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UM2153
User manual

Discovery kit for IoT node, multi-channel communication with STM32L4

Introduction

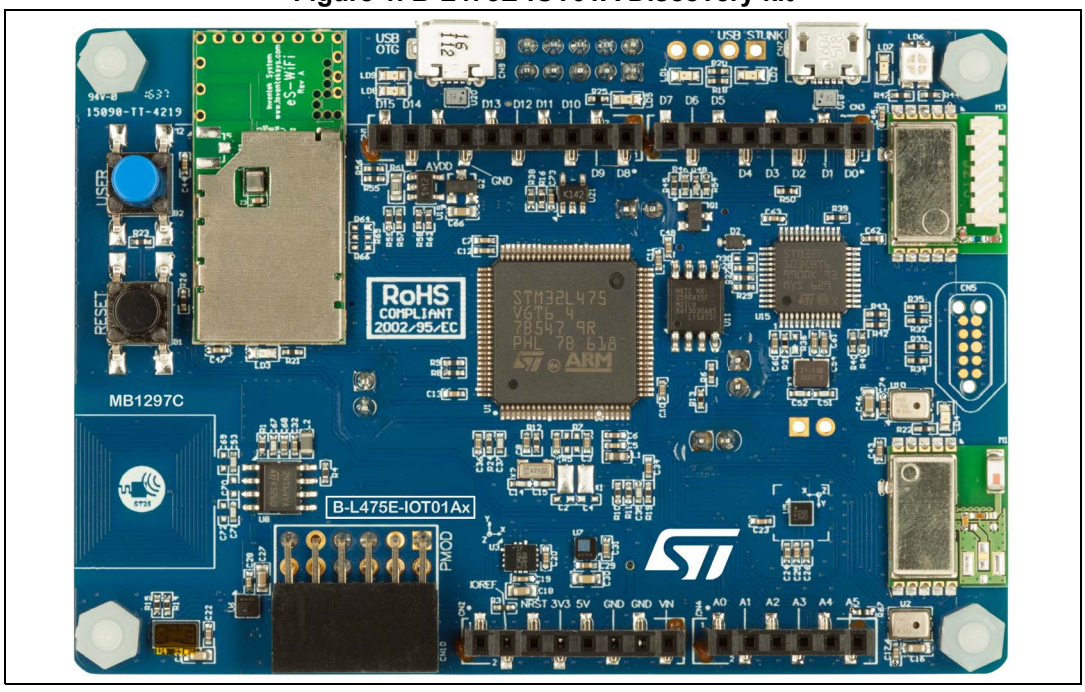
The STM32L4 Discovery kit for IoT node (B-L475E-IOT01A) allows users to develop applications with direct connection to cloud servers.

The STM32L4 Discovery kit enables a wide diversity of applications by exploiting low-power multilink communication (BLE, Sub-GHz), multiway sensing (detection, environmental awareness) and ARM® Cortex®-M4 core-based STM32L4 Series features.

Arduino™ Uno V3 and PMOD connectivity provide unlimited expansion capabilities with a large choice of specialized add-on boards.

The STM32L4 Discovery kit includes an ST-LINK debugger/programmer, and comes with the comprehensive STM32Cube software libraries together with packaged software examples to seamlessly connect to cloud servers.

Figure 1. B-L475E-IOT01A Discovery kit



1. Picture is not contractual.

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1 Features

- Ultra-low-power STM32L4 Series MCUs based on ARM® Cortex®-M4 core with 1 Mbyte of Flash memory and 128 Kbytes of SRAM, in LQFP100 package.
- 64-Mbit Quad-SPI (Macronix) Flash memory
- Bluetooth® V4.1 module (SPBTLE-RF)
- Sub-GHz (868 or 915 MHz) low-power-programmable RF module (SPSGRF-868 or SPSGRF-915)
- Wi-Fi® module Inventek ISM43362-M3G-L44 (802.11 b/g/n compliant)
- Dynamic NFC tag based on M24SR with its printed NFC antenna
- 2 digital omnidirectional microphones (MP34DT01)
- Capacitive digital sensor for relative humidity and temperature (HTS221)
- High-performance 3-axis magnetometer (LIS3MDL)
- 3D accelerometer and 3D gyroscope (LSM6DSL)
- 260-1260 hPa absolute digital output barometer (LPS22HB)
- Time-of-Flight and gesture-detection sensor (VL53L0X)
- 2 push-buttons (user and reset)
- USB OTG FS with Micro-AB connector
- Expansion connectors:
  - Arduino™ Uno V3
  - PMOD
- Flexible power-supply options:
  - ST-LINK USB V_{BUS} or external sources
- On-board ST-LINK/V2-1 debugger/programmer with USB re-enumeration capability: mass storage, virtual COM port and debug port
- Comprehensive free software including a variety of examples, as part of the STM32Cube package, as well as a cloud connector software expansion, enabling direct access to cloud servers
- Support of wide choice of Integrated Development Environments (IDEs) including IAR™, Keil®, GCC-based IDEs
- ARM® mbed-Enabled™ (see http://mbed.org)

2 Product marking

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

"E" or "ES" marking examples of location:

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

3 System requirements

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

4 Development toolchains

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

a. On Windows® only.

5 Demonstration software

The demonstration software is preloaded in the STM32 Flash memory for easy demonstration of the device peripherals in standalone mode. The latest versions of the demonstration source code and associated documentation can be downloaded from the www.st.com/stm32app-discovery webpage.

6 Ordering information

To order the B-L475E-IOT01A Discovery kit for IoT node, depending on the frequency of the Sub-GHz module, refer to *Table 1*.

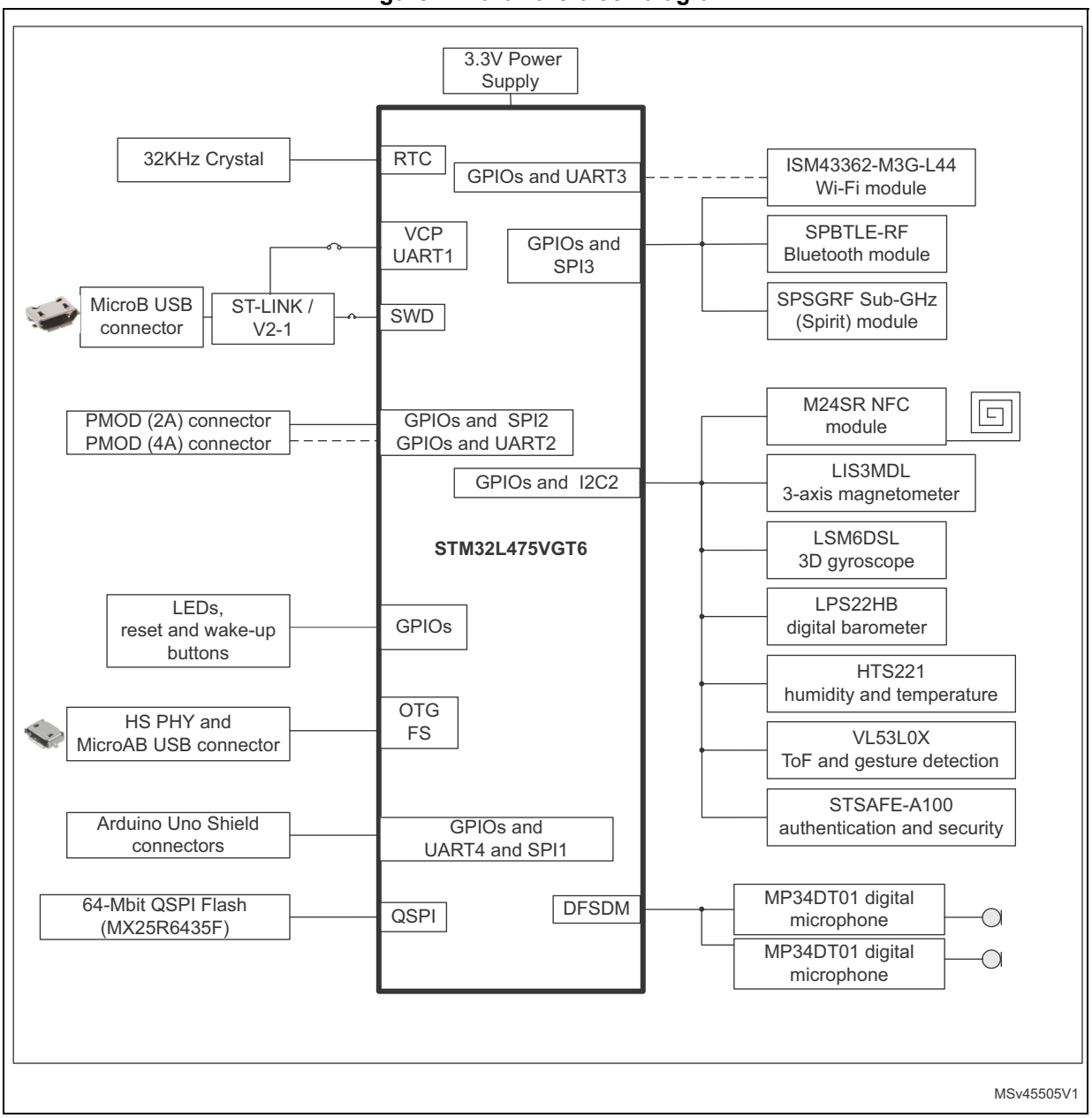
Table 1. Ordering information

Order code	Sub-GHz operating frequency
B-L475E-IOT01A1	915 MHz
B-L475E-IOT01A2	868 MHz

7 Hardware layout and configuration

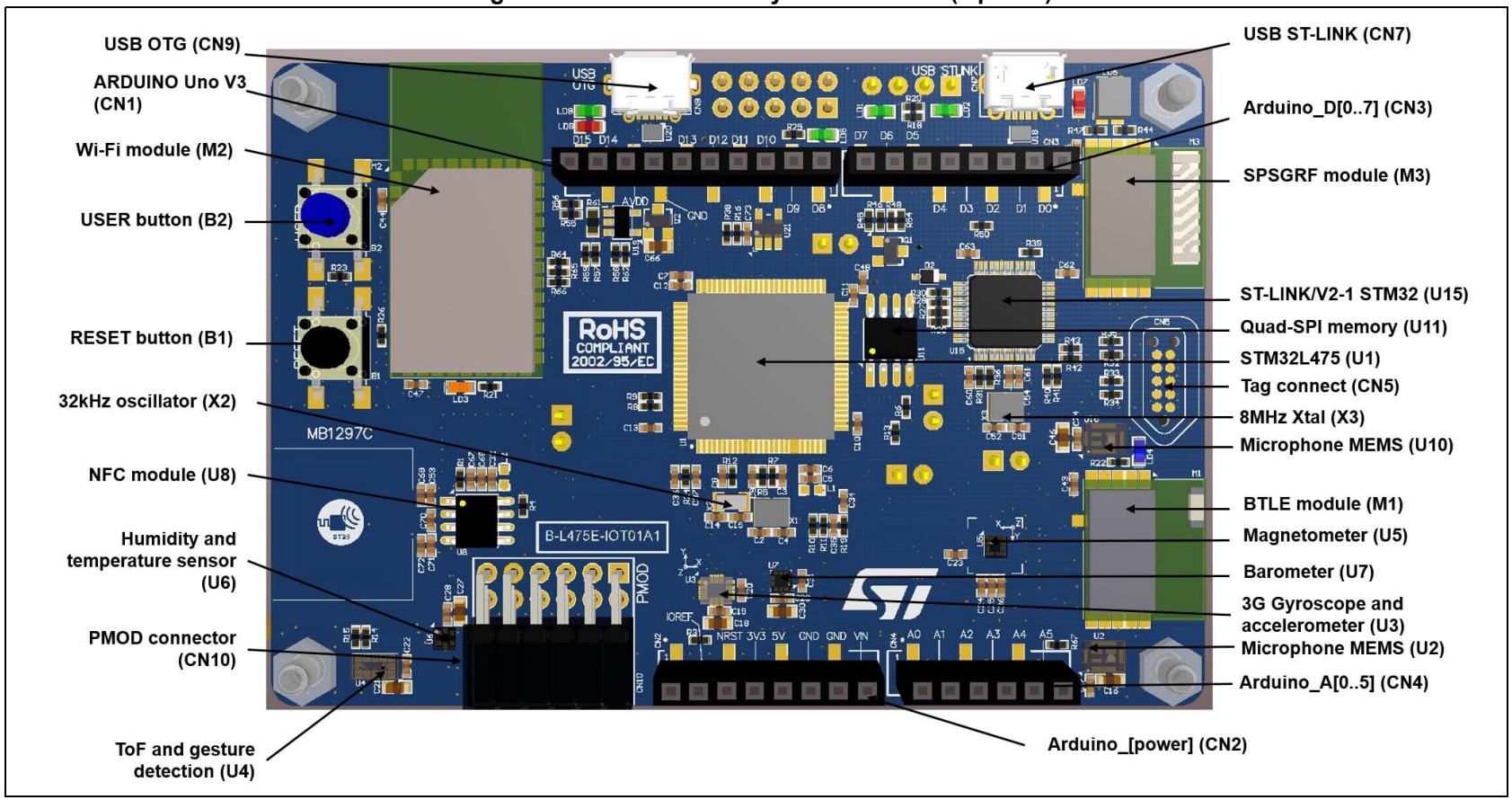
The STM32L4 Discovery kit for IoT node is designed around the STM32L475VGT6 (100-pin, LQFP package). The hardware block diagram (see *Figure 2*) illustrates the connection between the STM32 and peripherals (embedded ST-LINK, Arduino Uno V3 shields, PMOD connector, Quad-SPI Flash memory, USB OTG connectors, digital microphones, various ST-MEMS sensors and the four RF modules (Wi-Fi, Bluetooth, Sub-GHz and NFC)). *Figure 4* and *Figure 5* help users to locate these features on the STM32L4 Discovery kit.

Figure 2. Hardware block diagram



7.1 STM32L4 Discovery kit for IoT node layout

Figure 3. STM32L4 Discovery kit for IoT node (top view)



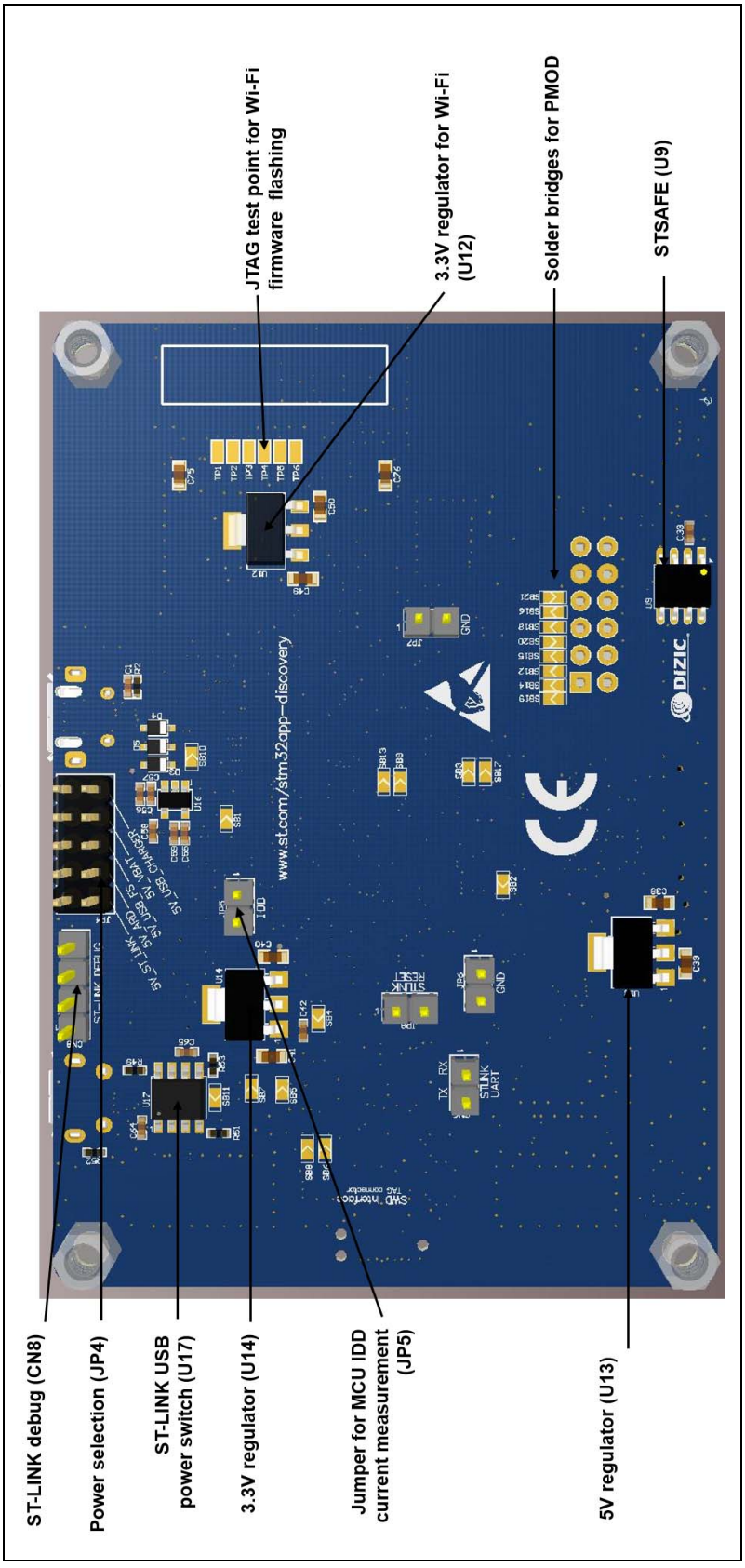
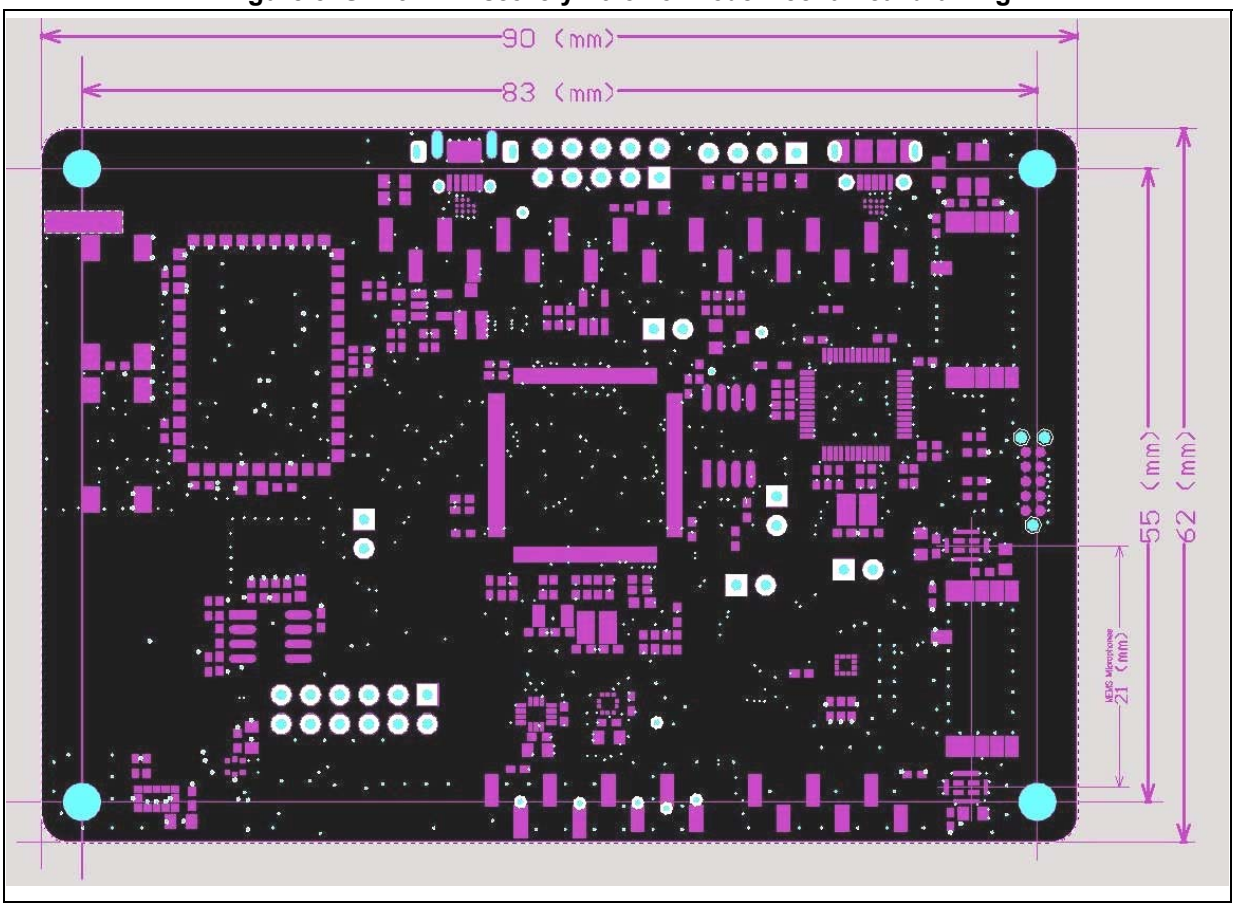


Figure 4. STM32L4 Discovery kit for IoT node (bottom view)

7.2 STM32L4 Discovery kit for IoT node mechanical drawing

Figure 5. STM32L4 Discovery kit for IoT node mechanical drawing



7.3 Embedded ST-LINK/V2-1

The ST-LINK/V2-1 programming and debugging tool is integrated on the STM32L4 Discovery kit for IoT node. Compared to the ST-LINK/V2 the changes are listed below.

The new features supported on the ST-LINK/V2-1 are:

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

The following features are no more supported on the ST-LINK/V2-1:

- SWIM interface
- Application voltage lower than 3 V

For all general information concerning debugging and programming features common between V2 and V2-1 versions, refer to *ST-LINK/V2 in-circuit debugger/programmer for STM8 and STM32* User manual (UM1075) at the *www.st.com* website.

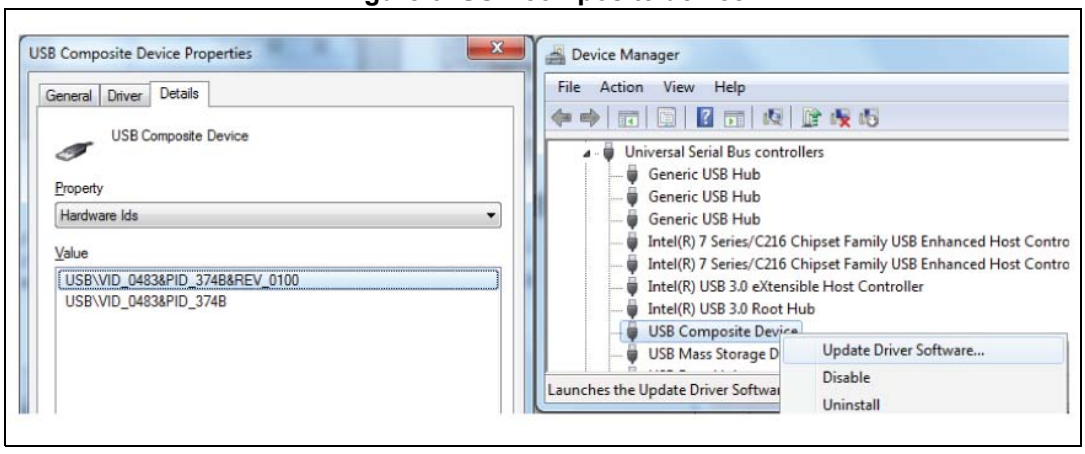
7.3.1 Drivers

Before connecting STM32L475VG to a Windows® PC (XP, 7, 8 or 10) via USB, a driver for the ST-LINK/V2-1 must be installed. It is available at the *www.st.com* website.

In case the STM32L4 Discovery kit for IoT node is connected to the PC before the driver is installed, some STM32L4 Discovery kit interfaces may be declared as “unknown” in the PC device manager. In this case the user must install the driver files, and update the driver of the connected device from the device manager (see *Figure 6*).

Note: Prefer using the “USB Composite Device” handle for a full recovery.

Figure 6. USB composite device



7.3.2 ST-LINK/V2-1 firmware upgrade

The ST-LINK/V2-1 embeds a firmware upgrade mechanism for in-situ upgrade through the USB port. As the firmware may evolve during the lifetime of the ST-LINK/V2-1 product (for example new functionalities, bug fixes, support for new microcontroller families), it is recommended to visit the *www.st.com* website, before starting to use the STM32L4 Discovery kit for IoT node and periodically, to stay up-to-date with the latest firmware version.

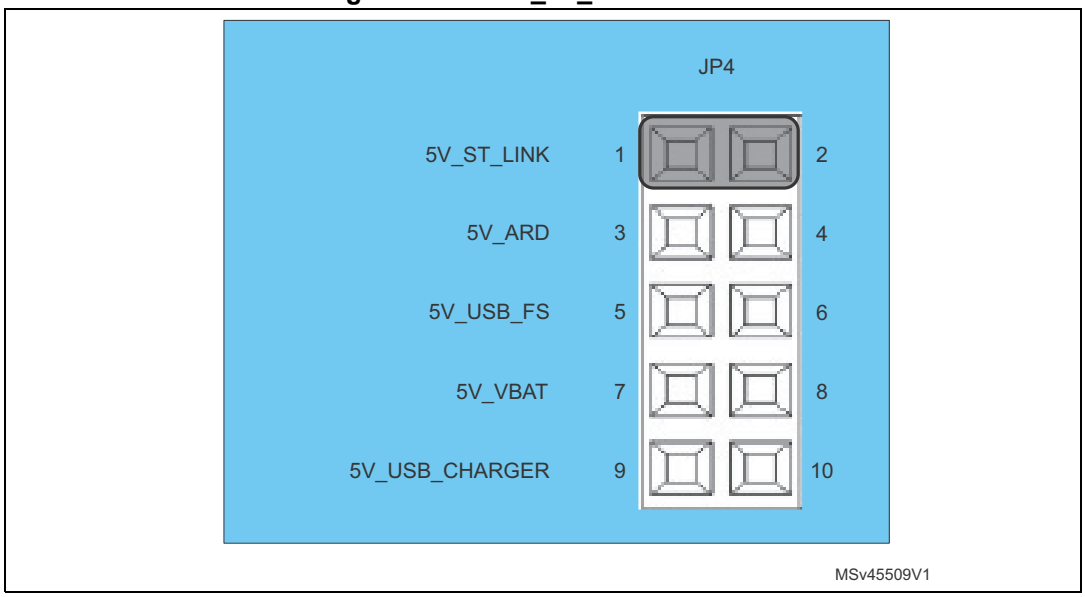
7.4 Power supply

The STM32L4 Discovery kit for IoT node is designed to be powered by 5 V DC power supply. It is possible to configure the STM32L4 Discovery kit to use any of the following five sources for the power supply: 5V_ST_LINK, 5V_ARD, 5V_USB_FS, 5V_VBAT and 5V_USB_CHARGER.

In case of external 5 V DC power adapter, the STM32L4 Discovery kit must be powered by a power supply unit or by an auxiliary equipment complying with the standard EN-60950-1: 2006+A11/2009, and must be Safety Extra Low Voltage (SELV) with limited power capability.

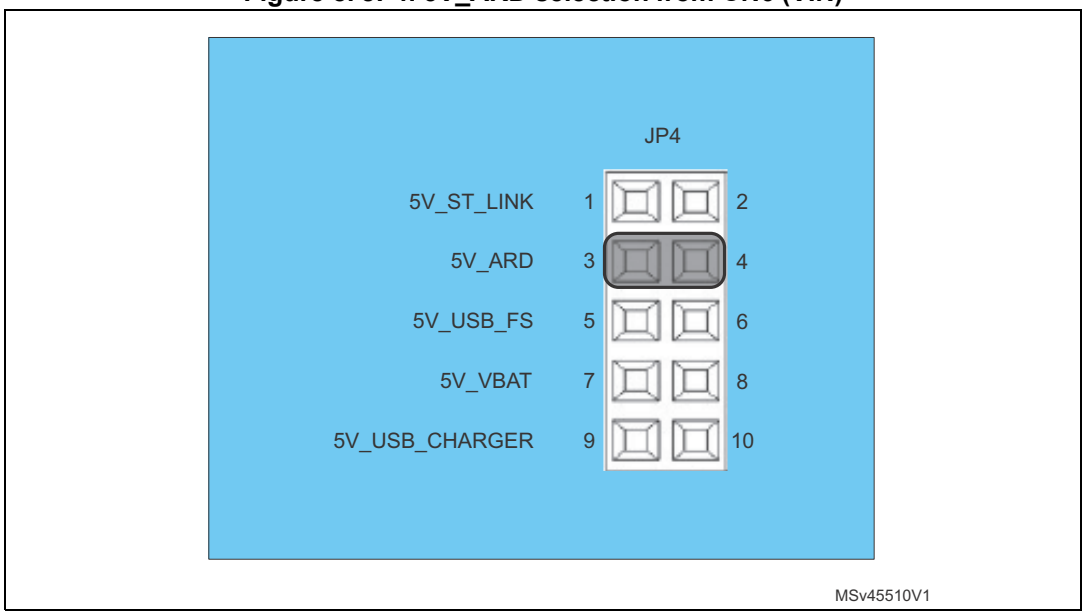
- **5V_ST_LINK** (See *Figure 7*) is a 5V DC power with limitation from CN7 (the USB type Micro-B connector of ST-LINK/V2-1). In this case, jumper of JP4 should be on pins 1 and 2 to select the 5V_ST_LINK power source on silkscreen of JP4. This is the default setting. If the USB enumeration succeeds, the 5V_ST_LINK power is enabled, by asserting the PWR_ENn signal (from STM32F103CBT6). This pin is connected to a power switch ST890, which powers the board. This power switch features also a current limitation to protect the PC in case of a short-circuit on board (more than 750 mA). STM32L4 Discovery kit for IoT node can be powered from the ST-LINK USB connector CN7, but only ST-LINK circuit has the power before USB enumeration, because the host PC only provides 100 mA to the board at that time. During the USB enumeration, STM32L4 Discovery kit for IoT node asks for the 500 mA power to the host PC. If the host is able to provide the required power, the enumeration finishes by a “SetConfiguration” command and then, the power transistor ST890 is switched ON, the red LED LD7 is turned ON, thus the STM32L4 Discovery kit for IoT node consumes up to 500 mA current, but no more. If the host is not able to provide the requested current, the enumeration fails. Therefore the ST890 remains OFF and the MCU part including the extension board is not powered. As a consequence the red LED LD7 remains turned OFF. In this case it is mandatory to use an external power supply.

Figure 7. JP4: 5V_ST_LINK selection



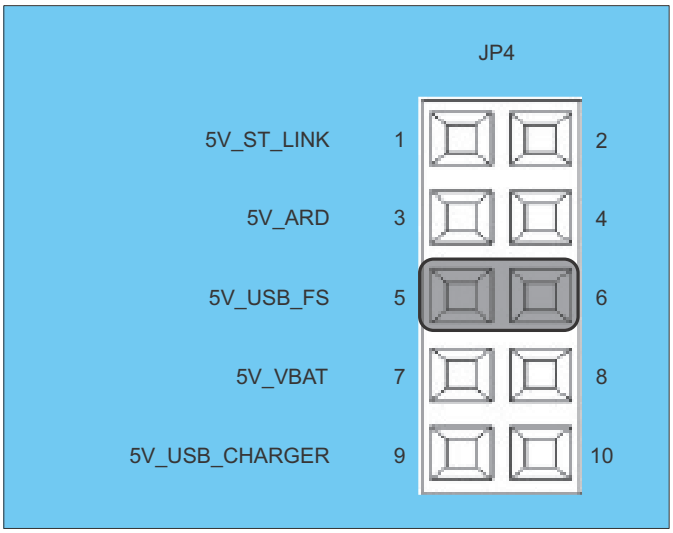
- **5V_ARD** (see *Figure 8*) is the 7 to 12 V DC power from Arduino CN2 pin 8 (named VIN on Arduino connector silkscreen). In this case, jumper of JP4 should be on pins 3 and 4 to select the 5V_ARD power source on silkscreen of JP4. In that case, the DC power comes from the power supply through the Arduino Uno V3 battery shield (compatible with Adafruit PowerBoost 500 Shield).

Figure 8. JP4: 5V_ARD selection from CN6 (VIN)



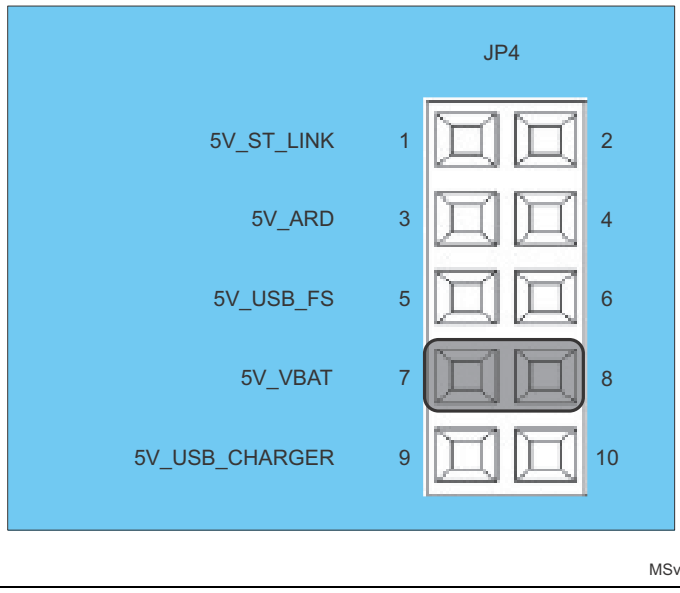
- **5V_USB_FS** (see *Figure 9*) is the DC power with 500 mA limitation from CN9, the USB OTG FS micro-AB connector. In this case, jumper of JP4 should be on pins 5 and 6 to select the 5V_USB_FS power source on silkscreen of JP4.

Figure 9. JP4: 5V_USB_FS



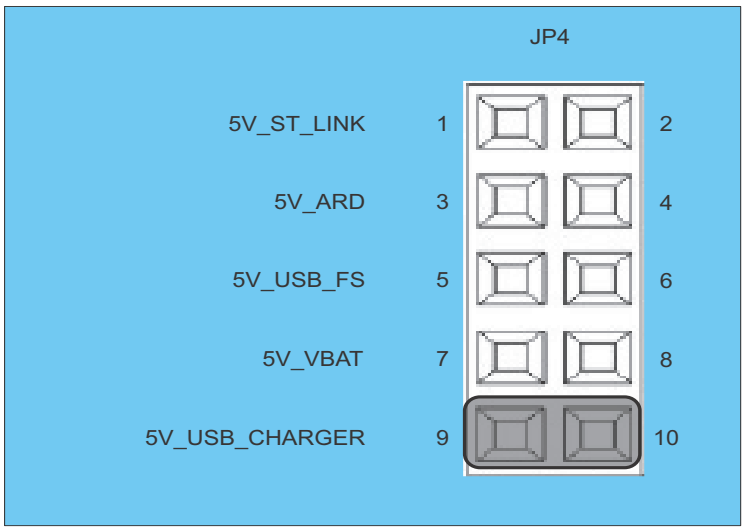
- **5V_VBAT** (see *Figure 10*) is the DC power coming from external. In this case, jumper of JP4 should be on pins 7 and 8 to select the 5V_VBAT power source on silkscreen of JP4.

Figure 10. JP4: 5V_VBAT



- **5V_USB_CHARGER** (see *Figure 11*) is the DC power charger connected to the USB ST-LINK (CN7). To select the 5V_USB_CHARGER power source on silkscreen of JP4, the jumper of JP4 should be on pins 9 and 10. In this case, if the STM32L4 Discovery kit for IoT node is powered by an external USB charger then the debug is not available. If the PC is connected instead of the charger, the limitation is no more effective, in this case the PC could be damaged.

Figure 11. JP4: 5V_USB_CHARGER selection



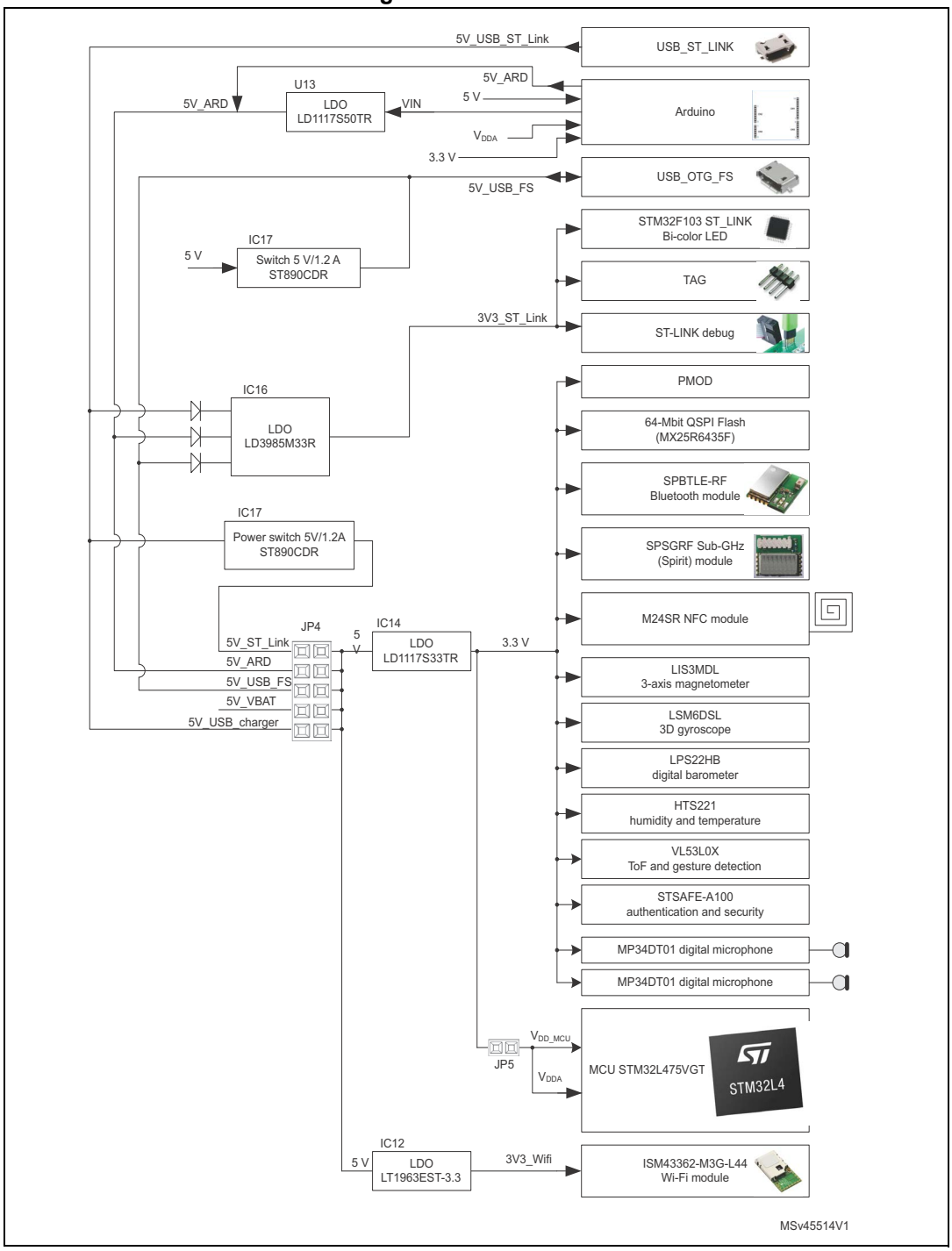
Note: If the board is powered by a USB charger, there is no USB enumeration, so the led LD7 remains OFF permanently and the board is not powered. In this specific case only, the resistor R30 needs to be soldered, to allow the board to be powered anyway.

Caution: Do not connect the PC to the ST-LINK (CN7) when R30 is soldered. The PC may be damaged or the board may not be powered correctly.

The green LED LD5 is lit when the STM32L4 Discovery kit for IoT node is powered by the 5 V correctly.

The power tree is showed in the *Figure 12*.

Figure 12. Power tree



7.5 Programming/debugging when the power supply is not from ST-LINK (5V_ST_LINK)

It is mandatory to power the board first using CN2 (V_{IN}) or CN9 (USB_FS_OTG), then connecting the USB cable to the PC. Proceeding this way ensures that the enumeration succeeds thanks to the external power source.

The following power sequence procedure must be respected:

- Connect the jumper JP4 on (5V_ARD) or (5V_USB_FS)
- Connect the external power source to CN2 in case of an Arduino shield or to CN9 in case of USB FS host interface
- Check that the red LED LD5 is turned ON
- Connect the PC to USB connector CN7

If this sequence is not respected, the board may be powered by V_{BUS} first from ST-LINK, and the following risks may be encountered:

- If more than 500 mA current is needed by the board, the PC may be damaged or current can be limited by PC. As a consequence the board is not powered correctly.
- 500 mA is requested at the enumeration, so there is a risk that the request is rejected and enumeration does not succeed if the PC cannot provide such current.

7.6 Clock sources

Three clock sources are described below:

- X1 which is the 8 MHz oscillator for STM32L475VG microcontroller. This clock is not implemented in a basis configuration.
- X2 which is the 32.768 KHz crystal for the STM32L475VG embedded RTC
- X3 which is the 8 MHz clock from ST-LINK MCU for the STM32L475VG microcontroller.

7.7 Reset sources

The reset signal of the STM32L4 Discovery kit is active low and the reset sources includes:

- A reset button B1
- An Arduino Uno V3 shield board from CN2
- An embedded ST-LINK/V2-1

7.8 USB OTG FS

The STM32L4 Discovery kit supports USB OTG FS communication via a USB Micro-AB connector (CN9).

To do that and to fulfill USB OTG requirements, an 8 MHz crystal must be fitted at X1 position (not implemented as basis). The components to be added by users are:

- 8 MHz crystal (at X1 position); ref: NX3225GD-8.00M
- 8.2 pF capacitor (0402 size) at C2 position
- 8.2 pF capacitor (0402 size) at C4 position

- 0 ohm resistor (0402 size) at R5 position
- 0 ohm resistor (0402 size) at R7 position

The STM32L4 Discovery kit can be powered by the USB connectors at 5 V DC with 500 mA current limitation.

A USB power switch (IC19) is also connected on V_{BUS} and provides power to CN9. The green LED LD9 is lit when either:

- Power switch is ON and STM32L4 Discovery kit works as an USB host
- V_{BUS} is powered by another USB host when STM32L4 Discovery kit works as a USB device.

The red LED LD8 is lit when an over-current occurs.

7.9 Quad-SPI NOR Flash memory

64-Mbit Quad-SPI NOR Flash memory (N25Q128A13EF840F from MICRON) is connected to the Quad-SPI interface of the STM32L475VGT6.

7.10 Virtual COM port

The serial interface USART6 is directly available as a virtual COM port of the PC connected to the ST-LINK/V2-1 USB connector CN7. The virtual COM port settings are configured as: 115200 b/s, 8 bits data, no parity, 1 stop bit, no flow control.

7.11 RF modules

Four RF interfaces are available on the STM32L4 Discovery kit for IoT node board:

- Bluetooth (V4.1 compliant) SPBTLE-RF module
- Sub-GHz (868 or 915 MHz) low-power-programmable RF module (SPSGRF-868 or SPSGRF-915),
- Wi-Fi module Inventek ISM43362-M3G-L44 (802.11 b/g/n compliant)
- Dynamic NFC tag based on M24SR with its printed NFC antenna (double layer inductive antenna etched on the PCB).

7.11.1 Bluetooth (V4.1 compliant) SPBTLE-RF module.

The ST SPBTLE-RF module (M1) is implemented on top side of the STM32L4 Discovery kit for IoT node board.

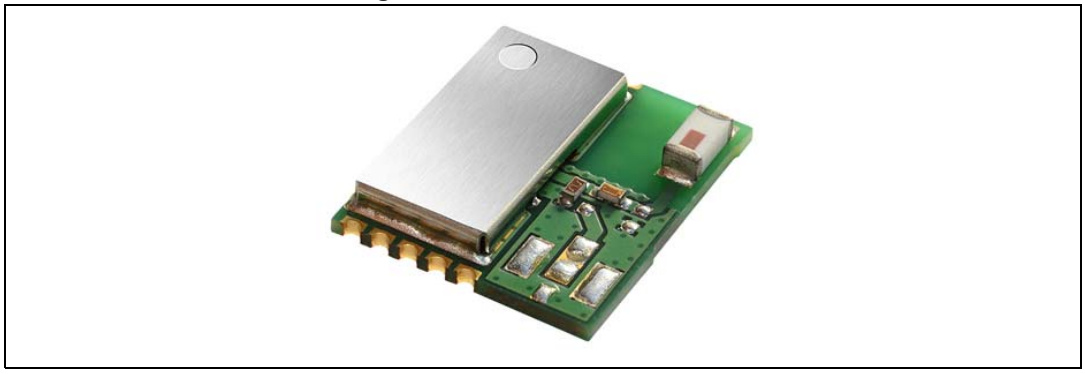
The SPBTLE-RF is an easy to use Bluetooth smart master/slave network processor module, compliant with Bluetooth V4.1. The SPBTLE-RF B-Smart module supports multiple roles simultaneously, and it can act at the same time as Bluetooth Smart sensor and hub device.

The entire Bluetooth Smart stack and protocol are embedded into the SPBTLE-RF B-Smart module. The external host application processor, where the application resides, is connected to the SPBTLE-RF B-Smart module through a standard SPI interface (SPI3 of STM32L475VGT6).

The SPBTLE-RF B-Smart module provides a complete RF platform in a tiny form factor (foot print of this module is 13.5 mm x 11.5 mm). Radio, antenna, high frequency and LPO

oscillators are integrated to offer a certified solution to optimize the time to market of the final applications.

Figure 13. SPBTLE-RF module



The main features of the ST SPBTLE-RF module are listed below.

- Bluetooth V4.1 compliant (supports master and slave modes, multiple roles supported simultaneously
- Embedded Bluetooth low-energy protocol stack (GAP, GATT, SM, L2CAP, LL, RFPHY)
- Bluetooth low-energy profiles provided separately
- Bluetooth radio performance:
- Embedded ST BlueNRG-MS
- Tx power: + 4 dBm
- Host interface: SPI, IRQ, and RESET. On-field stack upgrading available via SPI.
- Certification: CE qualified, FCC, IC modular approval certified, BQE qualified
- On-board chip antenna

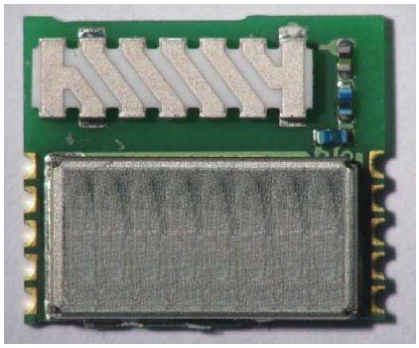
7.11.2 Sub-GHz low-power-programmable RF module (SPSGRF-868 or SPSGRF-915)

Two modules are available depending on the frequency of the Sub-GHz module (M3). The SPSGRF-868 and SPSGRF-195 are easy-to-use, low-power Sub-GHz modules based on the SPIRIT1 RF transceiver, operating respectively in the 868 MHz SRD and 915 MHz ISM bands.

The modules provide a complete RF platform in a tiny form factor (foot print of this module is 13.5 mm x 11.5 mm). The SPSGRF-915 is an FCC certified module (FCC ID: S9NSPSGRF) and IC certified (IC 8976CSPSGRF), while the SPSGRF-868 is certified CE0051.

The modules include four programmable I/O pins and an SPI serial interface (SPI3 of STM32L475VG).

Figure 14. SPSGRF module



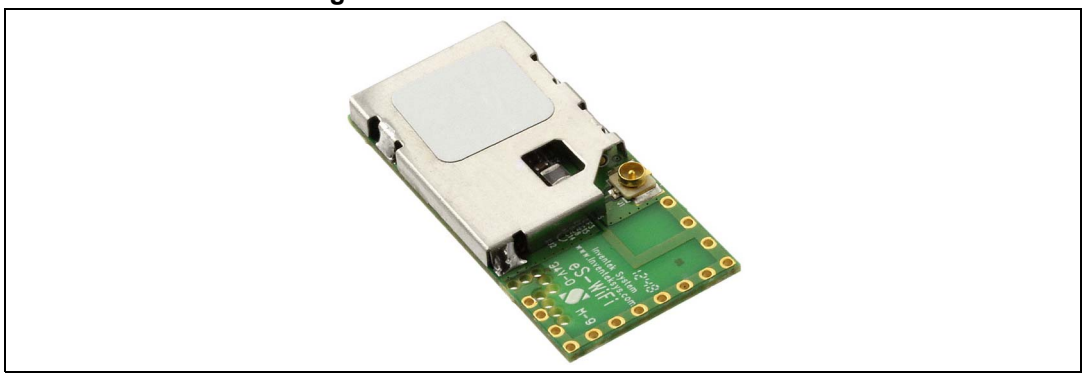
The main features of the ST SPSGRF module are listed below.

- Programmable radio features:
  - Based on Sub-1GHz SPIRIT1 transceiver and integrated Balun (BALF-SPI-01D3)
  - Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOk and ASK
  - Air data rate from 1 to 500 kbps
  - On-board antenna
- Programmable RF output power up to +11.6 dBm
- Host interface: SPI
- General I/O (up to 32 programmable I/O functions on 4 GPIO programmable module pins
- Two typical carrier frequency versions:
  - SPSGRF-868 with 868 MHz tuned antenna
  - SPSGRF-195 with 915 MHz tuned antenna

7.11.3 Wi-Fi module Inventek ISM43362-M3G-L44 (802.11 b/g/n)

The Inventek ISM43362-M3G-L44 module (M2) is implemented on top side of the STM32L4 Discovery kit for IoT node board. This module is an embedded (eS-WiFi) wireless Internet Connectivity device. The Wi-Fi module hardware consists of an ST Cortex® -M3 host processor, an integrated antenna (or optional external antenna) and a Broadcom Wi-Fi device. The module uses either a UART (UART3 of STM32L475VG) or an SPI (SPI3 of STM32L475VG) interface. As default, an SPI interface is used, as the corresponding firmware (for SPI capability) is downloaded on the Wi-Fi ISM43362-M3G-L44 module. The Wi-Fi module requires no operating system and has a completely integrated TCP/IP stack that only requires AT commands to establish connectivity for wireless product. The foot print of this module is 14.5 mm x 30 mm.

Figure 15. ISM43362-M3G-L44 module



The main features of the Inventek ISM43362-M3G-L44 module are:

- Based on the Broadcom BCM43362 MAC/Baseband/Radio device
- Supports Broadcom WICED SDK
- CPU ARM® Cortex®-M3 32-bit RISC core from ST Microelectronics
- IEEE 802.11n D7.0 -OFDM-72.2 Mbps -single stream w/20 MHz, Short GI
- IEEE 802.11g (OFDM 54 Mbps)
- IEEE 802.11b (DSSS 11 Mbps)
- IEEE 802.11i (Security)
  - WPA (Wi-Fi Protected Access) –PSK/TKIP
  - WPA2 (Wi-Fi Protected Access 2)- AES/CCMP/802.1x Authentication
- GPIO, 5 ADC (SPI interface utilizes ADC pins)
- Power-saving mode allows the design of low-power applications
- Lead Free Design which is compliant with ROHS requirements
- EMI/EMC Metal Shield for best RF performance in noisy environments and to accommodate for lower RF emissions/signature for easier FCC compliance.
- FCC/CE compliance certification

On MB1297 rev C, the FW revision inside the Wi-Fi module must be: C3.5.2.3.BETA9. The Wi-Fi module maximum output power is limited to 9 dBm to fulfill FCC/IC/CE requirements. A Wi-Fi output power higher than 9 dBm at the Wi-Fi antenna is not allowed.

Note: Since Wi-Fi and BLE modules are using the same frequency ISM band (2.4 to 2.485 GHz), the simultaneous activity of both modules may affect the RF performances of Wi-Fi and/or BLE (in term of range or throughput).

7.11.4 Dynamic NFC Tag based on M24SR with its printed NFC antenna

M24SR64-Y belongs to the ST25 family which includes all STMicroelectronics NFC/RFID Tag and reader products. The M24SR64-Y device is a dynamic NFC/RFID Tag IC with a dual interface. It embeds an EEPROM memory. It can be operated from an I^2C interface or by a 13.56 MHz RFID reader or by an NFC phone. The I^2C interface uses a two-wire serial interface, consisting of a bidirectional data line and a clock line. It behaves as a slave in the I^2C protocol.

The RF protocol is compatible with ISO/IEC 14443 Type A and NFC Forum Type 4 Tag.

The main features of the M24SR64-Y are:

- I^2C interface (I2C2 of STM32L475VGT6). The two-wire I^2C serial interface supports 1 MHz protocol.
- Contactless interface:
  - NFC Forum Type 4 Tag
  - ISO/IEC 14443 Type A
  - 106 Kbps data rate
  - Internal tuning capacitance: 25 pF
- Memory:
  - 8-Kbyte (64-kbit) EEPROM
  - Support of NDEF data structure
  - Data retention: 200 years
  - Write cycle endurance:
    1 million Write cycles at 25 °C
    600 K Write cycles at 85 °C
    500 K Write cycles at 105 °C
- Read up to 246 Bytes in a single command
- Write up to 246 Bytes in a single command
- 7-Byte unique identifier (UID)
- 128-bit password protection

7.12 ST sensors

Several ST Microelectronics sensors are available on the STM32L4 Discovery kit for IoT node board, they are listed below:

- 2 on-board ST-MEMS audio sensor omnidirectional digital microphones (MP34DT01)
- Capacitive digital sensor for relative humidity and temperature (HTS221)
- High-performance 3-axis magnetometer (LIS3MDL)
- 3D accelerometer and 3D gyroscope (LSM6DSL)
- 260-1260 hPa absolute digital output barometer (LPS22HB)
- Time-of-Flight and gesture detection sensor (VL53L0X)

7.12.1 Two on-board ST-MEMS audio sensor omnidirectional digital microphones (MP34DT01)

The MP34DT01 is an ultra-compact, low-power, omnidirectional, digital ST-MEMS microphone built with a capacitive sensing element and an IC interface.

The sensing element, capable of detecting acoustic waves, is manufactured using a specialized silicon micromachining process dedicated to produce audio sensors.

The IC interface is manufactured using a CMOS process that allows designing a dedicated circuit able to provide a digital signal externally in PDM format.

The MP34DT01 has an acoustic overload point of 120 dBSPL with a 63 dB signal-to-noise ratio and –26 dBFS sensitivity.