIS, or Brainpool 256-bit and 384-bit), elliptic curve digital signature generation and validation with SHA-256 and SHA-384, protection against faults and side-channel attacks, logical and physical attacks.

Note: As the STSAFE-A110 is mounted on the board, the anti-tamper function of the STM32 cannot be used as the pins are shared with the I²C bus interface used by STSAFE-A110.

STEVAL-SMARTAG2 optional components

- STL4P3LLH6 P-channel MOS could be mounted with the secure element STSAFE-A110 to gate the power to the secure element and enable 0-power standby.
  It is driven by the MCU and it is off by default.
- LSM6DSO32X configured as a sensor hub: the I²C bus interface of each environmental sensors (excluding the ambient light sensor) can be re-routed to the LSM6DSO32X, which is equipped with an auxiliary I²C bus interface. It can collect data from internal and external sensors in its 3 kB FIFO, which can store up to 9 kB worth of data, if the embedded lossless compression is enabled.

Note: When environmental sensors are routed to LSM6DSO32X, their power supply must be reconfigured to come from the same source (VDD_ACC).

- STBC15 ultra-low current consumption linear battery charger. It is bases on a constant current and constant voltage (CC/CV) charging algorithm. It embeds overdischarge and overcurrent protections to protect the battery. The device can be put in shelf-mode, consuming only 10 nA and not discharging the battery before the activation. The power consumption is of only 250 nA when the power source is removed. It is 10 nA if the overdischarge protection is triggered.

Note: The battery charger can be used only with rechargeable batteries (LIR2032). By default, it is bypassed.

  - The battery charger is fed by a full-wave rectifier for NFC energy harvesting. The following components are also needed with the battery charger:
    - Optional inductors to regulate the harvesting and keep the tuning of the NFC antenna
    - BAT54SFILM: four diodes in a full-wave rectifier configuration
    - STL4P3LLH6 P-channel MOS to gate the full-wave rectifier. It is driven by an N-channel MOS and it is off by default
    - STL6N3LLH6 N-channel MOS to drive the P-channel MOS. It is driven by the MCU
    - Capacitor bank to store the harvested energy
    - Zener protection diode to clip and protect from overvoltage
    - Exit shelf-mode button needed to deactivate the shelf mode

Note: The full-wave rectifier might need to be gated and disabled to improve the NFC communication. For the same reason, you should limit the charging current from the battery charger.

- M41T62 real-time clock with the embedded crystal oscillator to support accurate time keeping. It can be adjusted within ±2 parts per million (±5 seconds per month).

Note: If the M41T62LC is mounted on the board, the anti-tamper function of the STM32 cannot be used as the pins are shared with the I²C bus interface used by M41T62LC.

Additional devices can be connected on the same I²C bus interface of the M41T62. The anti-tamper function of the STM32 cannot be used as the pins are the same.

Some components have a footprint and pinout chosen to enable the substitution with other pin-to-pin compatible components:

- Microcontroller in UFQFPN48 pin package: the STM32L4+ Cortex-M4F microcontroller (STM32L4P5CGU6) can be swapped with a pin-to-pin compatible STM32L0 Cortex-M0 (STM32L071CZU6) to optimize cost and power consumption.
- iNEMO inertial modules in LGA-14L package: the LSM6DSO32X inertial module can be replaced with the following components:
  - LSM6DSR accelerometer and gyroscope with enhanced temperature stability; 2, 4, 8, 16 g accelerometer full scale; 125, 250, 500, 1000, 2000, 4000 dps gyroscope full scale. The output data rate is from 1.6 Hz to 6.6 kHz. The peak power consumption is of 1.2 mA in the high-performance mode at a 6.6 kHz data rate.
  - LSM6DSRX has the same features of the LSM6DSR but it is also equipped with an MLC and FSM core.
  - LSM6DSV16X accelerometer and gyroscope with triple processing chain; 2, 4, 8, 16 g accelerometer full-scale, 16 g for the secondary channel; 125, 250, 500, 1000, 2000, 4000 dps gyroscope full-scale. The output data rate is from 1.875 Hz to 7.68 kHz. It features an enhanced MLC and FSM core. The FSM core can also reconfigure the sensor.
- Inertial sensors in LGA-12 package: the LIS2DUXS12 accelerometer can be replaced with the following components:
  - LIS2DW12 low-power digital smart accelerometer: 2, 4, 8, 16 g full scale; 1.6 Hz to 1.6 kHz output data rate, 32 level FIFO, five different power modes (one high-performance low-noise, and four low-power modes to trade-off noise and power)
  - LSM303AH enhanced digital smart accelerometer and magnetometer
  - LSM303AGR digital smart accelerometer and magnetometer
  - LIS2DS12 digital three-axis accelerometer. It features an analog anti-alias filter, 2, 4, 8, 16 g full scale, and an output data rate from 1 to 6.4 kHz
  - LIS2DH12 cost effective digital three-axis accelerometer, with 2, 4, 8, 16 g full scale and an output data rate from 1 Hz to 5.3 kHz

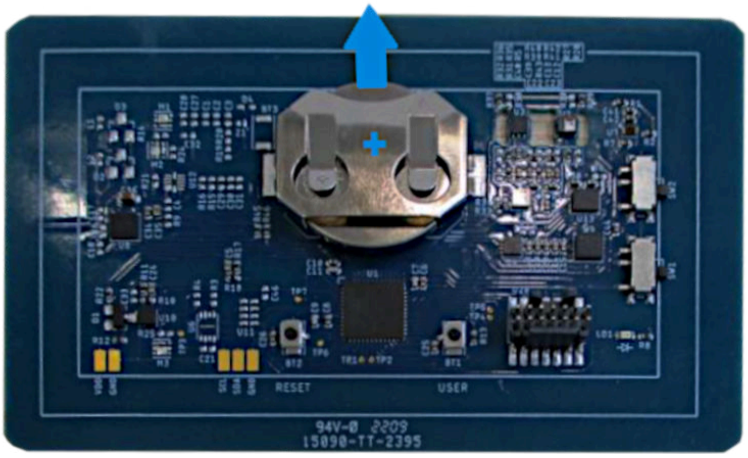
1.3 RF specifications for the ST25DV64KC

- RF power: not applicable, as the NFC tag is an RF receiver not an RF transmitter
- Operating band: the NFC tag receives at an operating band of 13.56 MHz
- Channel spacing: the tag receives on a unique channel

1.4 Battery insertion/removal

Insert/remove the battery as shown below.

Figure 3. STEVAL-SMARTAG2 - battery insertion/removal



Important: *To make the board operate correctly, ensure that the battery is inserted with the positive pole up.*

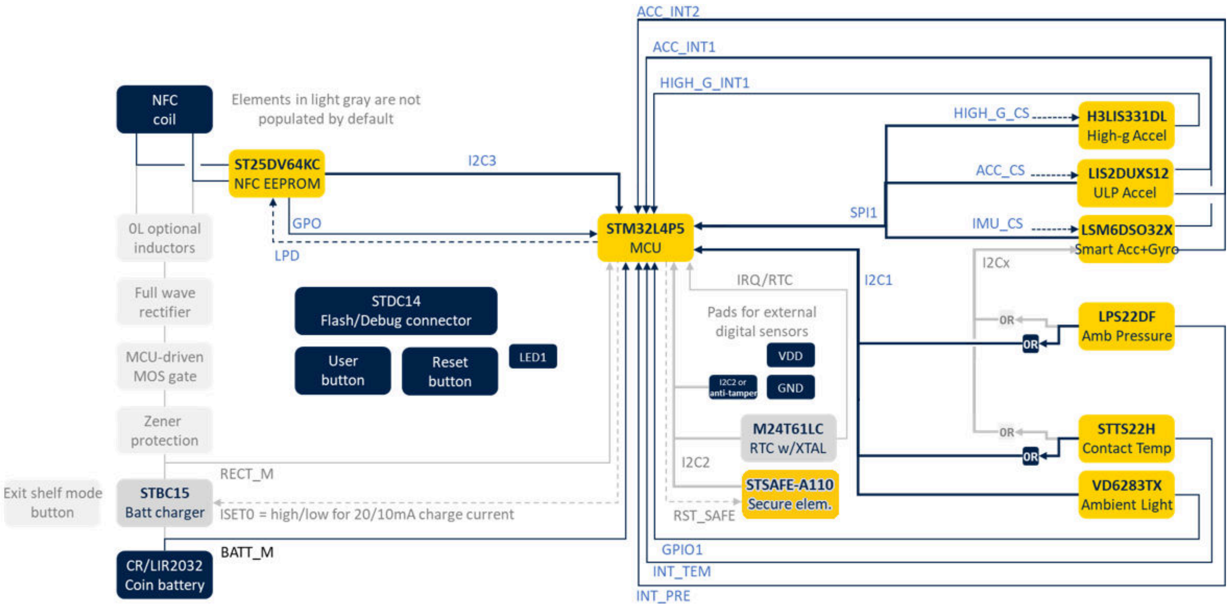
2 System architecture

The microcontroller is the system hub. It communicates with and controls every component in the system.

ST25DV64KC NFC/EEPROM has a dedicated I²C bus interface (I2C3). The following pins are also connected:

- GPO general purpose output, which can be configured to signal RF events to the host microcontroller (field change, memory write, RF activity, fast transfer end, user set/reset/pulse). This is useful to avoid conflicts in the communication protocols when the dynamic tag is accessed simultaneously via RF and via I²C (the microcontroller can wait for no RF activity before accessing the EEPROM).
- low-power down (LPD), set by the microcontroller when the ST25DV64KC must be put in standby in its lowest power mode (typical 0.84 µA, maximum 1.5 µA).

Figure 4. STEVAL-SMARTAG2 architecture and communication paths



Components highlighted in yellow are populated at the factory. Components highlighted in gray are optional.

Inertial sensors have a dedicated SPI bus interface (SPI1). This SPI supports a faster communication speed (up to 10 Mbps) with respect to the I²C. Inertial sensors can generate data at a high output data rate (up to 6.6k samples per second) and require a fast interface. The following pins are also connected:

- HIGH_G_CS, ACC_CS, and IMU_CS chip select: needed by the SPI interface respectively to select the high-g accelerometer H3LIS331DL, the low-power accelerometer LIS2DUXS12, or the smart IMU LSM6DSO32X
- HIGH_G_INT1, ACC_INT1, and ACC_INT2 interrupt line from the H3LIS331DL high-g accelerometer, and two interrupt lines from both LIS2DUXS12 and LSM6DSO32X in the wired-OR configuration.

Note: *HIGH_G_INT1 (PA2) and USER (PB2) are mutually exclusive and cannot be used at the same time with the EXTI peripheral (external interrupt handler on the MCU).*
ACC_INT1 (PA0) e ACC_INT2 (PB0) are mutually exclusive and cannot be used at the same time with the EXTI peripheral (external interrupt handler on the MCU).

Note: *When the microcontroller supplies power to other components in the system, follow specific sequences to enable/disable the SPI interface and use the CS chip select. Incorrect sequences can allow power to flow from the communication bus to the components, through the protection diodes, compromising their operation.*

Ambient and environmental sensors have a dedicated I²C bus interface (I2C1). Optionally, each environmental sensor (except the ambient light sensor) can be rerouted to the LSM6DSO32X, which is the sensor hub. The following pins are also connected:

- GPIO1, INT_TEM, and INT_PRE interrupt lines respectively from VD6283TX ambient light sensor, STTS22H contact temperature sensor, and LPS22DF ambient pressure sensor.

Note: When the microcontroller supplies power to other components in the system, follow specific sequences to enable/disable the SPI interface and use the CS chip select. Incorrect sequences can allow power to flow from the communication bus to the components, through the protection diodes, compromising their operation.

Connections of STSAFE-A110 secure element:

- The VDD_SAF_CTRL line is the power supply provided by the microcontroller GPIO. It can be switched to 0 to obtain 0-power standby for the secure element
- RST_SAFE line to the STSAFE-A110 to keep it under reset and reduce power consumption. The power can be completely gated to achieve 0-power standby by controlling the dedicated microcontroller GPIO VDD_SAF_CTRL

Optional components (M41T62 RTC) have a dedicated I²C bus interface (I2C2). The following pins are also connected:

- IRQ/RTC interrupt line from the M41T62 RTC

The optional battery charger (STBC15) is controlled by dedicated lines:

- RECT_M to monitor the harvested energy available at the input of the charger
- ISET0 to control the battery charging current (20 mA or 10 mA)

Note: The charging current from the battery charger might need to be limited to improve the NFC communication. For the same reason, it might be useful to gate and disable the full-wave rectifier.

A dedicated line, BATT_M, allows the application to monitor the voltage level of the battery, when it is present.

2.1 RF communication performance

For a reliable communication, RF antennas should be close to each other and similar in shape and size. When the form factors of communicating antennas are highly dissimilar, the area overlap is small and the magnetic flux generated by the transmitting antenna does not concatenate with the receiving antenna as expected, negatively impacting the communication.

The CRC included in the communication frame checks that data read from or written to the NFC EEPROM are correct, and several attempts might be required before the operation is completed successfully.

Antennas with different form factors affect the energy harvesting performance, too. For further information, see AN4913.

3 Power path configuration

The system is configured at the factory without the full-wave rectifier and without the STBC15 battery charger.

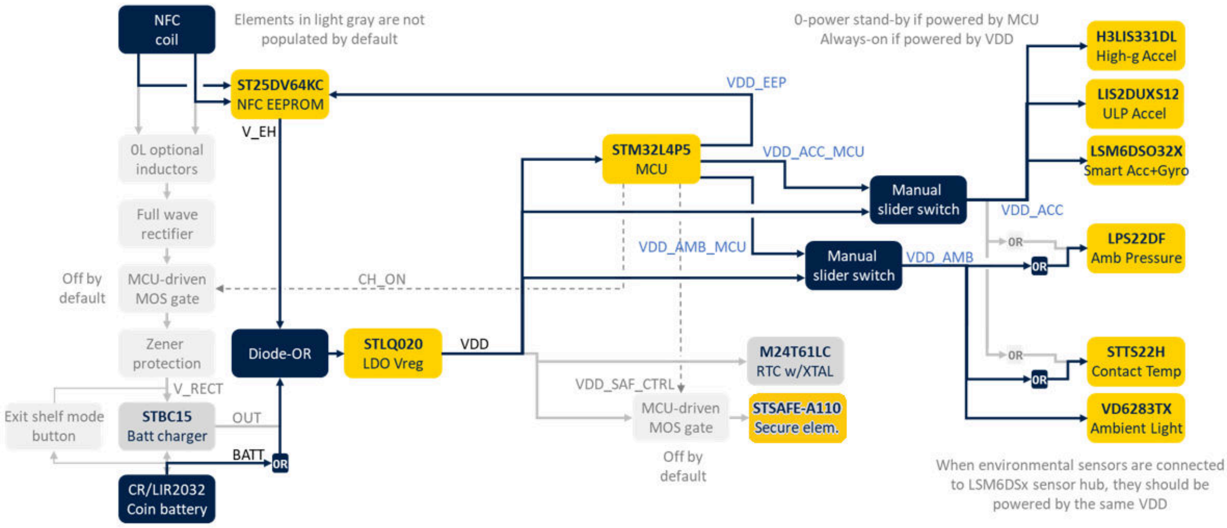
There are two power sources:

- V_EH from the NFC energy harvester embedded in the ST25DV64KC NFC/EEPROM
- BATT from the CR2032 battery

The power sources are connected in diode-OR to the input of the STLQ020 voltage regulator, which powers the main supply line VDD at 1.9 V. The system can therefore work in two modes:

- Battery-less mode: the CR2032 battery is not present. V_EH is available when the NFC field is strong enough to activate the NFC energy harvester in the ST25DV64KC.
- Battery mode: the CR2032 must be present and its voltage must be higher than the voltage of the V_EH line.

Figure 5. STEVAL-SMARTAG2 power path



Components highlighted in yellow are populated at the factory. Components highlighted in gray are optional.

The ST25DV64KC NFC EEPROM can be powered via the NFC field or via the dedicated line from the microcontroller (VDD_EEP).

Inertial and ambient/environmental sensors can be powered through the main supply line (VDD) for the always-on operation or through a dedicated GPIO of the microcontroller for 0-power standby operation.

- Inertial sensors are powered via the VDD_ACC line. A first manual slider switch can connect this line to the main supply line (VDD) or to the dedicated GPIO (VDD_ACC_MCU)
- Ambient/environmental sensors are powered via the VDD_AMB line. A second manual slider switch can connect this line to the main supply line (VDD) or to the dedicated GPIO (VDD_AMB_MCU)

Note: When the I²C bus interface of the environmental sensors is rerouted to the LSM6DSO32X sensor hub, their power supply must also be rerouted to come from the same source of the LSM6DSO32X (VDD_ACC). This can be done by removing and installing the appropriate 0 R resistors.

The system can optionally mount the M41T62 real-time clock. This component must be always-on to support the time keeping. It is powered directly through the main supply line (VDD).

The system can optionally be configured with an additional NFC energy harvester and a battery charger (STBC15).

- The additional energy harvester consists of a chain of tuning inductors or 0 R resistors, four diodes in a full-wave rectifier configuration, MOSFETs for power gating, a capacitor bank for energy storage, and a Zener diode for the overvoltage protection.

Note: When the full-wave rectifier is active, the power absorbed from the NFC antenna can affect the NFC communication. For this reason, the MOSFET is configured to be off by default.

- The STBC15 battery charger is by-passed by default. Therefore, you must remove the 0 R that connects the battery to the diode-OR. In this way, the energy does not come directly from the battery but from the battery charger output.
- The STBC15 battery charger is in shelf-mode by default: even if the battery is present, it is not connected to the output to preserve its charge. Press the “exit shelf-mode” button to start the normal operation.
- The microcontroller can monitor the input level of the battery charger through the RECT_M line, and can then disable the harvesting through the CH_ON line or limit the charging current through the ISET0 line. Disabling the harvester or limiting the charging current ensures the NFC communication.

3.1 Power-on and power-off sequences

When the microcontroller supplies power to other components in the system, follow the specific power-up and power-down sequences described below. Incorrect sequences can allow the power to flow from the communication bus through the protection diodes to the components, compromising their operation.

3.1.1 Power-on sequence

Step 1. Bus pins must be in the high-impedance state. If they are in the pull-down state, execute a deinitialization (see step 3 in Section 3.1.2 Power-off sequence).

Step 2. VDD can be applied to the VDD_ACC_MCU and/or to the VDD_AMB_MCU. Configure for the pull-up state and execute the initialization.

Step 3. Bus pins can be taken out of the high-impedance state. Configure and initialize all bus pins (for the SPI, pull-up all chip select pins).

3.1.2 Power-off sequence

Step 1. Bus pins must be put in the high-impedance state. Execute a deinitialization.

Step 2. VDD can be removed. Pull-down is recommended to ensure that the POR circuit is triggered (power-on-reset) at the subsequent power-up.

Step 3. Optional step: bus pins can also be pulled down. Configure for pull-down and execute the initialization.

Put the pins back to the high-impedance state before the power-on sequence (see step 0 in Section 3.1.1 Power-on sequence).

4 Programming and debugging

4.1 System requirements

To program and debug the STEVAL-SMARTAG2, you need:

- an STLINK-V3MINI in-circuit debugger
- a GUI utility (STM32CubeProgrammer) to program the target microcontroller through the in-circuit debugger
- a serial terminal emulator such as Tera Term

4.2 How to program the board

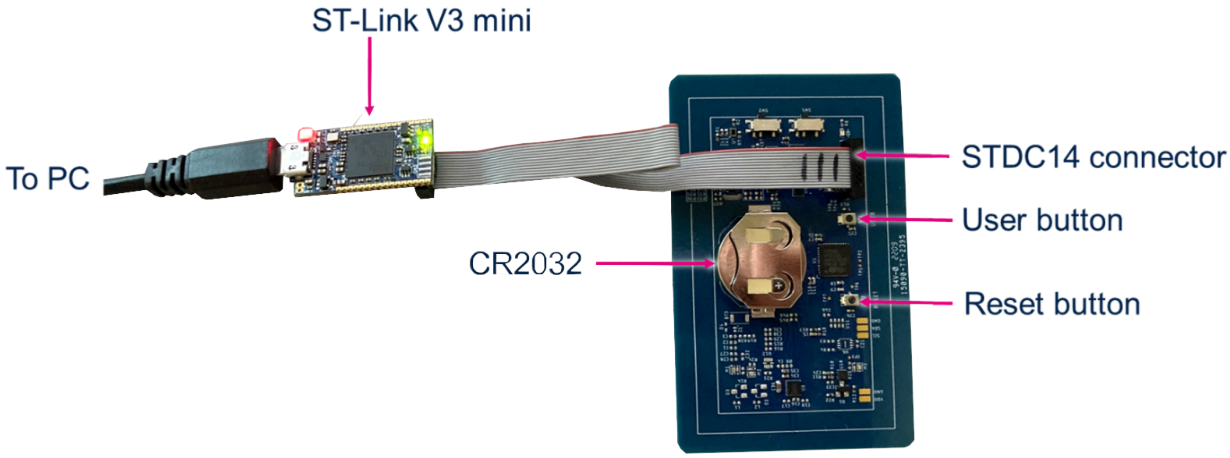
Step 1. Connect the STLINK-V3MINI in-circuit debugger to the on-board STDC14 connector using a 14-pin cable.
The red wire corresponds to pin 1.

Step 2. Connect the STLINK-V3MINI to the laptop via a USB cable.

Step 3. Power the target microcontroller by inserting a CR2032 coin cell battery in the battery holder.
If the battery is depleted, the programming procedure will not be successful.

Step 4. Run the STM32CubeProgrammer GUI utility and follow the steps described in Section 4.2.1.

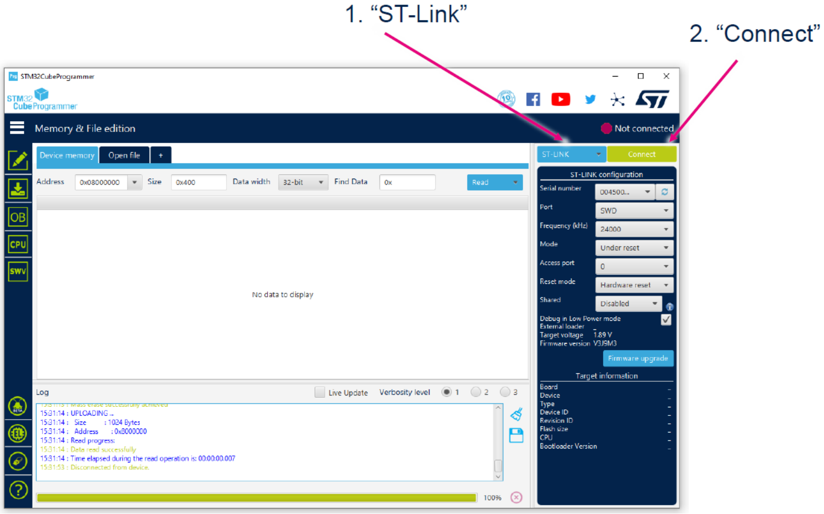
Figure 6. STEVAL-SMARTAG2 connected to STLINK-V3MINI



4.2.1 How to program the board with STM32CubeProgrammer

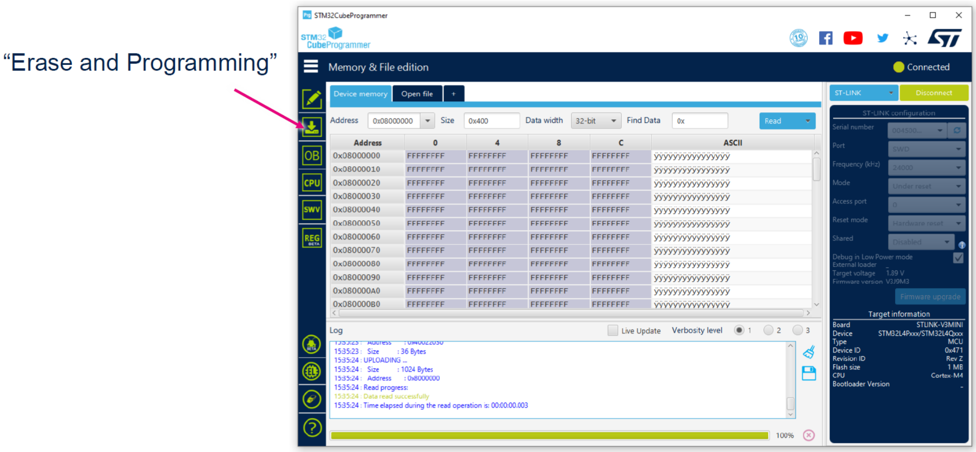
Step 1. Select ST-LINK from the pull-down menu in the top left corner. Then, press the [**Connect**] button.

Figure 7. Selecting ST-LINK and connecting the board



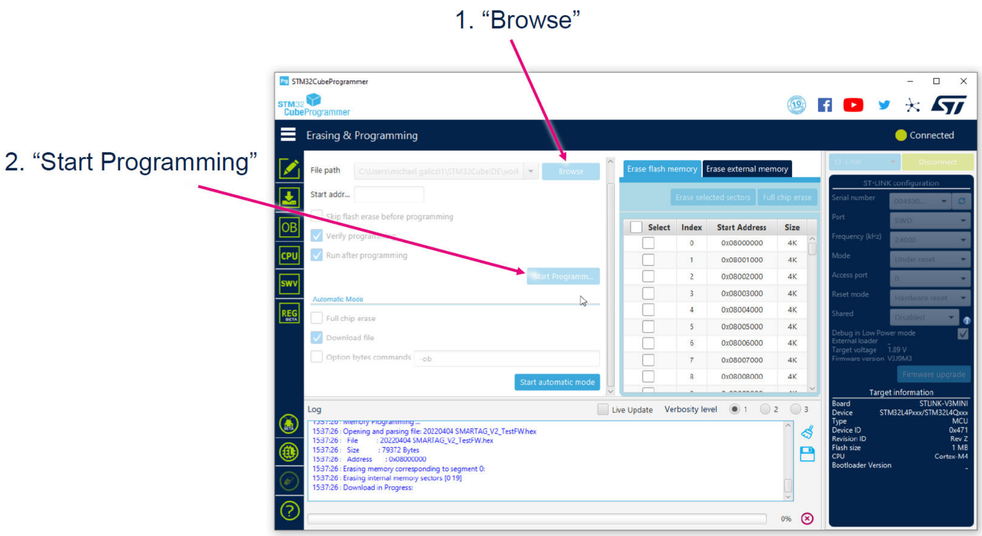
Step 2. The memory map of the target microcontroller is displayed. Press the [**Erase and Programming**] button on the side bar on the left.

Figure 8. Erase and programming



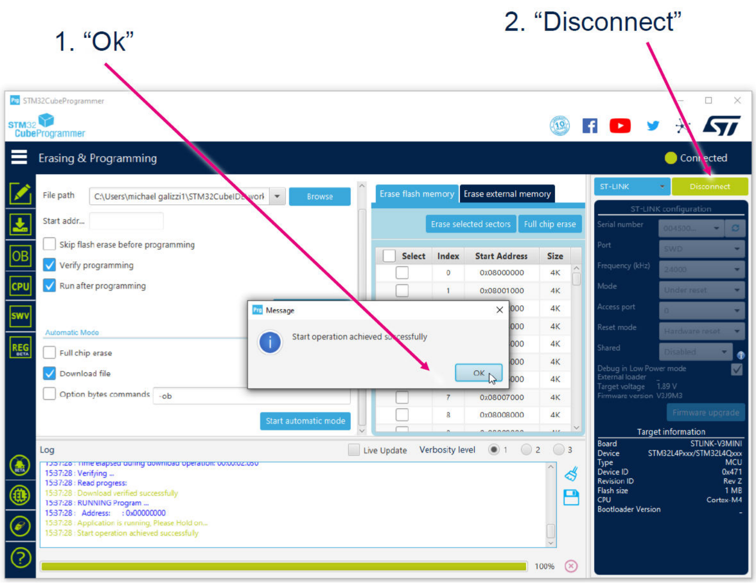
Step 3. Press [**Browse**] to navigate the file system, select, and open the binary program. Then press [**Start Programming**] and wait for the process to be completed.

Figure 9. Browse and start programming



Step 4. Press [**OK**] to acknowledge the completion of the programming process. Then, press [**Disconnect**].

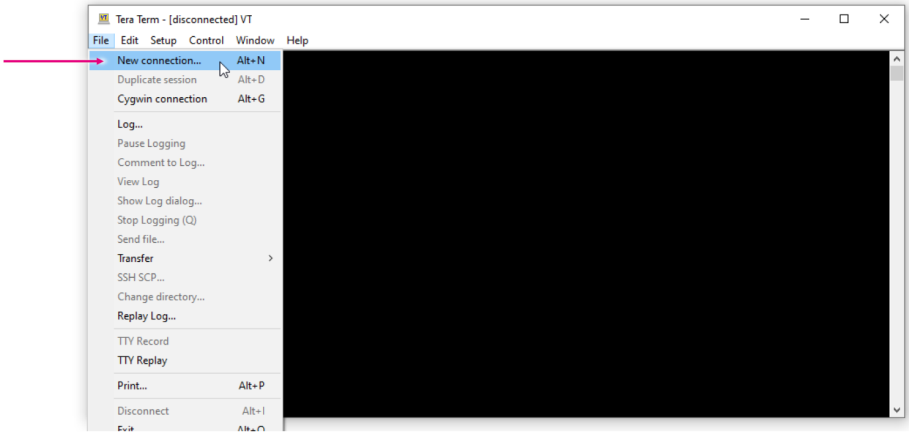
Figure 10. Disconnect



4.2.2 How to display the firmware output using Tera Term

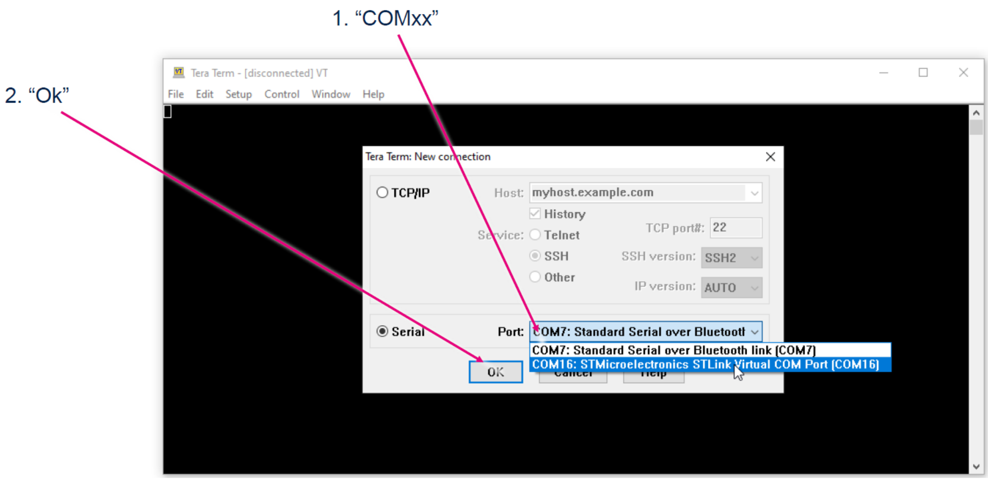
Step 1. Select [**File**][**New Connection**].

Figure 11. **New connection selection**



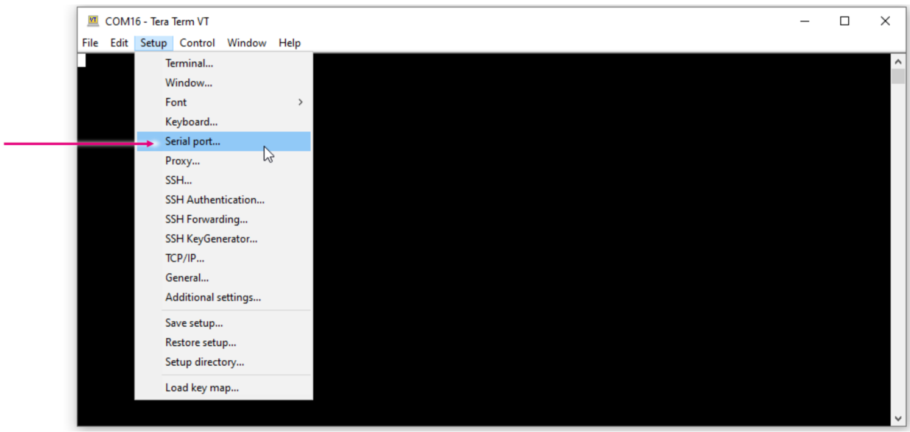
Step 2. Select the COM port associated with the ST-LINK and confirm with [**OK**].

Figure 12. **COM port selection**



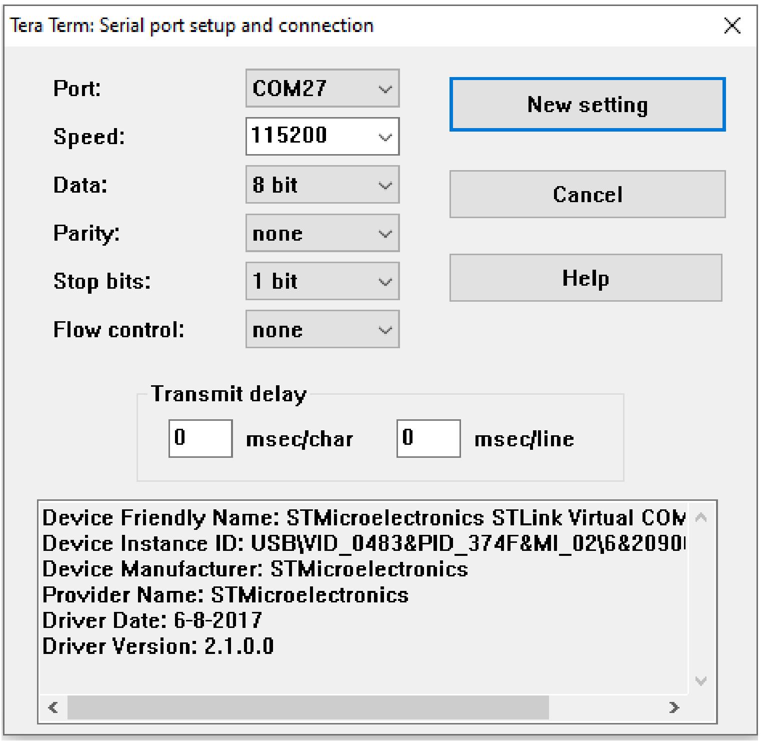
Step 3. Select [**Setup**]>[**Serial Port**].

Figure 13. **Serial port selection**



Step 4. Configure the serial port parameters as shown in the figure below.

Figure 14. Serial port configuration



Note: To enable/disable this UART functionality on the STEVAL-SMARTAG2 board, you must recompile the code by uncommenting/commenting the line:

```
#define SMARTAG2_ENABLE_PRINTF
```

in the Projects\ STM32L4P5CE-SmarTag2\Examples\SmarTag2\Inc\SMARTAG2_config.h file.

When you first press the reset button, the application:

– starts initializing the UART and I²C interfaces
– shows the SmarTag UID
– reads the last configuration written on to NFC tag (if available)
– sets the NFC behavior
– sets the wakeup timer

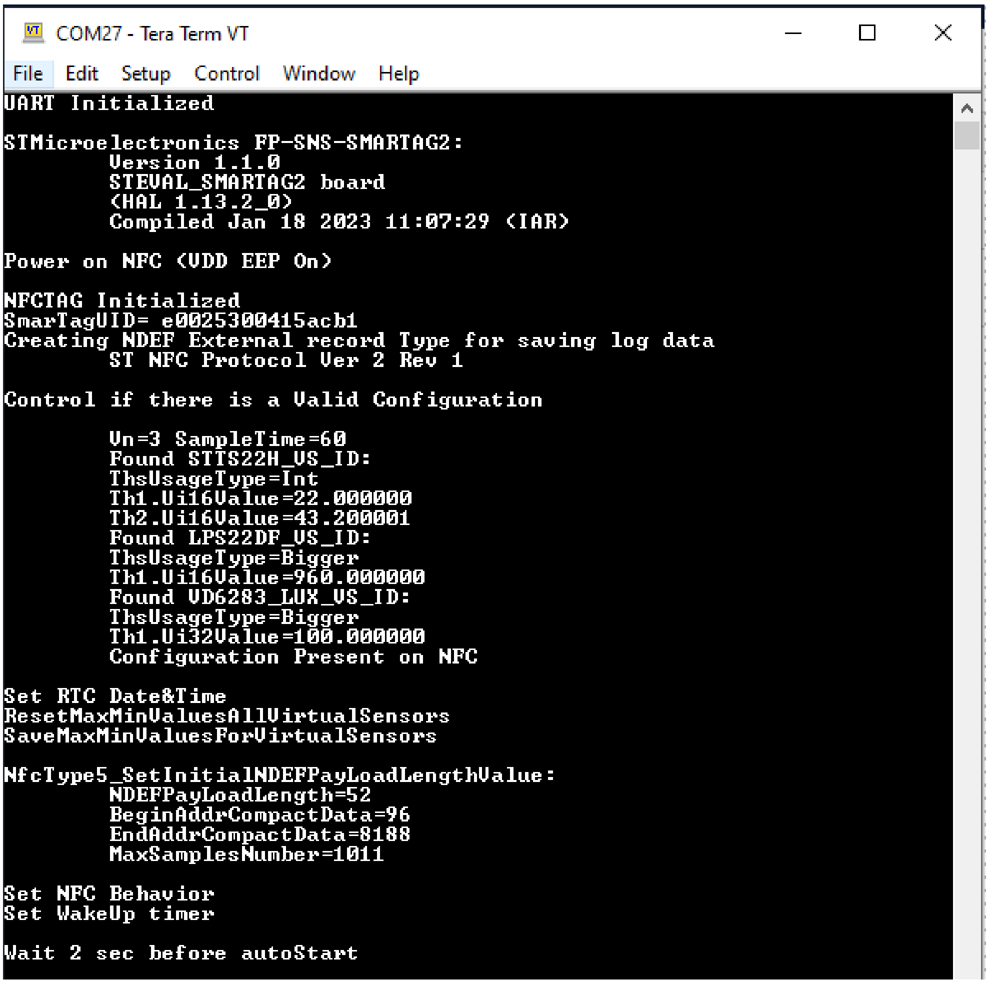


Figure 15. FP-SNS-SMARTAG2 UART output initialization

After the auto-start range time, the samples are logged using the written configuration on the NFC tag (or the default one, if not available).

Figure 16. FP-SNS-SMARTAG2 UART output auto-start

When the smartphone is close to the NFC tag, the message "Detected NFC FIELD On" appears.

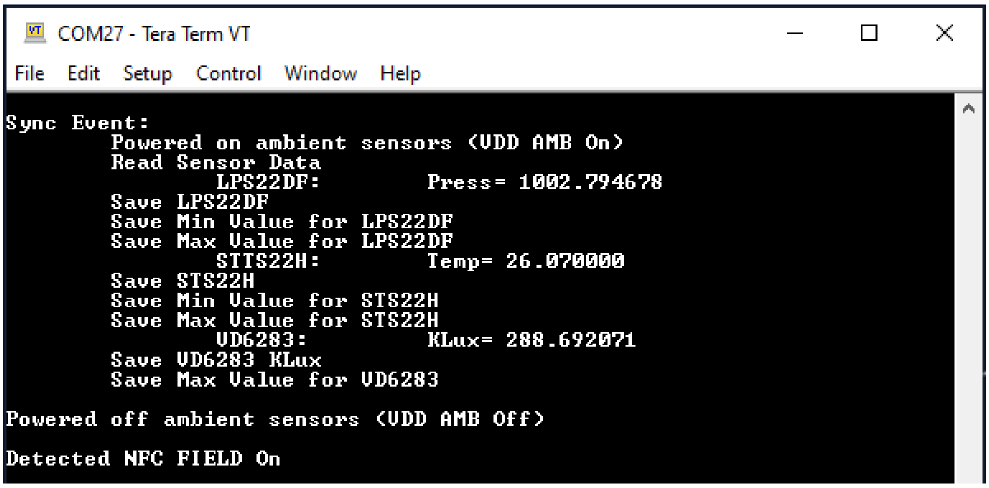


Figure 17. FP-SNS-SMARTAG2 UART output NFC on

When the smartphone is kept distant from the NFC tag, the message "Detected NFC FIELD Off" appears together with the new configuration if a new one is detected.

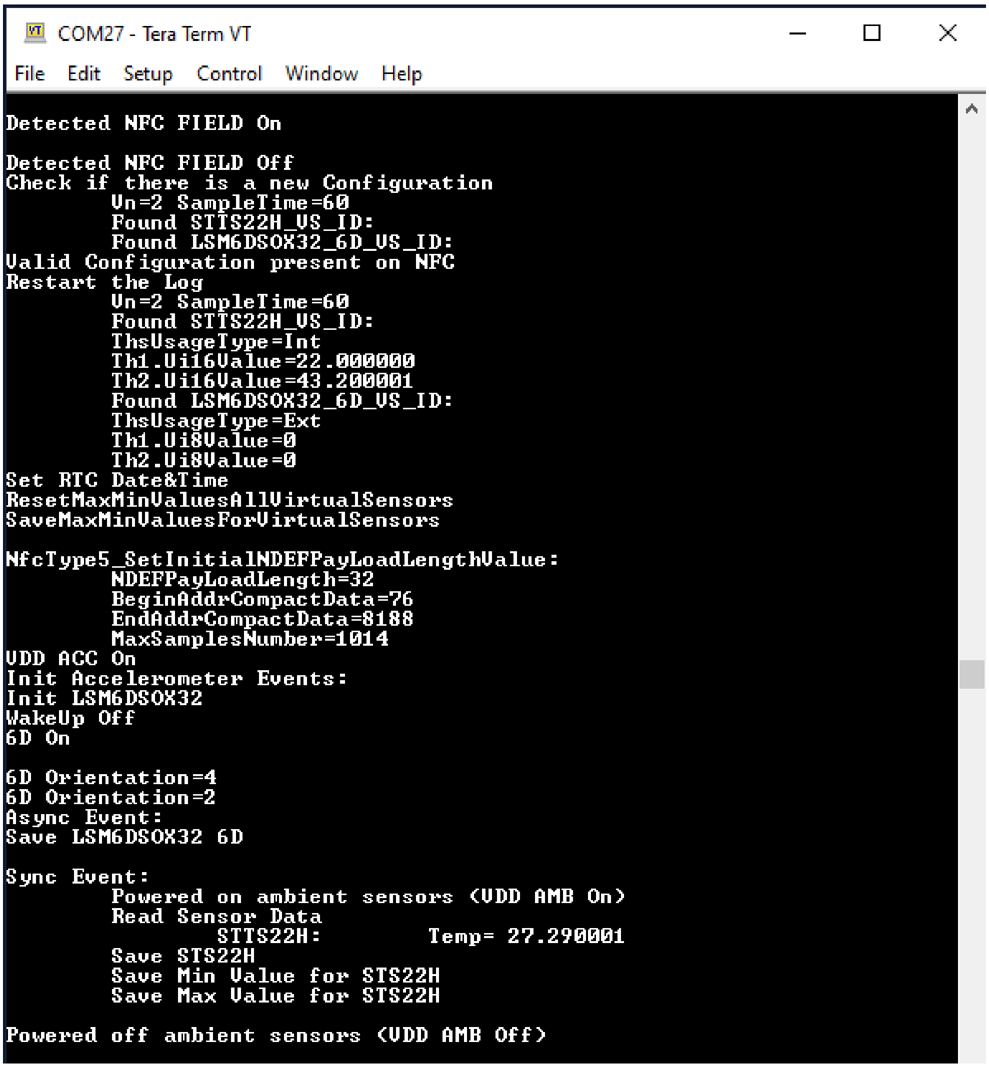


Figure 18. FP-SNS-SMARTAG2 UART output NFC off

5 Schematic diagrams

Figure 19. **STEVAL-SMARTAG2 circuit schematic (1 of 6)**

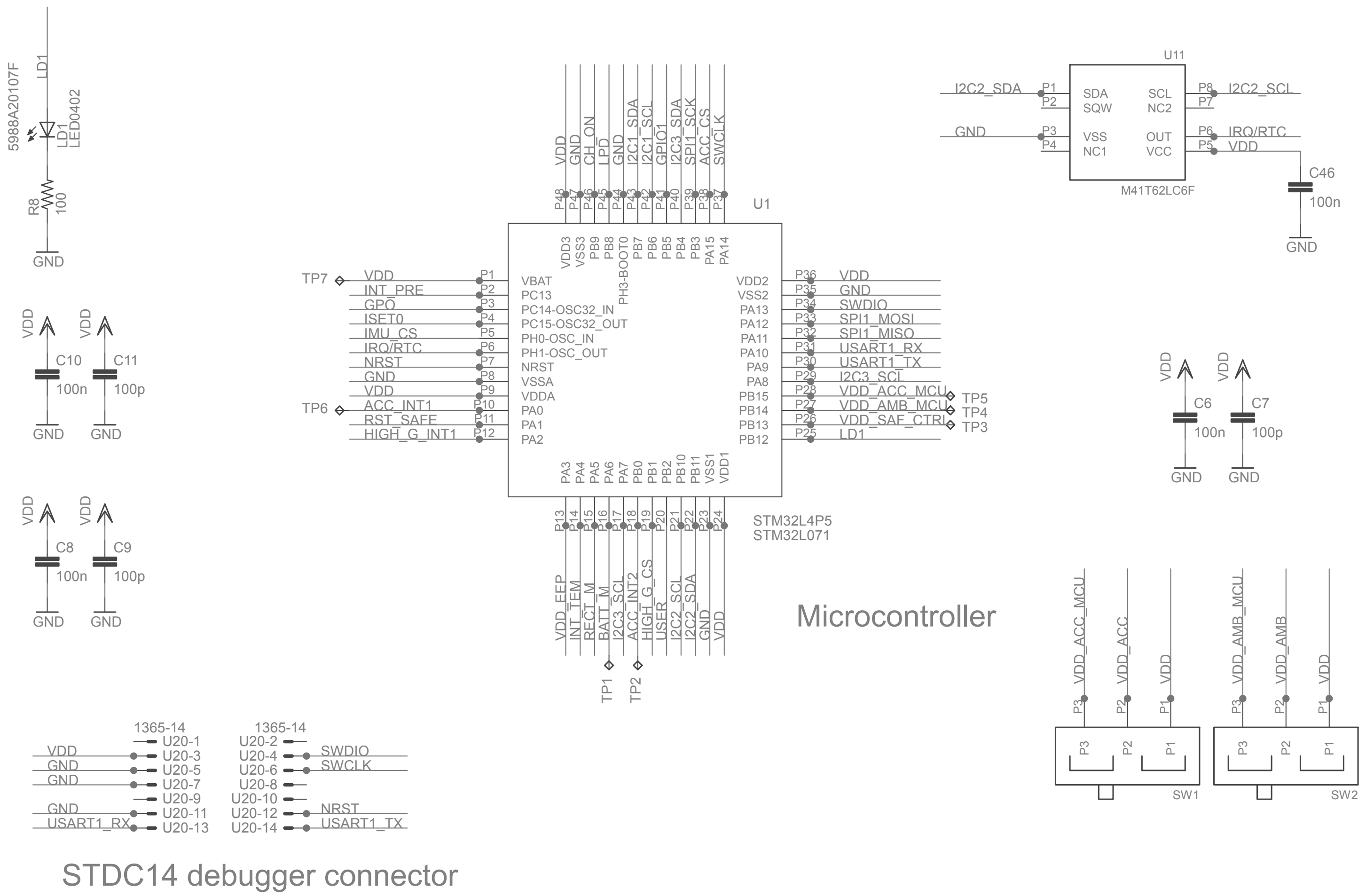


Figure 20. STEVAL-SMARTAG2 circuit schematic (2 of 6)

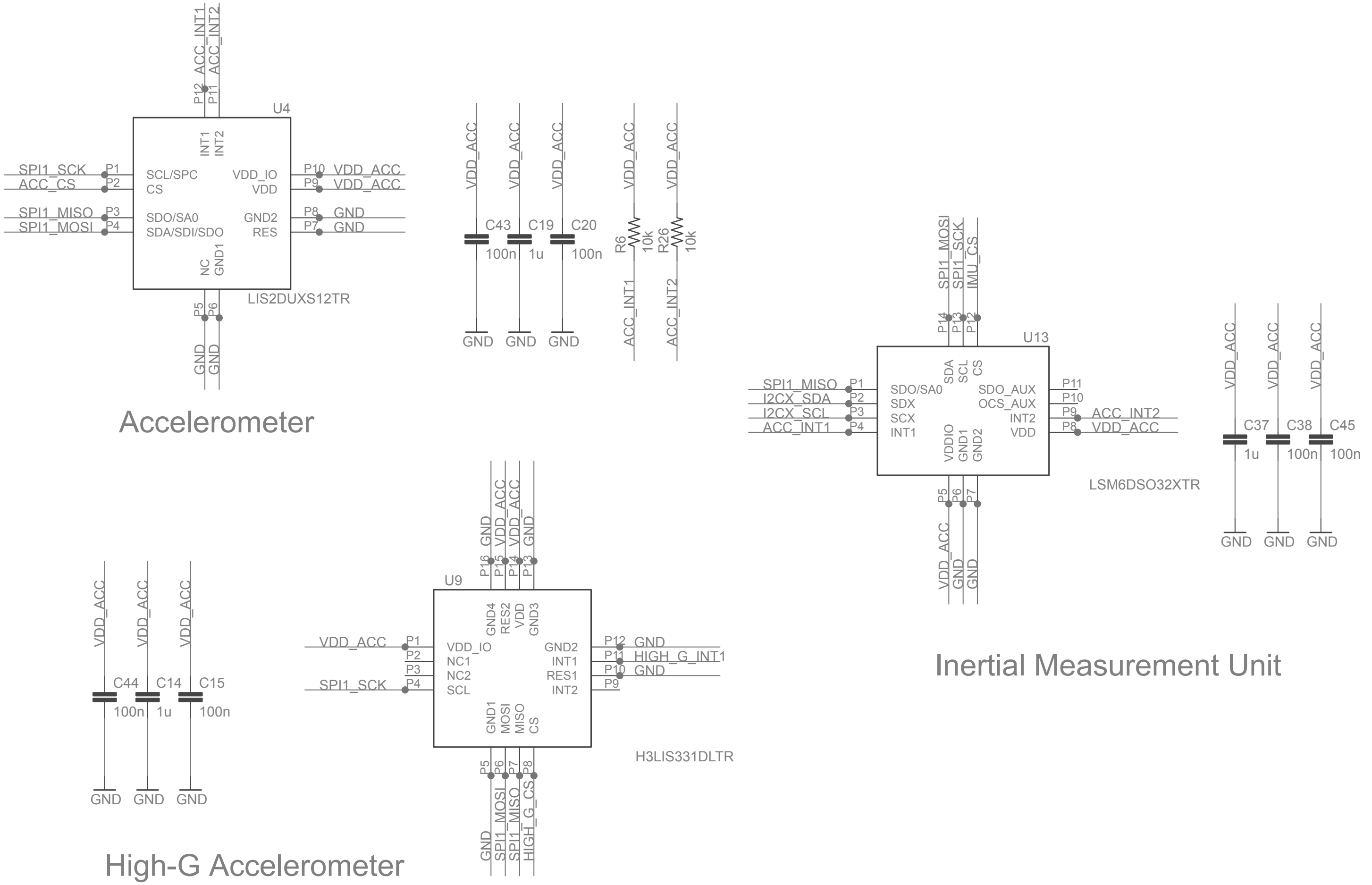


Figure 21. STEVAL-SMARTAG2 circuit schematic (3 of 6)

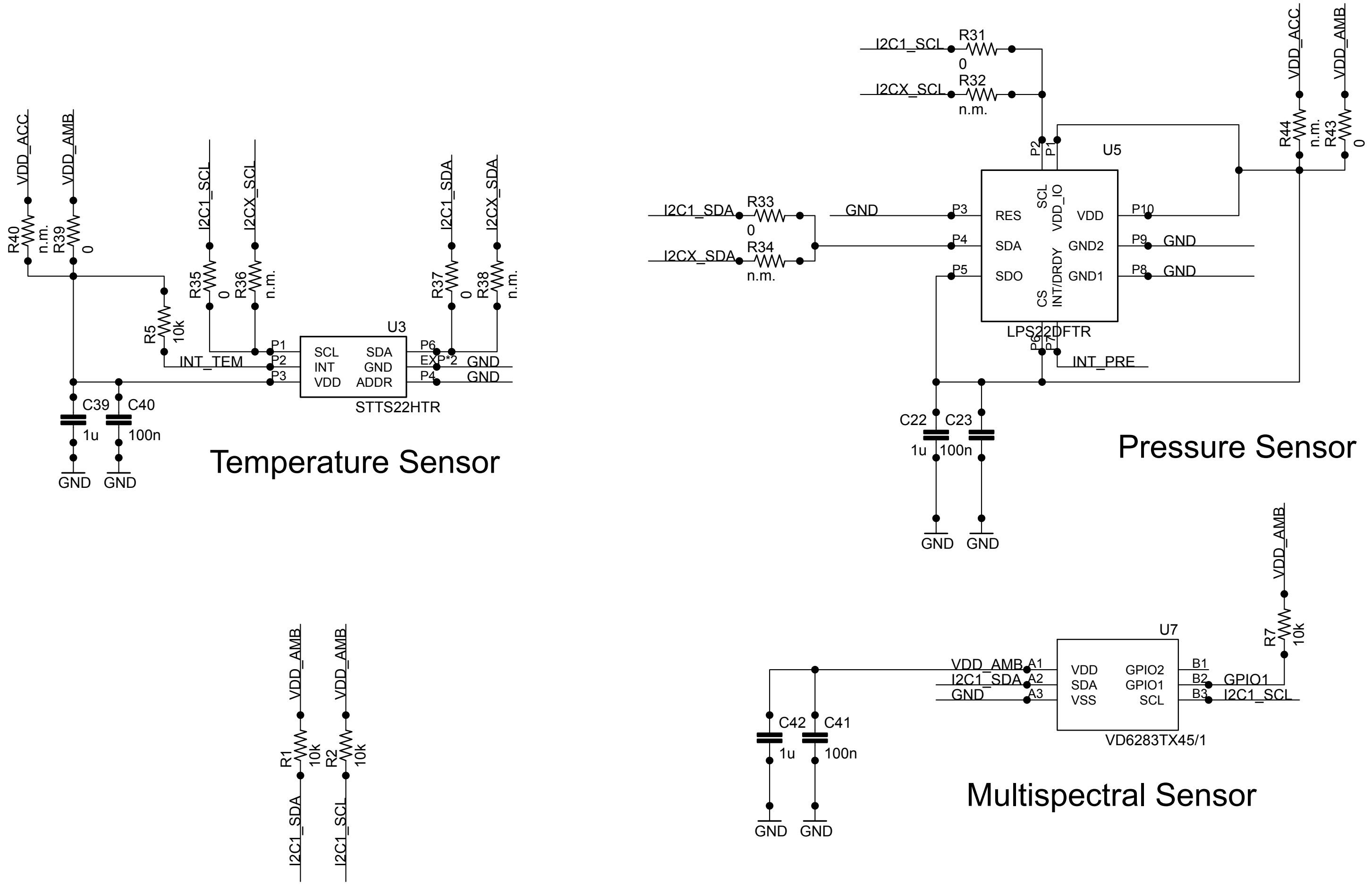


Figure 22. STEVAL-SMARTAG2 circuit schematic (4 of 6)

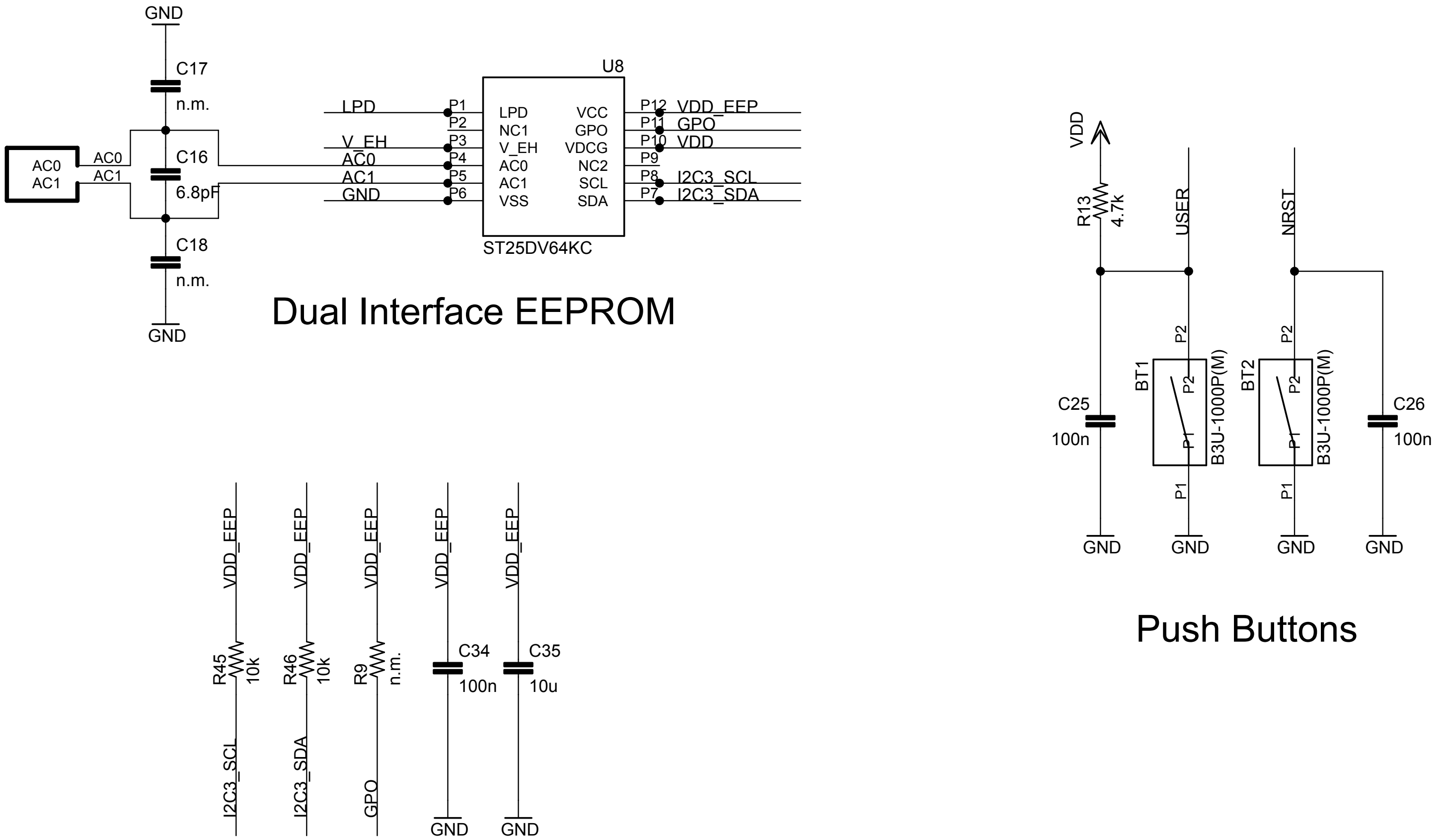


Figure 23. STEVAL-SMARTAG2 circuit schematic (5 of 6)

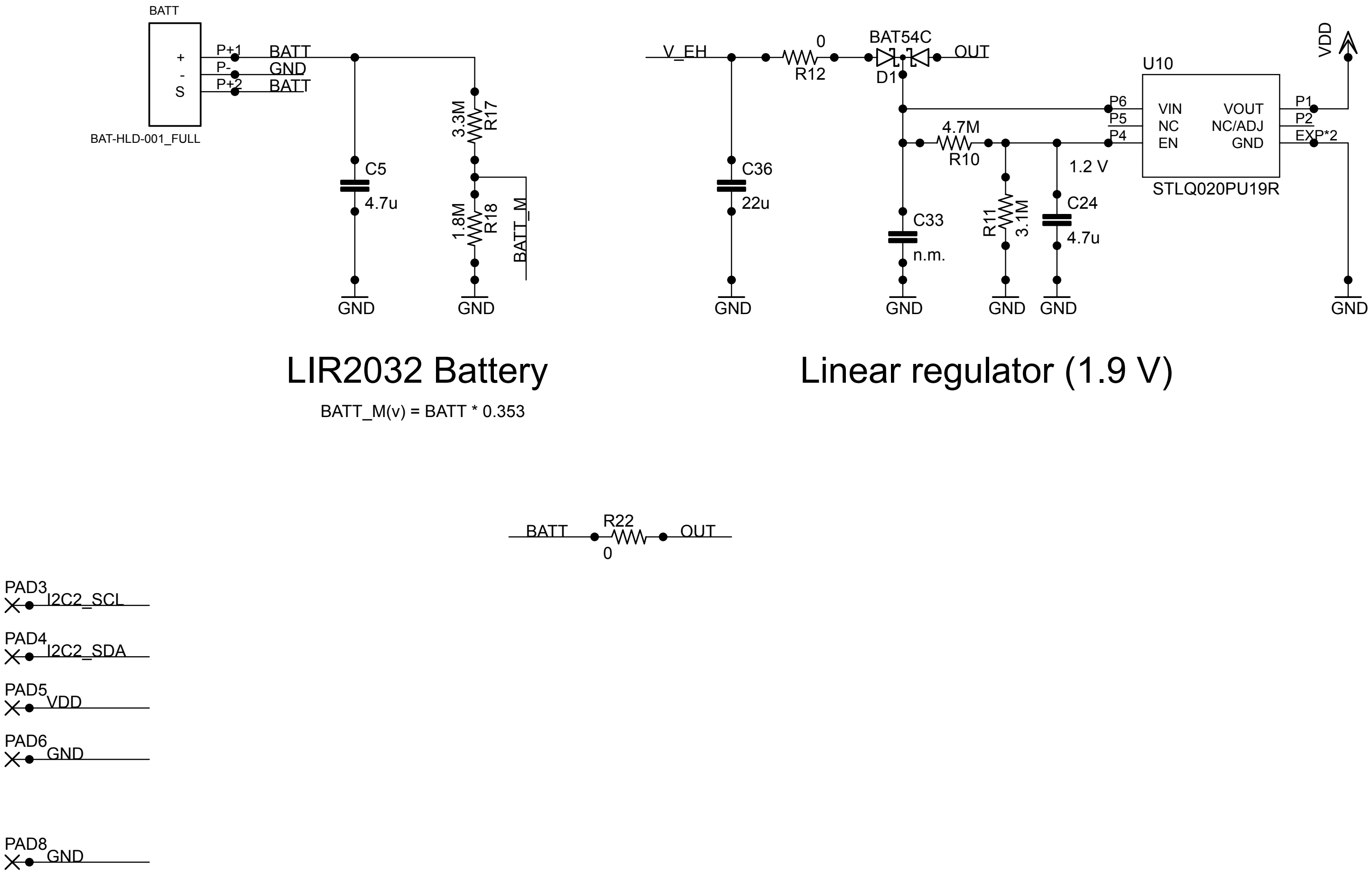
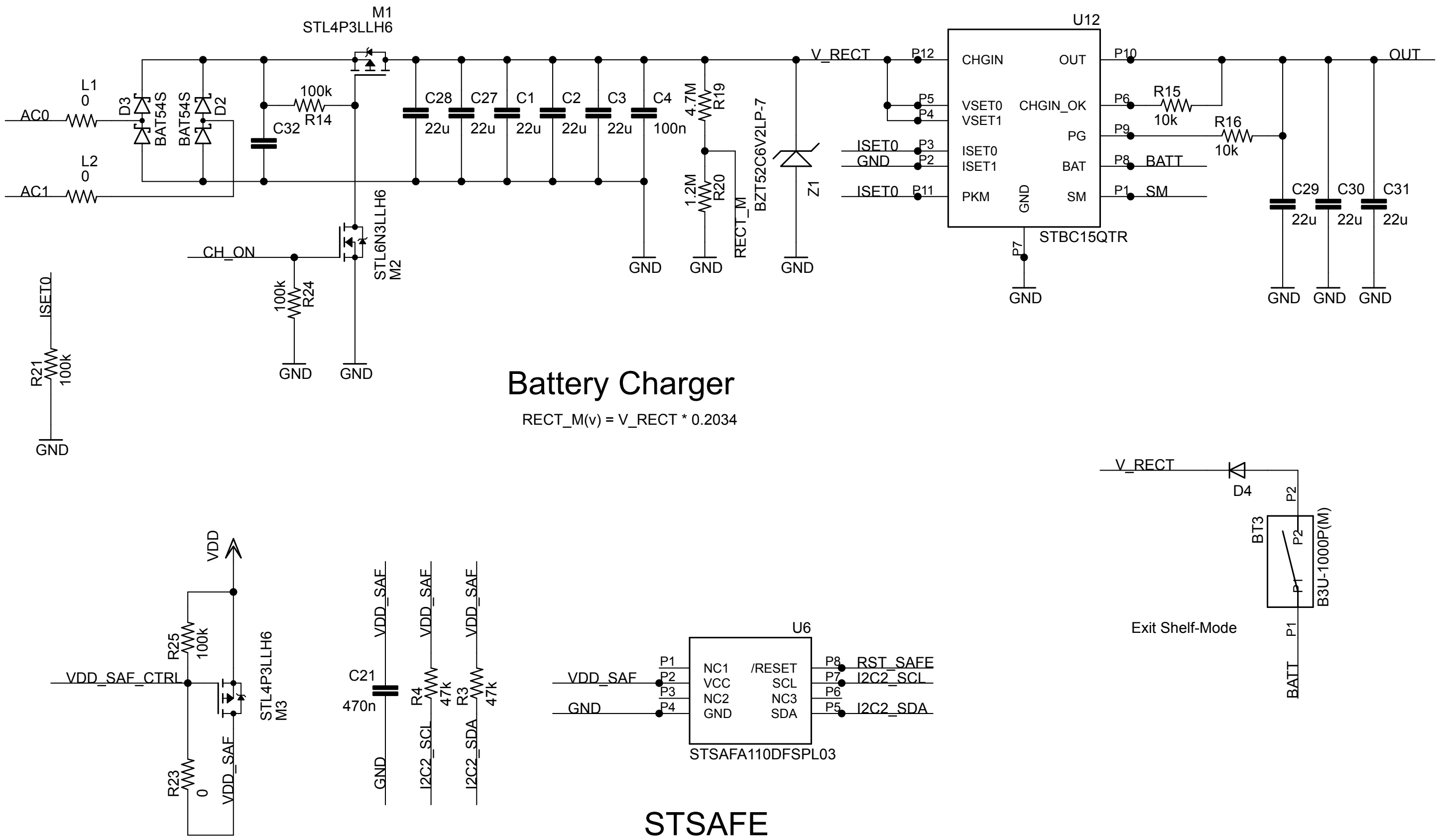


Figure 24. STEVAL-SMARTAG2 circuit schematic (6 of 6)



6 Bill of materials

Table 1. STEVAL-SMARTAG2 bill of materials

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
1	1	U1	STM32L4P5CGU6, UFQFPN 48 7x7x0.55 mm	Ultra-low-power with FPU Arm Cortex-M4 MCU 120 MHz with 1024 kbytes of flash memory, USB OTG, DFSDM, CHROM-ART	ST	STM32L4P5CGU6
2	1	U1	STM32L071CZU6, UFQFPN 48 7x7x0.55 mm	Ultra-low-power Arm Cortex-M0+ MCU with 192 Kbytes of flash memory, 32 MHz CPU (not assembled)	ST	STM32L071CZU6
3	1	U13	LSM6DSO32XTR, VFLGA2.5X3X.86 14L P.5 L.475X.25	iNEMO inertial module: always-on 3D accelerometer and 3D gyroscope	ST	LSM6DSO32XTR
4	1	U8	ST25DV64KC-JF6D3, UFDFPN 12L 3X3X0.55 pitch 0.50	Dynamic NFC/RFID tag IC with 64-Kbit EEPROM and fast transfer mode capability	ST	ST25DV64KC-JF6D3
5	1	U12 N.A.	STBC15QTR, MLPQ/QFN 1.7x2.0x0.55 12L P0.4	Ultra-low current consumption linear battery charger	ST	STBC15QTR
6	1	U4	LIS2DUXS12TR, LGA 2X2X0.74MAX 12 LEADS	High-performance ultra-low-power 3-axis accelerometer	ST	LIS2DUXS12TR
7	1	U5	LPS22DFTR, HLGA 2X2X.8 10L EXP. SILIC .91SQ	Low-power and high-precision MEMS nano pressure sensor: 260-1260 hPa absolute digital output barometer	ST	LPS22DFTR
8	1	U7	VD6283TX45/1, WLCSP T-SHAPE	Hybrid filter multispectral sensor with light flicker engine	ST	VD6283TX45/1

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
9	1	U9	H3LIS331DLTR, LLGA 16 3x3x1.0	Low power high-g 3-axis accelerometer, SPI/I2C digital output MEMS motion sensor, user-selectable full scales of ±100g/±200g/ ±400g	ST	H3LIS331DLTR
10	1	U3	STTS22HTR, UDFN 2X2X.55 6L PITCH0.65	Low-voltage, ultra-low-power, 0.5°C accuracy I2C/SMBus 3.0 temperature sensor	ST	STTS22HTR
11	1	U6	STSAFA110DFSPL02, UFDFPN 8 2x3x0.6	Authentication, state-of-the-art security for peripherals and IoT devices (not assembled)	ST	STSAFA110DFSPL02
12	1	U10	STLQ020PU19R, DFN6 2x2	200 mA ultra-low quiescent current LDO	ST	STLQ020PU19R
13	1	D1	BAT54CFILM, SOT23	40 V, 300 mA general purpose Schottky diode	ST	BAT54CFILM
14	2	D2, D3	BAT54SFILM, SOT23	40 V, 300 mA general purpose Schottky diodes (not assembled)	ST	BAT54SFILM
15	2	M1, M3 N.A.	STL4P3LLH6, PowerFLAT 2x2	P-Channel 30 V, 0.048 Ohm typ., 4 A STripFET H6 power MOSFET in PowerFLAT 2x2 package	ST	STL4P3LLH6
16	1	D4	BAT54KFILM, SOD-523	40 V, 300 mA general purpose Schottky diode (not assembled)	ST	BAT54KFILM
17	1	M2 N.A.	STL6N3LLH6,PowerFLAT 2x2	N-channel 30 V, 0.021 Ohm typ., 6 A STripFET H6 Power MOSFET in a PowerFLAT 2x2 package	ST	STL6N3LLH6
18	2	C4, C46 N.A.	100n, C0402, 16 V, ±5 %	CAP CER 0.1UF 16V X5R 0402	Samsung Electro-Mechanics	CL05A104JO5NNNC
19	16	C6, C8, C10, C13, C15, C20, C23, C25, C26, C34, C38, C40, C41, C43, C44, C45	100n, C0402, 16 V, ±5 %	CAP CER 0.1UF 16V X5R 0402	Samsung Electro-Mechanics	CL05A104JO5NNNC

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
20	8	C1, C2, C3, C27, C28, C29, C30, C31 N.A.	22u, C0402, 6.3 V, ±20 %	CAP CER 22UF 6.3V X5R 0402	Samsung Electro-Mechanics	CL05A226MQ5N6J8
21	7	C12, C14, C19, C22, C37, C39, C42	1u, C0402, 6.3 V, ±5 %	CAP CER 1UF 6.3V X5R 0402	Samsung Electro-Mechanics	CL05A105JQ5NNNC
22	3	C7, C9, C11	100p, C0402, 50 V, ±5 %	CAP CER 100PF 50V C0G/NP0 0402	Samsung Electro-Mechanics	CL05C101JB5NNNC
23	1	C21 N.A.	470n, C0402, 10 V, ±10 %	CAP CER 0.47UF 10V X5R 0402	Samsung Electro-Mechanics	CL05A474KP5NNNC
24	2	C35	10u, C0402, 10 V, ±20 %	CAP CER 10UF 10V X5R 0402	Samsung Electro-Mechanics	CL05A106MP5NUNC
25	2	C5, C24	4.7u, C0402, 6.3 V, ±10 %	CAP CER 4.7UF 6.3V X5R 0402	Samsung Electro-Mechanics	CL05A475KQ5NRNC
26	1	Z1	BZT52C6V2LP-7 , D0402, 6.2 V, ±6 %,	DIODE ZENER 6.2V 250MW 2DFN (not assembled)	Diodes Incorporated	BZT52C6V2LP-7
27	1	U20	1365-14,	STDC14 - ARM MIPI10 compatible	Samtec	FTSH-107-01-L-DV-K
28	1	BATT	BAT-HLD-001	BATTERY RETAINER COIN 20MM SMD	Linx Technologies Inc.	BAT-HLD-001-TR
29	1	LD1	LED0402, LED0402, 1.8 V	SM LED 0402 RED 625NM	Dialight	5988A20107F
30	1	BT3 N.A.	B3U-1000P(M)	Tactile switch	Omron	B3U-1000PM
31	2	BT1, BT2	B3U-1000P(M)	Tactile switch	Omron	B3U-1000PM
32	2	R15, R16 N.A.	10k, R0402, 5 %	RES SMD 10K OHM 5% 0402	YAGEO	RC0402JR-0710KL
33	6	R1, R2, R5, R7, R45, R46	10k, R0402, 5 %	RES SMD 10K OHM 5% 0402	YAGEO	RC0402JR-0710KL
34	2	R6, R26	10k, R0402, 5 %	RES SMD 10K OHM 5% 0402 (not assembled)	YAGEO	RC0402JR-0710KL
35	4	R14, R21, R24, R25	100k, R0402, 5 %	RES SMD 100K OHM 5% 0402 (not assembled)	YAGEO	RC0402JR-07100KL
36	1	R8	100, R0402, 5 %	RES SMD 100 OHM 5% 0402	YAGEO	RC0402JR-07100RL
37	1	R10	4.7M, R0402, 5 %	RES SMD 4.7M OHM 5% 1/16W 0402	YAGEO	RC0402JR-074M7L
38	1	R19	4.7M, R0402, 5 %	RES SMD 4.7M OHM 5% 1/16W 0402 (not assembled)	YAGEO	RC0402JR-074M7L

Item	Q.ty	Ref.	Value	Description	Manufacturer	Order code
39	2	R3, R4	47k, R0402, 5 %	RES SMD 47K OHM 5% 0402 (not assembled)	YAGEO	RC0402JR-0747KL
40	1	R13	4.7k, R0402, 5 %	RES SMD 4.7K OHM 5% 0402	YAGEO	RC0402JR-074K7L
41	1	R17	3.3M, R0402, 5 %	RES SMD 3.3M OHM 5% 1/16W 0402	YAGEO	RC0402JR-073M3L
42	1	R11	3.09M, R0402, 1 %	RES SMD 3.09M OHM 1% 1/16W 0402	Vishay Dale	CRCW04023M09FKED
43	1	R18	1.8M, R0402, 5 %	RES SMD 1.8M OHM 5% 1/10W 0402	Panasonic Electronic Components	ERJ-2GEJ185X
44	1	R20	1.2M, R0402, 5 %	RES SMD 1.2M OHM 5% 1/16W 0402 (not assembled)	YAGEO	RC0402JR-071M2L
45	11	L1, L2, R28, R30, R32, R34, R36, R38, R40, R42, R44	0, R0402,	RES 0 OHM JUMPER 1/16W 0402 (not assembled)	YAGEO	RC0402FR-070RL
46	11	R12, R22, R23, R27, R29, R31, R33, R35, R37, R39, R41, R43	0, R0402,	RES 0 OHM JUMPER 1/16W 0402	YAGEO	RC0402FR-070RL
47	2	SW1, SW2	PCM12SMTR	SWITCH SLIDE SPDT 300MA 6V	C&K	PCM12SMTR
48	1	U11	M41T62LC6F, LCC8 3.2x1.5 mm	Low-power serial real-time clocks (RTCs) with alarm (not assembled)	ST	M41T62LC6F
49	1	C16	6.8pF, C0402, 50V, ±0.25pF	AP CER 6.8PF 50V C0G/NP0 0402	Murata Electronics	GJM1555C1H6R8CB01D
50	1	C36	22uF, C0603, 10V,±20%	CAP CER 22UF 10V X5R 0603	Samsung Electro-Mechanics	CL10A226MP8NUNE

7 Board versions

Table 2. **STEVAL-SMARTAG2 versions**

PCB version	Schematic diagrams	Bill of materials
STEVAL$SMARTAG2A (1)	STEVAL$SMARTAG2A schematic diagrams	STEVAL$SMARTAG2A bill of materials
STEVAL$SMARTAG2B (2)	STEVAL$SMARTAG2B schematic diagrams	STEVAL$SMARTAG2B bill of materials

1. *This code identifies the STEVAL-SMARTAG2 evaluation board first version. It is printed on the board PCB.*
2. *This code identifies the STEVAL-SMARTAG2 evaluation board second version. It is printed on the board PCB.*

8 Regulatory compliance

Formal Notice Required by the U.S. Federal Communications Commission

Responsible party’s contact located in the United States: name: Francesco Doddo; address: STMicroelectronics Inc, 30 Corporate Drive, Suite 300, Burlington MA, 01803, U.S.A.; e-mail: francesco.doddo@st.com

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. Changes or modifications not expressly approved by the manufacturer could void the user’s authority to operate the equipment.

Note: 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 instructions, 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 the 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 a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Formal Product Notice Required by Industry Canada

Responsible party’s contact located in Canada: name: John Langner; address: STMicroelectronics, Inc., 350 Burnhamthorpe Road West, Suite 303 L5B 3J1, Mississauga, ON, Canada; e-mail: john.langner@st.com

Innovation, Science and Economic Development Canada Compliance

This device complies with Innovation, Science and Economic Development RSS standards. 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. Changes or modifications not expressly approved by the manufacturer could void the user’s authority to operate the equipment.

Conformité à Innovation, Sciences et Développement Économique Canada

Cet appareil est conforme aux normes RSS d'Innovation, Science et Développement économique. L'utilisation est soumise aux deux conditions suivantes: (1) cet appareil ne doit pas causer d'interférences nuisibles, et (2) cet appareil doit accepter de recevoir tous les types d’interférence, y comprises les interférences susceptibles d'entraîner un fonctionnement indésirable. Les changements ou les modifications non expressément approuvés par le fabricant pourraient annuler le permis d'utiliser l'équipement.

Notice for the European Union

The kit STEVAL-SMARTAG2 is in conformity with the essential requirements of the Directive 2014/53/EU (RED) and of the Directive 2015/863/EU (RoHS). Harmonized standards applied are listed in the EU Declaration of Conformity.

Notice for the United Kingdom

The kit STEVAL-SMARTAG2 is in compliance with the UK Radio Equipment Regulations 2017 (UK SI 2017 No. 1206 and amendments) and with the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (UK SI 2012 No. 3032 and amendments). Applied standards are listed in the UK Declaration of Conformity.

Revision history

Table 3. **Document revision history**

Date	Revision	Changes
07-Oct-2022	1	Initial release.
12-Jun-2023	2	Updated Introduction, Section 1.1 Safety operating use and conditions, Section 1.2 Overview, Section 2 System architecture, Section 3 Power path configuration, Section 5 Schematic diagrams, Section 6 Bill of materials and Section 7 Board versions.

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