Wireless connectivity
for IoT applications

Wi-Fi
Bluetooth®
Bluetooth® **Smart**
Sub 1 GHz

life.augmented

Content

Tools and resources 33

Useful links 48

Online support 48

Wireless connectivity for IoT applications

Overview

INTRODUCING IoT

IoT, or the Internet of Things, can be loosely defined as a network of small, low-cost, low-power, ubiquitous electronic devices where sensing data and communicating information occur without direct human intervention. Each device functions as a "smart node" in the network by sensing information and performing low-level signal processing to filter signals from noise and to reduce the bandwidth needed for node-to-node communications. The nodes need to communicate with a centralized "cloud" in a secure manner to protect, store and process data, and bounce actionable information down to humans. Analysts forecast that IoT will grow to an estimated 36 billion connected devices by 2020 (Fig.1).

Bilion Units installed base
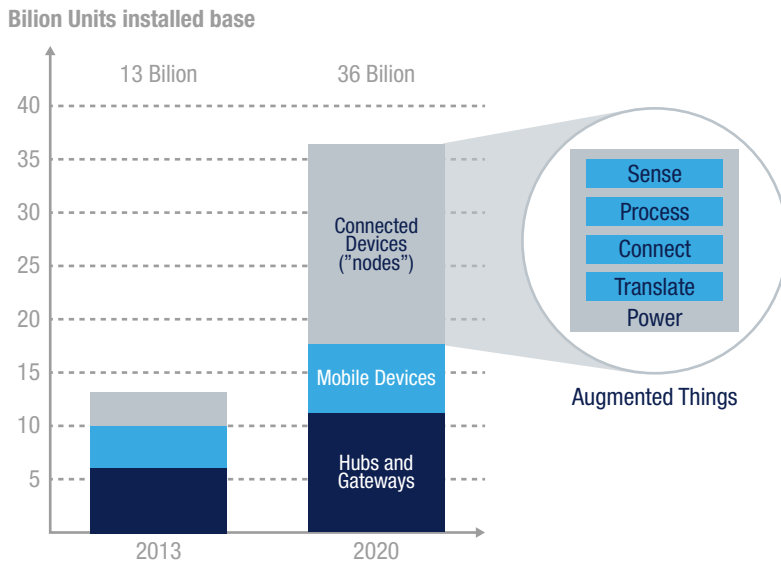
Fig.1 – Connected nodes in 2020 (*) Source ABI research
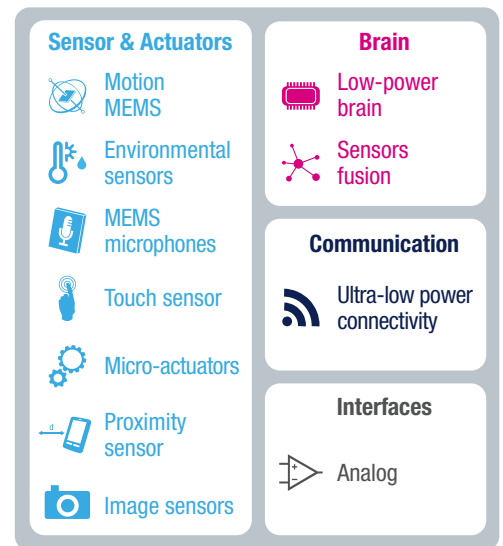
Fig.2 – STMicroelectronics building blocks for IoT

ST'S ECO-SYSTEM FOR IoT

With one of the broadest portfolios using state-of-the-art technology in the semiconductor industry , **ST provides all the building blocks for IoT** from **sensors**, **amplifiers** and **low-power microcontrollers** to **power management**, **security IP**, **analog** and **connectivity** ICs (Fig.2).

BUILDING VALUABLE APPLICATIONS IN THE AGE OF IoT

Regulation and lifestyle are driving the change: the need to conserve energy, increase efficiency and use technology to work for us and improve how we live. These trends push connectivity in applications such as:

- Wearable devices: smart wrist and arm bands, watches, fitness and healthcare devices
- Smart Home: smart lighting, appliances, energy-control and home-security devices
- Smart City: smart metering, asset tracking, etc.
- Smart Car: connectivity in the car and smart electric-vehicle charging stations

ST'S WIRELESS CONNECTIVITY PORTFOLIO

Low-power wireless connectivity represents the key technology for connecting smart objects to the internet and the cloud. As a matter of fact, wireless connectivity is not dominated by one single technology. Depending on application needs or technology constraints, different hardware and software integration requirements must be considered. The chart below describes the main wireless connectivity schemes that are part of ST's portfolio:

- Wi-Fi
- Bluetooth
- Bluetooth Smart (or Bluetooth Low Energy, 4.x)
- Sub-1 GHz

			Advantages	Disadvantages
Wi-Fi node	Wi-Fi gateway	Cloud	• Existing infrastructure • Customer familiarity	• Power consumption • Limited range • Large stack • Costly radio • Difficult set-up
BLE node	Cell phone	Cloud	• Connection to smartphone • Low power • Easy set-up	• Limited range • Royalties
SubGhz node	SubGhz / WiFi concentrator	Wi-Fi gateway / Cloud	• Light stack • Multi radio support • Multi P/S support • Good range • Very low power	• Additional concentrator required

Connectivity inside

What are the main reasons for choosing ST's connectivity devices?

The majority of objects used in IoT applications are battery-operated sensors; implying very stringent energy consumption requirements for months or years of battery life. The ultimate goal is to keep IoT devices in a low-power state as long as possible when exchanging data, and entering an active state only when absolutely necessary. The recognized added value of ST's connectivity devices is the fact that they have the world's highest energy efficiency. This unmatchable result is due to the ultra-low power consumption of every IP constituting our SoCs but also to an incredible transition speed between low-power and active states. These characteristics are possible thanks to ST's state-of-the-art design in CMOS technology.

Steady state current consumption

Comp C

Comp B

ST

Comp A

State transition speed

Energy efficiency

ST

Comp A

Comp B

Comp C
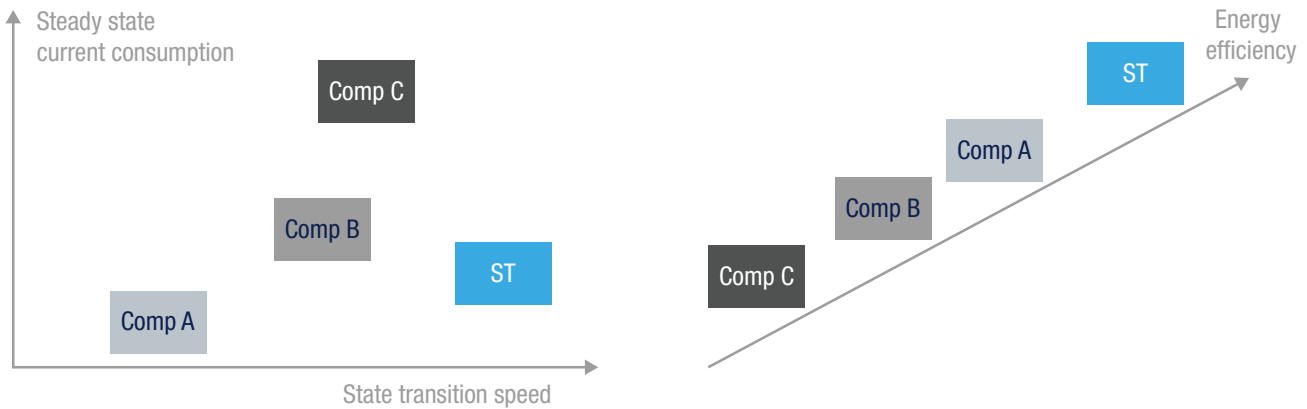
How to select the ideal wireless technology for your IoT network

When selecting a wireless technology for connected devices, a few considerations must be taken into account depending on the final application. Four main factors however are always involved in the selection:

- Maximum throughput
- Power consumption
- Maximum distance range
- Web access: gateway connecting the device to the internet (e.g. Wi-Fi, ADSL router, Mobile network)

The charts below help answer these questions to select the best technology from the ST portfolio.

TYPICAL DISTANCE RANGE [m]

■ NFC ■ Bluetooth Smart ■ Bluetooth ■ Wi-Fi for IoT ■ SubGHz

SLEEP CURRENT [uA]

■ NFC ■ Bluetooth Smart ■ Bluetooth ■ Wi-Fi for IoT ■ SubGHz

MAXIMUM THROUGHPUT [Mbps]

■ NFC ■ Bluetooth Smart ■ Bluetooth ■ Wi-Fi for IoT ■ SubGHz

BATTERY LIFE [years]

■ NFC ■ Bluetooth Smart ■ Bluetooth ■ Wi-Fi for IoT ■ SubGHz

6
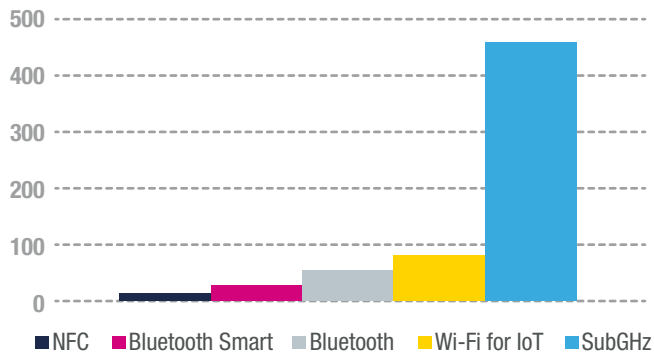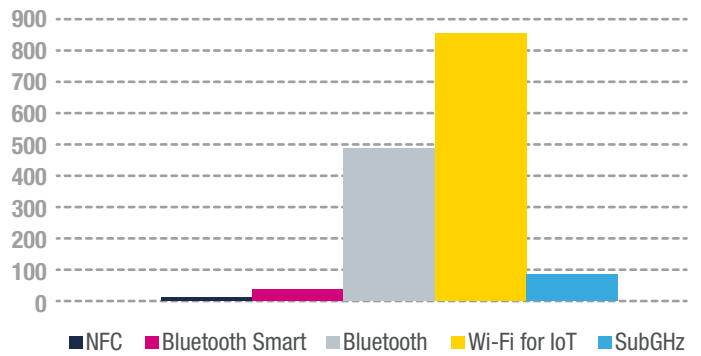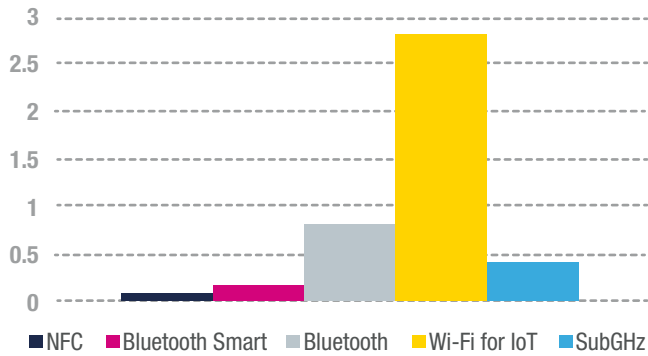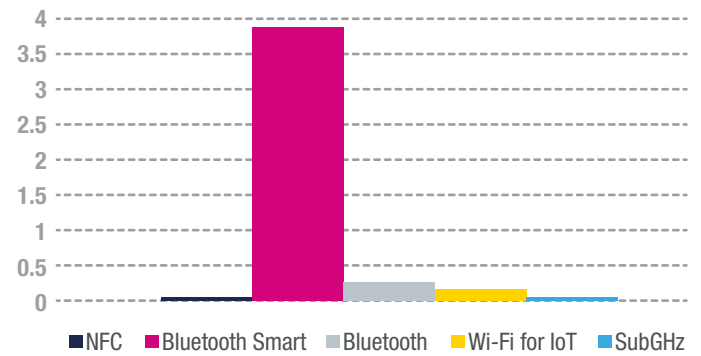
Wireless solution ICs and modules

Low-power wireless technologies play a crucial role in providing connectivity for hundreds of different devices in the Internet of Things (IoT). However, designing a low-power wireless interface integrating an IC directly on a printed-circuit board is a **challenging task**, requiring time, money and expertise in designing a custom-built implementation of a complex RF technology starting with a bare radio IC.

At the same time, wireless communication is often a **portion of a more complex design** that involves other components and IPs, as well as the software expertise required to build the ecosystem around a device.

Thus when **time to market** is essential, wireless modules really help take care of the RF portion without a struggle.

With the increasing number of wireless nodes, a modular approach is becoming more and more popular and now represents a steady portion of today's market. (Today modules represent 32% of the overall low-power wireless market according to IHS.)

While small companies may prefer a plug-and-play solution ready to be easily and quickly integrated into their product, modules are not limited to low-volume applications. In some cases, modules are a logical choice even for devices shipping millions of units, since they simplify manufacturing and increase flexibility.

To meet different customer expectations and needs, ST complements its well-known offer of ICs with wireless modules providing an easy solution or an intermediate step before chip-down implementation.

STMicroelectronics offers a variety of wireless modules to address the needs of designers for their applications:

- Wi-Fi modules
- Bluetooth 3.0 Class II and Class I modules
- Sub-GHz modules

All ST modules are FCC and CE certified.

SELECTING THE RIGHT CONNECTIVITY SOLUTION: ICs OR MODULES

Both IC and module solutions present benefits and drawbacks that must be carefully evaluated in relation to your various needs. This section analyzes the factors, unrelated to applications and technology, which may influence the decision to adopt a module or directly integrate an IC solution.

Benefits of using a module

Let's define a module as a self-contained subsystem that utilizes a standard IC and includes various components required to realize a fully functioning RF solution. For example, a module may include a crystal oscillator, power amplifiers, capacitors, inductors, an antenna connection and an RF shield. Modules are supplied tested, calibrated and pre-certified to the required standard(s) (e.g. FCC, ETSI) by the module vendor, and therefore can provide companies with a quicker and easier route to the market with what is, essentially, a plug-and-play solution. All the above components and the level of support provided can define a rank among high- and low-end modules that reflects the module's price range. The more a module is complete, the more it covers the advantages discussed below. We can summarize all the benefits of a module adoption in one word – time-to-market.

Time-to-market

Typically by using a module, the device manufacturer can take products to market more rapidly. It gives the manufacturer more time to develop functions for the final product while utilizing the module's plug-and-play functionality to quickly integrate RF technology, thus using a ready-made solution to minimize costs and development risk.

Let's view in detail what exactly time-to-market means.

RF expertise, certification and testing

RF design is described by many as being a "black art", and is not something every electronics company is capable of undertaking without first investing heavily in RF research and development. RF design requirements increase the initial cost of developing a device that includes direct RF IC integration. To build a direct IC integrated design, a good RF design expertise is required.

Components including filters, amplifiers, clocks, capacitors, inductors, crystal oscillators, and antennas need to be designed on the board. There needs to be network-matching circuitry to ensure the radio and antenna are well matched to avoid signal loss. The antenna is a very important part of the RF design and if the design uses an external one, it is important that the environment in which the device is to be used is taken into account.

The same level of RF expertise is not required to incorporate ST's modules into a device; they are pre-certified and come with the necessary hardware and software solutions to enable it to function "out of the box" and include an integrated antenna or UFL connector, so most of the RF matching has already been done.

ST's modules can save manufacturers the cost of acquiring the relevant skills to create an RF solution and are delivered pre-tested and certified by the required regulatory body.

Ease of integration

ST's modules can be easily integrated as an embedded system or in other words a "complete solution" which typically includes both the certified hardware and the software (with relevant certification if needed, e.g. for Bluetooth modules) required to integrate it. This allows the module to be plug and play, reducing the need for investment in software design. Furthermore, depending on the technology implemented (e.g. sub-GHz modules), some of ST's modules provide an open solution for taking advantage of the potential technology.

Risk

Using a module can reduce the risk associated with implementing RF functionality in a device. The modules absorb the associated risk related to the design, manufacture, testing, and certification of the RF functions. Moreover, manufacturing complexity is reduced; it is no longer necessary to deal with complex radio packages but with a simple, standard PCB.

Flexibility

Using a pre-certified module allows manufacturers to create a range of products without having to certify and test each individual design. Because the module is already certified, there is no need to re-test the new design if a module is used for RF capability.

This also applies when the product needs an update. It can be easily upgraded with the latest version of ST's module without having to be certified.

One-stop shop

When choosing to directly integrate an IC (rather than a module), the supply chain for the additional components required for the RF solution can be complex, leading to problems when parts are difficult to obtain. These difficulties are eliminated when using a module. Rather than sourcing up to 90 different components for an RF design, simply purchase the module at a single source to get the required hardware, software, certification and support.

Benefits of direct IC integration

Although there are many benefits to using a module, there are a number of important drawbacks. This section discusses the main drawbacks.

Cost

Cost is major part of any design activity. Typically, a module is more expensive than an IC, unit for unit. If an application has a stable design and high-volume output and the connectivity requirements are unlikely to change, then it makes more sense for companies with high volume over the years to make the transition to a design featuring direct IC integration.

The cost savings will be experienced within a few years of switching to an on-board IC design.

Form factor

In applications where space in the device is limited, this may lead to the choice of an on-board design. Direct IC integration can save on the footprint required by a module. The size of modules varies with each manufacturer technology, but in applications where space is vital, even the very compact size of ST's modules may be too large.

IP networking and mesh solutions

Wi-Fi / IEEE 802.11 communication interface

Wi-Fi OVERVIEW

Wi-Fi is one of the candidate technologies for the Internet of Things (IoT). It natively offers TCP/IP, the networking protocol that today connects billions of devices world-wide. Things can be connected to the internet through existing Wi-Fi access points in a growing number of private houses and public buildings including schools, hospitals, offices and industries. We already use Wi-Fi to remotely monitor and control things around us: smartphones, tablets and laptops all offer Wi-Fi and internet connectivity. This makes it easy for a remote agent in the cloud to take care of remotely handling things in a partial/fully automated manner. Thanks to its massive penetration and seamless integration with internet, Wi-Fi promises a simple and cost-effective scenario for IoT.

IoT applications

- **Smart Home and Smart Building**: remote wireless monitoring and management of lights, climate-control, appliances, power outlets, door and garage locks, sprinklers, etc.
- **Industrial**: manufacturing control, maintenance, diagnostics, and M2M data flow.
- **Medical**: M2M communication and fitness equipment.
- **Energy management**: metering systems
- **Security**: surveillance, presence-detection, and alarm actuators.

Home/building automation
Home life control: alarm, device remote control and monitoring

Smart cities
Monitoring of parking spaces, waste management

Wi-Fi enabled consumer devices

WiFi enabled IoT devices

Smart energy/smart grid
Connected smart meters

Industrial
Manufacturing control and management, machine to machine data flow communication
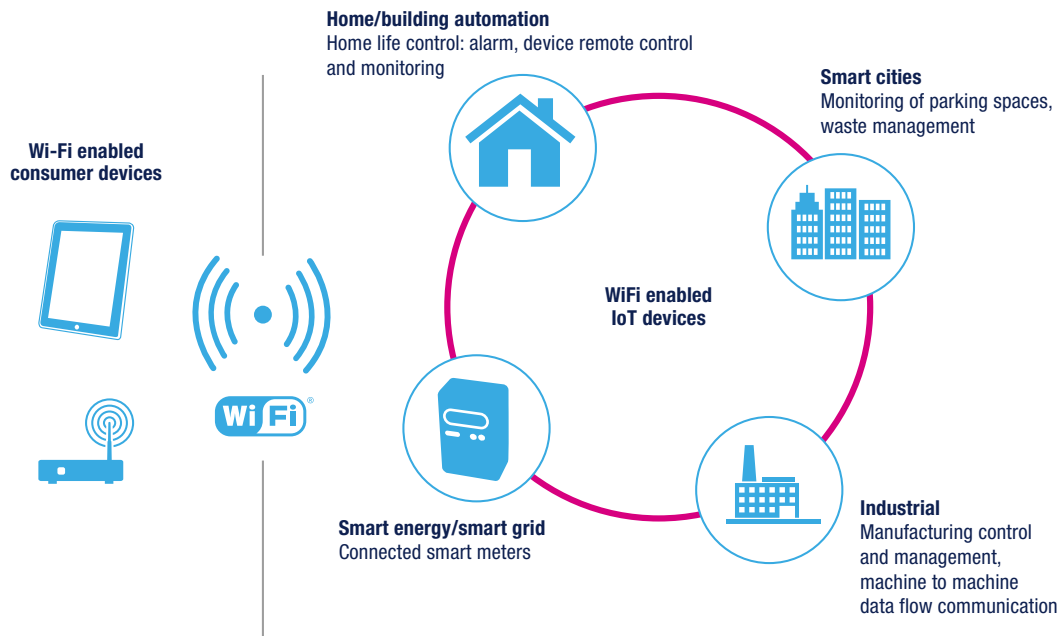
Wi-Fi technology

Wi-Fi technology was designed to connect electronic devices in a wireless local area network (WLAN). Devices within the WLAN can exchange data or connect to the Internet at a data rate of 54 Mbit/s or more. Wi-Fi is based on the IEEE 802.11 family of standards operating in the in the 2.4 GHz (IEEE 802.11b/g/n) and 5 GHz (IEEE 802.11a/n/ac unlicensed bands available worldwide. The Wi-Fi alliance is the non-profit organization ensuring that all "Wi-Fi certified" devices can interoperate. More information is available at www.wi-fi.org.

ST's Wi-Fi solution

ST offers a complete portfolio of IoT products ranging from sensors, amplifiers and microcontrollers to a family of ready-to-use TCP/IP Wi-Fi modules that can be easily integrated into customer IoT applications.

SPWF01S MODULE WITH STM32 MCU ON-BOARD

802.11 b/g/n compliant
Advanced Power saving modes
P2P (Mini-AP/IBSS) and stationary modes
Wireless Security (WEP, WPA/WPA2-PSK)

Flexible
- HTTP
- TCP/UDP socket client & server
- DHCP/DNS client & server
- Built-in application utilities

Easy interface
- Rich AT command set for RS232
- Field update via Wi-Fi or RS232

Host µC

AT over UART

AT commands
UART manager

Radio	UMAC	TCP/IP HTTP /Socket	MiniAP related tasks	WPA Supplicant

RTOS
Drivers (STM32 std lib)
STM32/Radio & Lower MAC
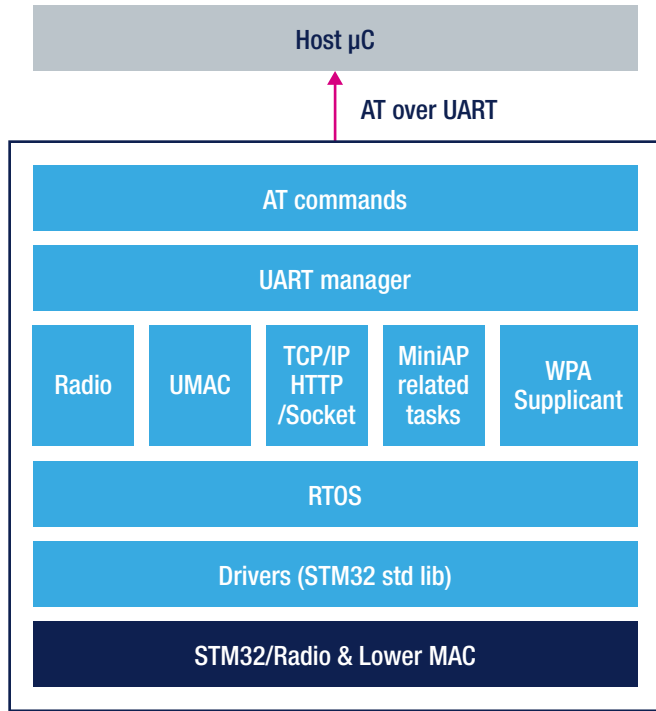
Wi-Fi is a pervasive technology; it ensures easy connection to internet, the largest network in the world. Billions of connected computers and smartphones already integrate this technology. ST provides ready-to-use Wi-Fi modules that integrate a Cortex-M3-based STM32 microcontroller and a powerful Wi-Fi transceiver compliant with IEEE 802.11.b/g/n standard for the 2.4 GHz band. They ensure an easy connection to any existing Wi-Fi access point without the need for specific drivers or RF knowledge.

CE, IC, FCC certifications are available, meaning the module can be added on top of an existing design to easily add Wi-Fi functionality without having to get in touch with a certification lab.

The module is provided with a maintained software package available on www.st.com/wifimodules to ensure the integration of new features according to market needs.

Hardware overview

One of the key objectives of ST's Wi-Fi module is to ensure its easy and quick integration into customer design. This is achieved in part thanks to its tiny form factor (15.2 x 26.9 mm^2). Two options are available: integrated antenna vs an RF connector and an integrated Flash memory vs an external one.

The four different modules are provided with the same certifications.

Models:
- SPWF01SA.11/SPWF01SC.11

Models:
- SPWF01SA.21/SPWF01SC.21

3.3 V

Voltage regulator

UART

GPIOs

STM32F103 — CW1100 b/g/n — Filter

A: integrated antenna

C: U.FI connector

Flash 1 MB

32 KHz

38 MHz

Flash file system FOTA

App, TCP/IP, UMAC program storage

To support low power modes

Integrated PA
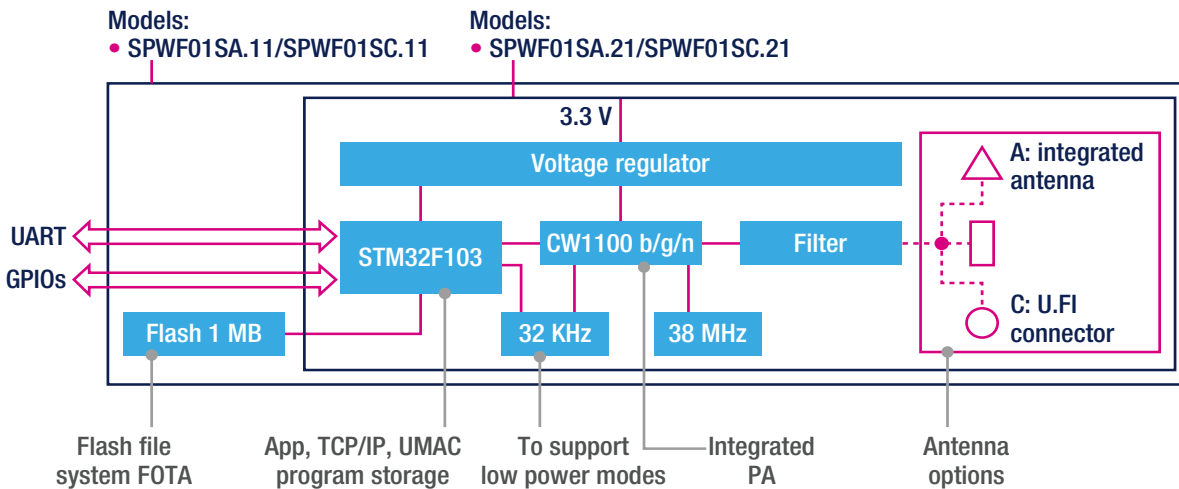
Antenna options

To further facilitate hardware integration, 16 GPIOs, a serial port and JTAG debug port are available.

| Order Code	Description
SPWF01SA.11	Extended Flash, Integrated Antenna, AT Full Stack
SPWF01SC.11	Extended Flash, Integrated U.F.I. connector, AT Full Stack
SPWF01SA.21	Integrated Antenna, AT Full Stack
SPWF01SC.21	Integrated U.F.I. connector, AT Full Stack

Software overview

SPWF01S modules come with a complete software protocol stack including TCP/IP for intuitive TCP/UDP socket creation. Secure sockets are possible with TLS/SSL ensuring secure end-to-end communications with the cloud. The modules can be controlled by an external host through AT commands. The modules can work both as a STA or miniAP (up to 5 clients can be connected).
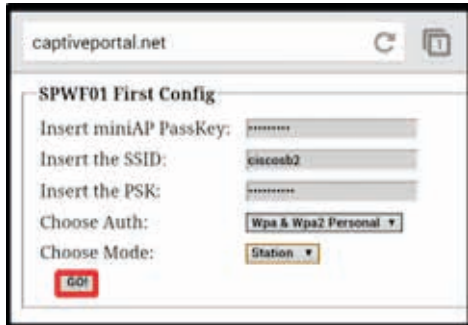
The miniAP function offers an easy method for configuring the module with the access point credentials at first association, i.e. SSID, password and security. A Wi-Fi-equipped smartphone or tablet can easily configure the module without the need for any specific software being pre-loaded or updated.

The module can act both as socket client and socket server. It integrates a built-in web server that can directly store HTML pages or other files and remotely access them using an internet browser without the need for integrating an additional software client on the host MCU.

HTTP server connection

- To access Internet & services
- Allows to upload generic files in Flash
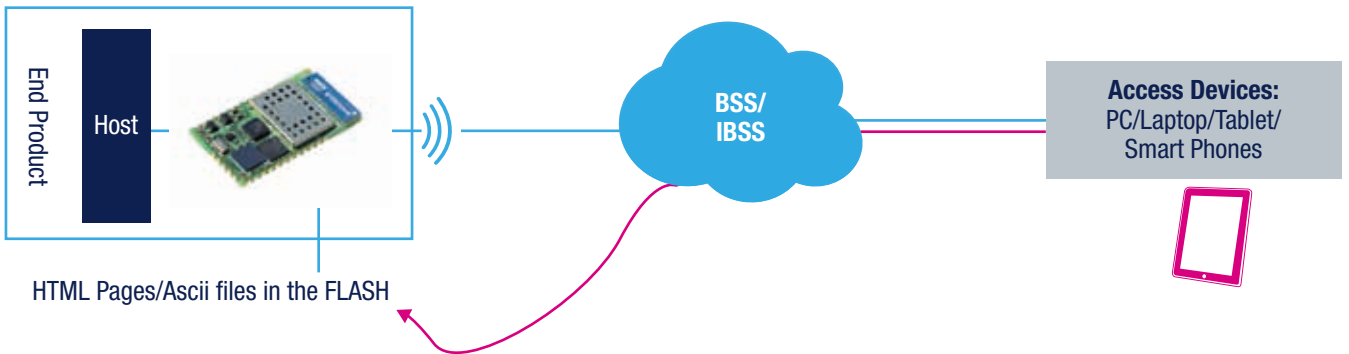
The module also implements a REST API (get, post) used to read remote pages over the serial port or to post data on a remote server. Modules equipped with 1 Mbyte of Extended Flash memory allow over-the-air firmware updates (FOTA).

6LoWPAN

6LoWPAN and mesh networks

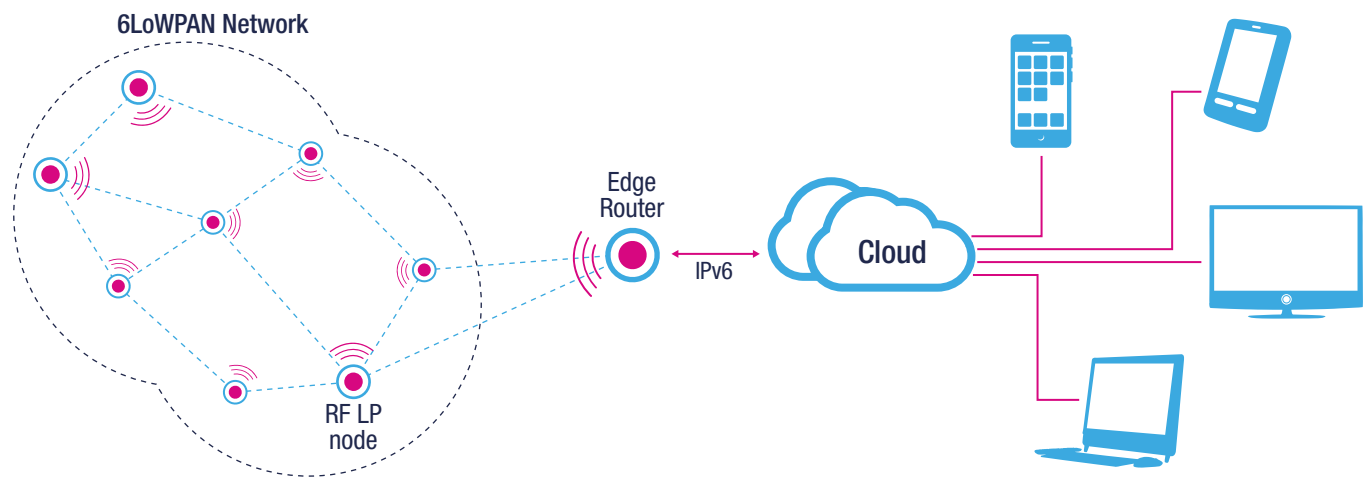6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks) is a communication protocol for transmitting IPv6 packets over low-power wireless networks. It is specified by a working group of the IETF (Internet Engineering Task Force). It provides the capability for a wireless sensor network (WSN) node to be identified in the cloud by a unique IP address.

Layer	
Application Layer	Custom Application (CoAP)
Transport Layer	UDP
Network Layer	uIPv6 and ContikiRPL
Adaptation Layer	6LoWPAN
MAC-Layer	CSMA/CA
Radio Duty Cycling	ContikiMAC, Sleepy meshing
Radio Layer	SPIRIT1 868MHz or 915MHz

Contiki is an open-source operating system designed for the Internet of Things which implements an open-source version of the 6LoWPAN protocol. More information on the Contiki OS is available at www.contiki-os.org.

The Network layer contains the IPv6 (uIPv6) and the RPL (routing protocol for low-power lossy IPv6 networks) protocols. RPL provides efficient and dynamic routing paths for battery-operated nodes. ContikiRPL is an open-source implementation of the RPL protocol. With mesh network devices relay messages for each other extending distance range to cover. The Mesh network is self-forming and self-handling.

The 6LoWPAN layer acts as a bridge between the existing IPv6 network and the low-power nodes. 6LoWPAN offers a header compression and encapsulation format optimized for sending and receiving IPv6 packets over low-power radio communication networks by reducing the packet header overhead.

The Data Link layer implements carrier sense multiple access with collision avoidance (CSMA/CA) and ContikiMAC, a radio duty cycling mechanism. ContikiMAC includes a sleepy router feature which extends the battery life of a mesh network's low-power nodes. To save power, nodes are switched off most of the time and are only woken up periodically to be able to receive and relay messages from other nodes. ContikiMAC is not implmented in first ST release porting.

ST worked with Contiki solution in order to provide a first reference package running on STM32 + SPIRIT1. Thanks to this software package, a complete set of protocols are integrated and allow the customer to prototype his application on top of high level protocol layer.

STMicroelectronics has developed a port of Contiki 3.0 for the STM32 Nucleo development board plugged with the supported expansion boards (X-NUCLEO)

The ST port allows to run the Contiki OS, 6LoWPAN protocol stack and related applications on a STM32 Nucleo development board plugged with a sub-1GHz RF expansion board and, optionally, a motion MEMS and environmental sensors expansion board.

- ST boards supported:
- NUCLEO-L152RE based on the STM32L152RET6 ultra-low power microcontroller
- X-NUCLEO-IDS01A4 based on sub-GHz SPSGRF-868 SPIRIT1 module (operating at 868 MHz)
- X-NUCLEO-IDS01A5 based on sub-GHz SPSGRF-915 SPIRIT1 module (operating at 915 MHz)
- X-NUCLEO-IKS01A1 based on motion MEMS and environmental sensors (optional)

NUCLEO-L152RE

Based on the
STM32L152RET6 ultra-low
power microcontroller

+

**X-NUCLEO-IDS01A4 or
X-NUCLEO-IDS01A5**

□ SPSGRF-868 or
  SPSGRF-915
□ EEPROM

SPIRIT1 868 and 915MHz RF
SubGHz module
communicates

+

X-NUCLEO-IKS01A1

□ HTS221   □ LPS25HB
□ LSM6DS0   □ LIS3MDL

Motion MEMS and
environmental sensor
evaluation board system

=
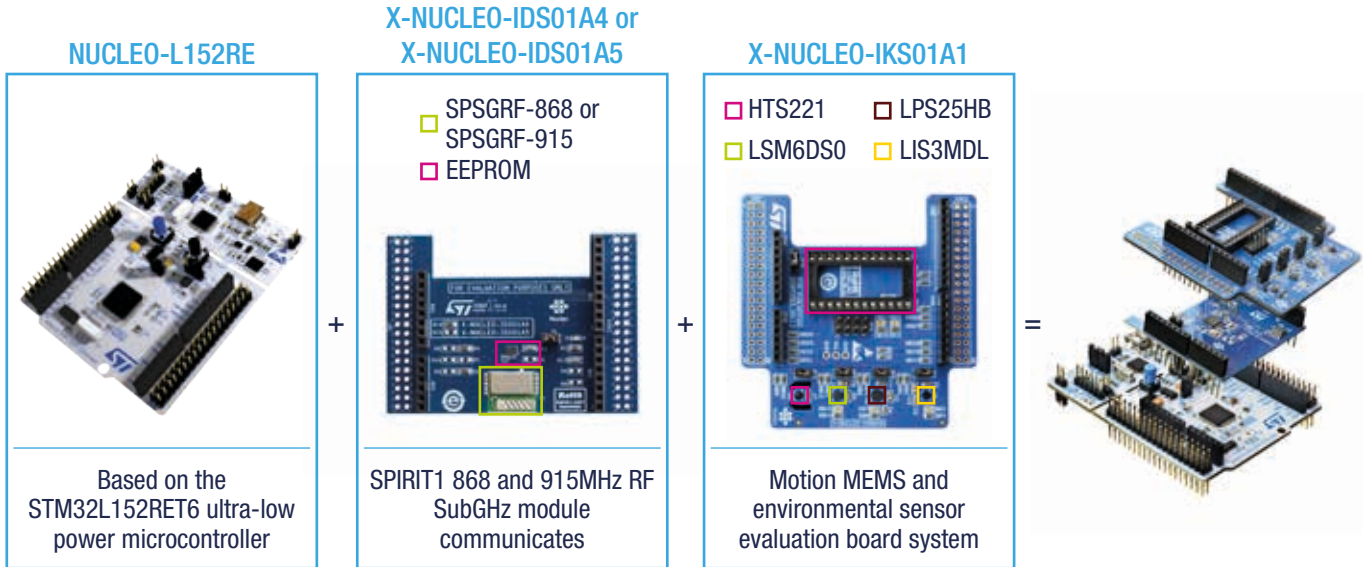
This package will be soon available as a starting point, several partners are available in case there is a need for optimization.

Wireless personal area networks

A wireless personal area network (WPAN) is used to wirelessly connect portable and mobile computing devices such as laptops, smartphones, phablets, tablets, headset, speakers, printers, TV-sets, set-top boxes, and an assortment of other consumer electronics equipment.
A WPAN is a short-distance network specifically designed to exchange data among devices within an area of tens of meters. One of the most common WPAN technologies is Bluetooth®.

Bluetooth® overview

Bluetooth technology is based on the IEEE 802.15 standard and is managed by the Bluetooth Special Interest Group (SIG) that directs the specification development defining the Bluetooth standard, manages the qualification program, and protects the trademarks. ST Microelectronics is a Bluetooth SIG member company.

Bluetooth wireless connectivity technology works in the 2.4 up to 2.485 GHz unlicensed ISM band, sharing an overcrowded spectrum with other technologies. It uses a coexistence technique such as adaptive frequency hopping (AFH) to ensure clean communications.

The Bluetooth world includes two different specifications: "classic Bluetooth" based on the Bluetooth 3.0 specification and "Bluetooth Low Energy" based on the Bluetooth 4.1 specification. Their main differences are described in the table below:

	Classic Bluetooth technology	Bluetooth Low Energy technology
Radio frequency	2.4 GHz	2.4 GHz
Air data rate	1-3 Mbps	1 Mbps
Data payload throughput	2 Mbps	220 kbps
Range	10 to 250 m	10 to 100 m
Security	AES-128	AES-128
LATENCY (from non connected state)	100 ms	3 ms
Network topology	Scatternet	Scatternet
Peak current consumption	< 30 mA	< 15 mA

The classic Bluetooth is used for streaming data based on dedicated application profiles such as the headset profile (HSP) or the audio distribution profile (A2DP). Bluetooth Low Energy is focused on battery-operated devices such as sensors for health care, sports and fitness, security and proximity applications. Furthermore, the classic Bluetooth and Bluetooth Low Energy technologies both address home automation and IoT applications. For more information about Bluetooth technology, visit www.Bluetooth.org

SPBT2632C2A.AT2 / SPBT2632C1A.AT1 BLUETOOTH®3.0 MODULES WITH EMBEDDED STACK AND PROFILES (UART INTERFACE)

Why choose ST's Bluetooth modules?

ST's SPBT2632C2A.AT2 and SPBT2632C1A.AT Bluetooth® modules, based on the STLC2690 radio transceiver and ST's STM32F microcontroller, implement leading-edge Bluetooth® Classic 3.0 technology in a fully integrated and compact solution. Designed for maximum performance in a minimal space, these modules combine a fast UART, general-purpose I/O lines, and high data throughput with fully integrated hardware that includes an on-board antenna. The module's optimized and certified design ensures quick integration into the final application and provides an easy-to-use solution reducing the time to market cycle, with low development cost and very low integration risk.

Best-in-class solution for smartphone communication

ST's Bluetooth® modules feature fast and secure transparent serial data transmission and simple automatic connection between predefined devices. In addition, the embedded firmware, which natively supports the iAP1 (iPOD®* accessory protocol) service, enables simple communication with Apple iOS Bluetooth-enabled devices. Support for iAP2 will be available on next Bluetooth® Classic module generation. ST's Bluetooth modules manage the connection with the Apple MFI authentication coprocessor. Customers using the Apple authentication IC must register as developers to become Apple-certified MFI members. Communication with the most popular Android smartphones is fully supported as well, with very good transmission rates.

BQE- and RF-certified modules

BQE-qualified and listed on the SIG website, ST's Bluetooth modules do not require manufacturers to invest time and resources for radio and stack comprehension and development and enable easy design declarations according to SIG rules. Fully RF-certified, these modules reduce RF design efforts and offer a secure pre-certified solution. Modules are FCC, IC, CE, and Telec certified.

Key features	Key benefits
Compliant with Bluetooth Classic version 3.0	Enhanced security, easier pairing, and compatible with Apple products
SPBT2632 series is BQE End product qualified and the relevant QDIDs are listed on SIG website	No BQE certification is required for the final product, saving qualification time and cost
Pre-qualified, pre-tested, with a fully integrated RF design in a unique highly reliable device	Reduced RF design effort saves development costs and minimizes resources for a fast time-to-market
Low-power mode supported	Reduced power consumption, increases final application's battery life
Manufactured in compliance with ST quality system	Robust manufacturing, full traceability of every single module, RoHS compliance
Micro-sized form factor	SMD-like component to fit miniaturized applications

Architecture overview

- ST's Bluetooth modules are easy to integrate thanks to the simple AT command interface
- Embedded modules have low impact on the system architecture
  - Module's microcontroller manages the Bluetooth stack and profiles
  - The host microcontroller is fully dedicated to the application
- The application software can be changed, modified or updated without impact on the Bluetooth implementation and therefore certification
- In addition, Bluetooth stack / profile updates will not affect the application (i.e. do not requiring new V&V, Certification, etc.)
- RF area is fully embedded in the module. This simplifies the application design and reduces system cost (special substrate for PCB or deep knowledge of RF design and antenna tuning rules are not required).

*IPOD is a registered trademark of Apple Corporation
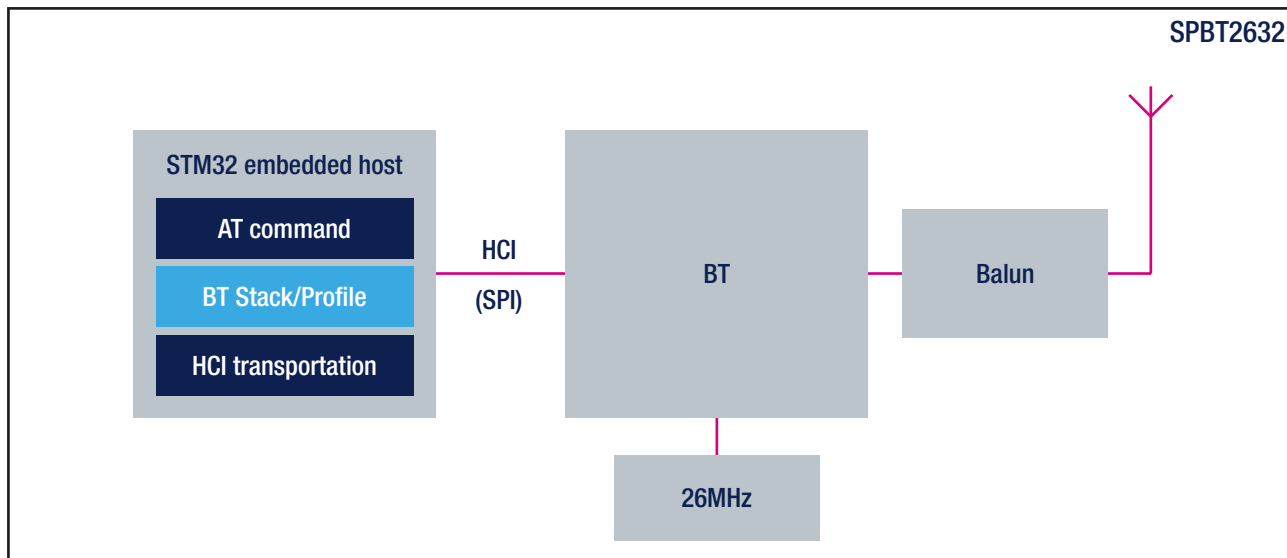
SPBT2632 module specification

Radio

- Bluetooth® radio 3.0
- Power Class 2 and Class 1.5 radio
- Radio RX sensitivity: -90 dBm
- Class 1 and Class 2 modules
- Integrated antenna

Hardware

- UART host interface
- Up to 16 GPIOs (depending on the module version)
- RF-certified
- Single voltage supply: 2.5 V (typical)

- Micro-sized form factor: 11.6 x 13.5 x 2.9 mm
- RoHS compliant

Software

- User interface: simple AT command set
- Firmware upgrade over UART
- BQE-qualified

Target applications

- Serial cable replacement
- M2M industrial control, service diagnostics, data acquisition equipment, and machine control
- Sensor monitoring
- Security systems
- Mobile health
- Consumer battery-operated devices

Support tool

- STEVAL-SPBT3ATV3 USB dongle based on SPBT2632C2A.AT2
- STEVAL-SPBT4ATV3 USB dongle based on SPBT2632C1A.AT2

Ordering number

Product name	Short description	Certification	Dimension	Web link
SPBT2632C2A.AT2	Bluetooth V3.0 module Class 2, with on-board antenna featuring SPP and iAP1 with AT command set	BQE, CE, FCC, IC, and TELEC	11.6 x 13.5 x 2.9 mm	http://www.st.com/web/catalog/ sense_power/PF253470
SPBT2632C1A.AT2	Bluetooth V3.0 module Class 1 with on-board antenna, featuring SPP and iAP1 with AT command set	BQE, CE, FCC, and IC	15.2 x 26.9 x 2.9 mm	http://www.st.com/web/catalog/ sense_power/PF253471

For documentation and more information related to SPBT2632C2A.AT2 and SPBT2632C1A.AT2 modules, visit www.st.com/bluemodules

Bluetooth® 4.0 / 4.1 Low Energy

BLUENRG NETWORK PROCESSOR

The BlueNRG Bluetooth® 4.0 Low Energy single-mode network processor provides the functions needed to link a Bluetooth® Smart device to a Bluetooth® Smart Ready host such as a smartphone or a tablet. Best-in-class active current consumption enables ultra-low-power devices to operate for months or even years from a small coin-cell battery. Compliant with the latest Bluetooth 4.0 standard, BlueNRG features its own radio, processor and Bluetooth firmware to simplify the wireless design allowing engineers to concentrate on creating innovative applications.

Bluetooth 4.0 Low Energy wireless technology consumes only a fraction of the power of Classic Bluetooth and is the technology behind the new wave of Bluetooth Smart devices now entering the market. All major mobile and desktop operating systems now support Bluetooth Smart Ready operations, paving the way for an ecosystem of Bluetooth Smart devices.

The Bluetooth Special Interest Group (SIG) has noted dramatic year-on-year growth in Smart and Smart Ready end-product listings, such as wellness monitors, fitness equipment, wearable devices and proximity tags. ABI Research predicts a growth in Bluetooth-smart "appcessories" from 150 million units this year to 500 million units per year by 2019 enabling IoT applications.

The BlueNRG shows an unmatched energy efficiency which enables superior battery life and excellent wireless-link performance. In addition to best-in-class current consumption, with a peak current of only 8.2 mA in Transmit mode at 0 dBm and 7.3 mA in Receive mode, BlueNRG also has frugal power management and transitions rapidly between operating modes thereby minimizing unproductive power.

Moreover, BlueNRG gives designers flexibility to choose their preferred host microcontroller and comes complete with Bluetooth Low Energy profiles to run in the external application processor. The on-chip non-volatile memory enables easy firmware upgrades in the field to maintain compliance with future releases of the Bluetooth specification.

BlueNRG main features:

- Embedded Bluetooth 4.0 Low Energy protocol stack: GAP, GATT, SM, L2CAP, LL, and RF-PHY
- Smart power management: step-down DC-DC / linear voltage regulator
- Operating supply voltage: from 2.0 to 3.6 V
- 16- or 32-MHz crystal oscillator
- Low-frequency crystal oscillator or integrated ring oscillator
- Input voltage monitor and temperature sensor
- Integrates a powerful Cortex-M0 microcontroller (running the whole Bluetooth Single Mode protocol)
- Interfaces with external microcontroller using SPI transport layer
- Master (up to 8 peripherals) and Slave roles supported
- On-chip non-volatile Flash memory allows OTA BLE-stack/firmware upgrades
- 128-bit AES co-processor
- Best-in-class power consumption:
  - RX: 7.3 mA
  - TX: 8.2 mA @ 0 dBm
  - Sleep: 1.7 µA
  - Reset: 5 nA
- Best-in-class output power level: +8 dBm
- RF link budget up to 96 dB
- QFN32 package (5 x 5 x 1 mm)
- WCSP34 package (2.6 x 2.6 x 0.5 mm)

BLUENRG-MS NETWORK PROCESSOR

The BlueNRG-MS Bluetooth® Smart network processor supports the latest Bluetooth version 4.1 enhancements and introduces 1.7 V operation for longer-lasting battery-powered applications integrating a complete Bluetooth PHY and 2.4 GHz radio, ARM® Cortex®-M0 microcontroller running the Bluetooth 4.1 protocol stack, and dedicated AES-128 security coprocessor. The API, power management, and Flash memory are already integrated, allowing a direct connection to the application host controller using a simple SPI bus leveraging clear software partitioning between the network processor and host microcontroller.

The new Bluetooth 4.1 specification further increases energy efficiency and supports dual-mode topologies containing devices operating as both master and slave. The new Low-Duty-Cycle Directed Advertising minimizes energy consumed when connecting to known devices. In addition, Bluetooth 4.1 introduces the Logical Link Control and Adaptation Protocol (L2CAP), which enables flexible data exchanges leveraging multi-channel communications and quality of service.

The BlueNRG-MS network processor can power devices such as a hub capable of collecting sensor data and subsequently acting as a peripheral to transfer the data to a smartphone supporting both master and slave roles simultaneously. It can also allow very large sensor networks with an unlimited communication range, controlled by a single smartphone. Moreover, BlueNRG-MS supports the latest moves towards IP-based connectivity added to Bluetooth 4.1, which lets developers target future opportunities in the Internet of Things.

The BlueNRG and the BlueNRG-MS are pin-to-pin compatible, Flash-based and have the same RF performance.

BALF-NRG-01D3 SINGLE-CHIP 2.4 GHZ BALUN

BALF-NRG-01D3 is an ultra-miniature balun. The BALF-NRG-01D3 integrates a matching network and harmonics filter. Matching impedance is customized for ST's BlueNRG and BlueNRG-MS transceiver (both QFN and WLCSP versions). It uses ST's IPD technology on a non-conductive glass substrate which optimizes RF performance.
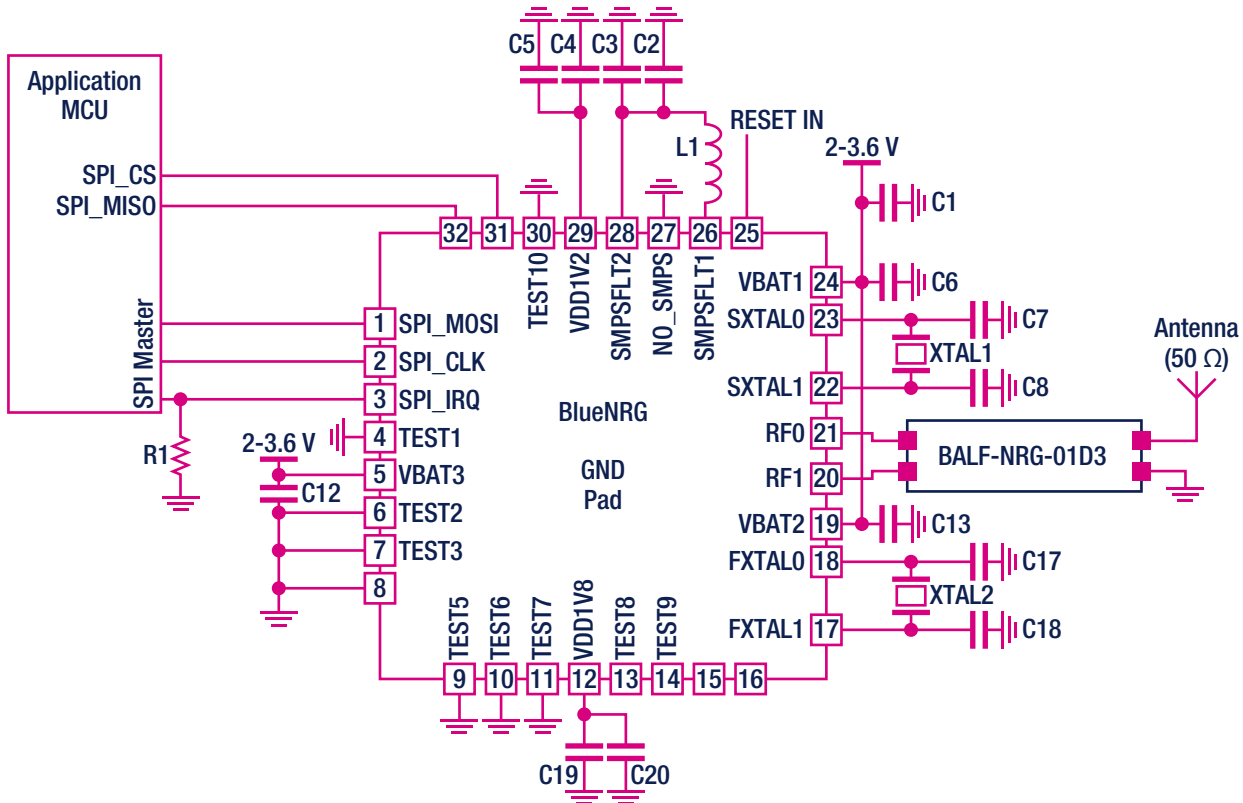
The BALF-NRG-01D3 is delivered in a 4-bump flip-chip package with a 1.2 mm² footprint.

SPBTLE-RF VERY LOW POWER MODULE FOR BLUETOOTH® SMART V4.1

Why choose ST's Bluetooth Smart modules?

The SPBTLE-RF is an easy-to-use Bluetooth® Smart master/slave network processor module compliant with Bluetooth® v4.1. The SPBTLE-RF is designed around ST's BlueNRG-MS network processor and takes advantage of its enhanced features to create a complete RF platform in a tiny form factor. Integrating radio, antenna, high frequency and LPO oscillators, the SPBTLE-RF offers a certified (ETSI, FCC, IC) solution to optimize the time to market of the final applications and to simplify the RF and wireless design, allowing engineers to concentrate on creating innovative applications.

The entire Bluetooth Smart stack and protocols are embedded in 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.

The SPBTLE-RF B-SmarT module is able to perform multiple roles simultaneously, and can act at the same time as both a Bluetooth Smart sensor and hub device.

The SPBTLE-RF B-SmarT module allows applications to meet the tight advisable peak current requirements imposed by the use of standard coin cell batteries. Optimized results are obtained when the embedded high-efficiency DC-DC step-down converter is used.

The SPBTLE-RF can be powered directly with a standard 3 V coin cell battery, a pair of AAA batteries or any power source from 1.7 to 3.6 V.

SPBTLE-RF features

The SPBTLE-RF B-SmarT module integrating ST's BlueNRG-MS 2.4 GHz radio and running a complete power-optimized stack for the Bluetooth single-mode protocol also provides:

- Master, slave role support
- GAP: central, peripheral, observer or broadcaster roles
- ATT/GATT: client and server
- SM: privacy, authentication and authorization
- L2CAP
- Link layer: AES-128 encryption and decryption

Moreover, the BlueNRG-MS radio embeds a non-volatile Flash memory which allows upgrading the stack when the device is deployed in the field.

In addition, in compliance with the Bluetooth specification v4.1, the SPBTLE-RF B-SmarT module provides support for performing:

- multiple roles simultaneously
- Simultaneous advertising and scanning
- Support for being slave for up to two masters simultaneously
- Compliance with Privacy V1.1 specifications
- Directed advertising with a low duty-cycle
- Connection parameter request procedure
- LE ping function
- 32-bit UUIDs
- L2CAP-connection oriented channels

What's more is that the SPBTLE-RF module is available in a micro-sized form factor: 11.6 x 13.5 x 2.0 mm.

SPBTLE-RF Architecture overview
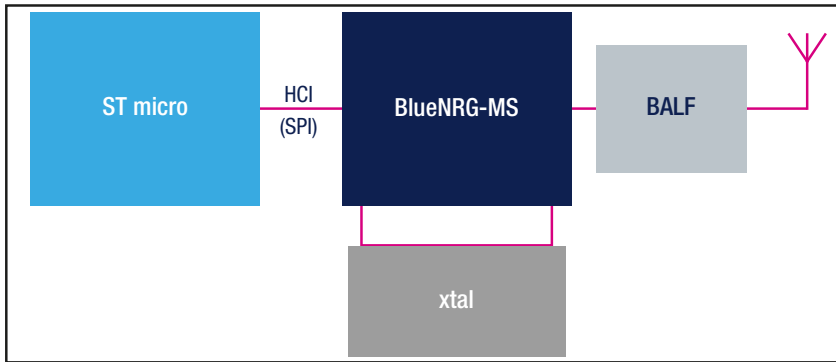
With the RF area fully embedded in the module, the application design is simplified; reducing costs as special PCB substrates or deep knowledge of RF design and antenna tuning are not required.

SPBTE-RF Software partitioning
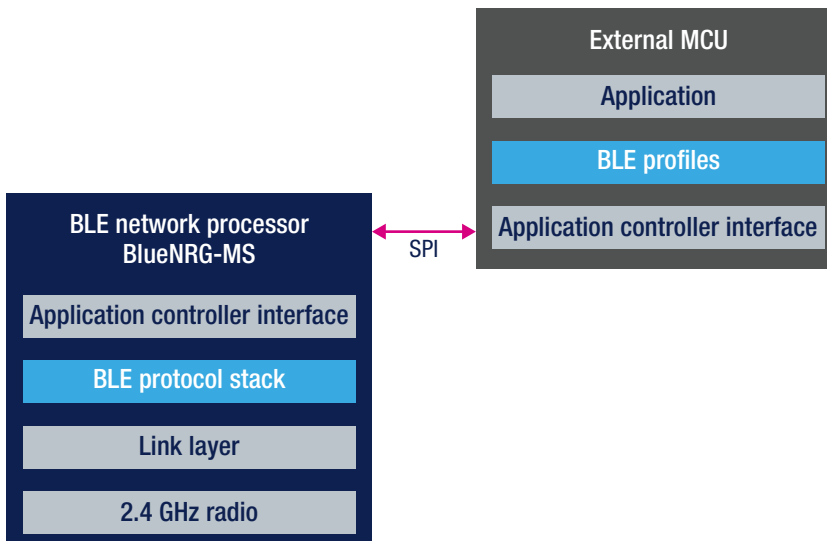
Host processor memory footprint:

- 9-Kbyte library
- Profiles from 1 to 2 Kbytes
- Several Kbytes remain for the application

Software partitioning lets you choose the MCU that best fits your application

- The SPBTLE-RF embeds the entire Bluetooth® Smart protocol stack
- The SPBTLE-RF is end-product qualified

SPBTLE-RF module specification

Bluetooth radio performance:

- Embedded ST BlueNRG-MS network processor
- Tx power: + 4 dBm
- Rx sensitivity: -88 dBm
- Provides link budget up to 92 dB with excellent link reliability

Hardware

- Host interface
  - SPI, IRQ, and RESET pins
  - Stack upgrading available via SPI
  - On-board chip antenna
  - Operating supply voltage: from 1.7 to 3.6 V
  - Operating temperature range: -40 °C to 85 °C

Target applications

- Watches
- Fitness, wellness and sports
- Consumer medical
- Security/proximity
- Remote control
- Home and industrial automation
- Assisted living
- Mobile phone peripherals
- PC peripherals

SPBTLE-RF certification

SPBTLE-RF modules are supplied tested, calibrated and pre-certified to the required standard(s) including ETSI, FCC and IC; reducing RF design efforts and offering a secure pre-certified solution. The BQE-End Product qualification is ongoing.

ST's Bluetooth modules do not require manufacturers to invest time and resources for radio and stack comprehension and development and enable easy design declarations according to SIG rules. In addition, the module is RoHS compliant.

Support tools

STEVAL-IDB006V1M USB dongle based on SPBTLE-RF

X-NUCLEO-IDB05A1 expansion board based on SPBTLE-RF

Order code

Product name	Short Description	Certification	Dimension	Web link
SPBTLE-RF	Very low power module for Bluetooth® Smart v4.1 with onboard antenna	BQE, CE, FCC, IC	11.6x13.5x2.0mm	http://www.st.com/web/en/resource/ technical/document/datasheet/ DM00184006.pdf

For more information and documentation related to the SPBTLE-RF module, visit www.st.com/bluemodules
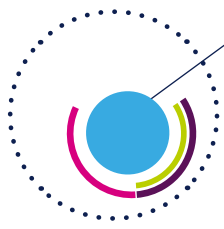
Proprietary RF communication systems

## Sub-1 GHz communication interfaces

SUB-1 GHZ OVERVIEW

The Industrial, Scientific and Medical (ISM) unlicensed frequency bands below 1 GHz are widely used by wireless communication systems mainly in industrial, home and building automation and automatic meter reading applications. The flexibility offered by national regulations in selecting physical layer characteristics such as output transmitted power, modulation scheme, data rate and channel bandwidth, together with the possibility to develop proprietary protocols lets users find the best solution for their needs as well as unmatchable performance and system efficiency at the expense of interoperability and development efforts. Moreover either a star or mesh network topology can be implemented and, in principle, without any limitations in the number of nodes connected simultaneously.

Based on sub-1 GHz systems, some standards target specific application cases. Such standards guarantee interoperability between nodes from different manufacturers or system providers, but at the same time achieve high protocol efficiency for the dedicated use case. Among others, the Wireless M-Bus is an open standard developed for very power efficient smart metering and Advanced Metering Infrastructure (AMI) applications and it is quickly spreading in Europe for gas, water and heat metering.

Sub-1 GHz proprietary solutions are widely used for the wireless connection of nodes in home networks and building automation systems as well as in industrial process applications. Real-time monitoring and control of thousands of nodes enables process optimization, more efficient resource management, prevents breakdowns and saves energy (Smart Factory).

Sub-1 GHz solutions are also used in the implementation of Smart City infrastructures where each wireless node is part of a network. Nodes are monitored and controlled and their data can be used for managing light, parking and traffic systems; saving energy and improving the quality of life. Thanks to the wireless coverage range, the efficiency and flexibility of the sub-1 GHz technology is one of the building blocks for enabling IoT growth, even if it requires an internet gateway for connecting to the IoT.
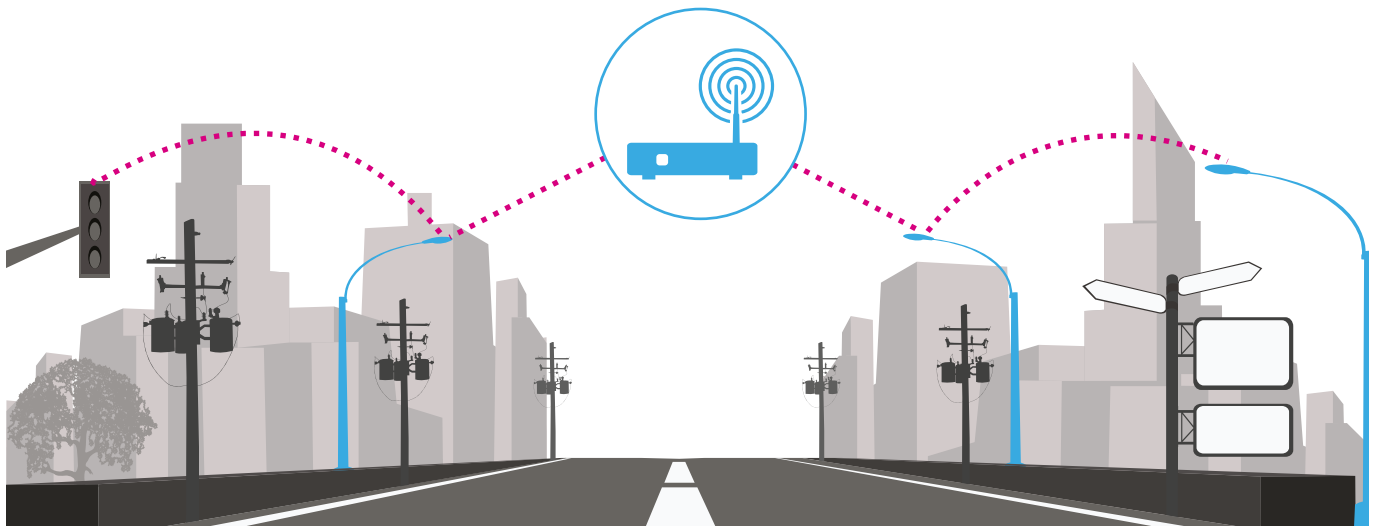
SPIRIT1 LOW-POWER TRANSCEIVER

The SPIRIT1 is a sub-GHz transceiver intended for RF wireless-sensor node applications such as advanced metering infrastructure, alarm and security systems, home and building automation, industrial monitoring and control.

It is designed to operate in ISM and SRD frequency bands at 169, 315, 433, 868, and 915 MHz, but can also be programmed to operate at other frequencies in the 300-348 MHz, 387-470 MHz, and 779-956 MHz bands.

The air data rate is programmable from 1 to 500 kbit/s, and the SPIRIT1 can be used in systems with channel spacing of 12.5/25 kHz. The SPIRIT1 supports different modulation schemes: 2-FSK, GFSK, OOK, ASK, and MSK. Transmitted/received data bytes are buffered in two different three-level FIFOs (TX FIFO and RX FIFO), accessible via the SPI interface for host processing.
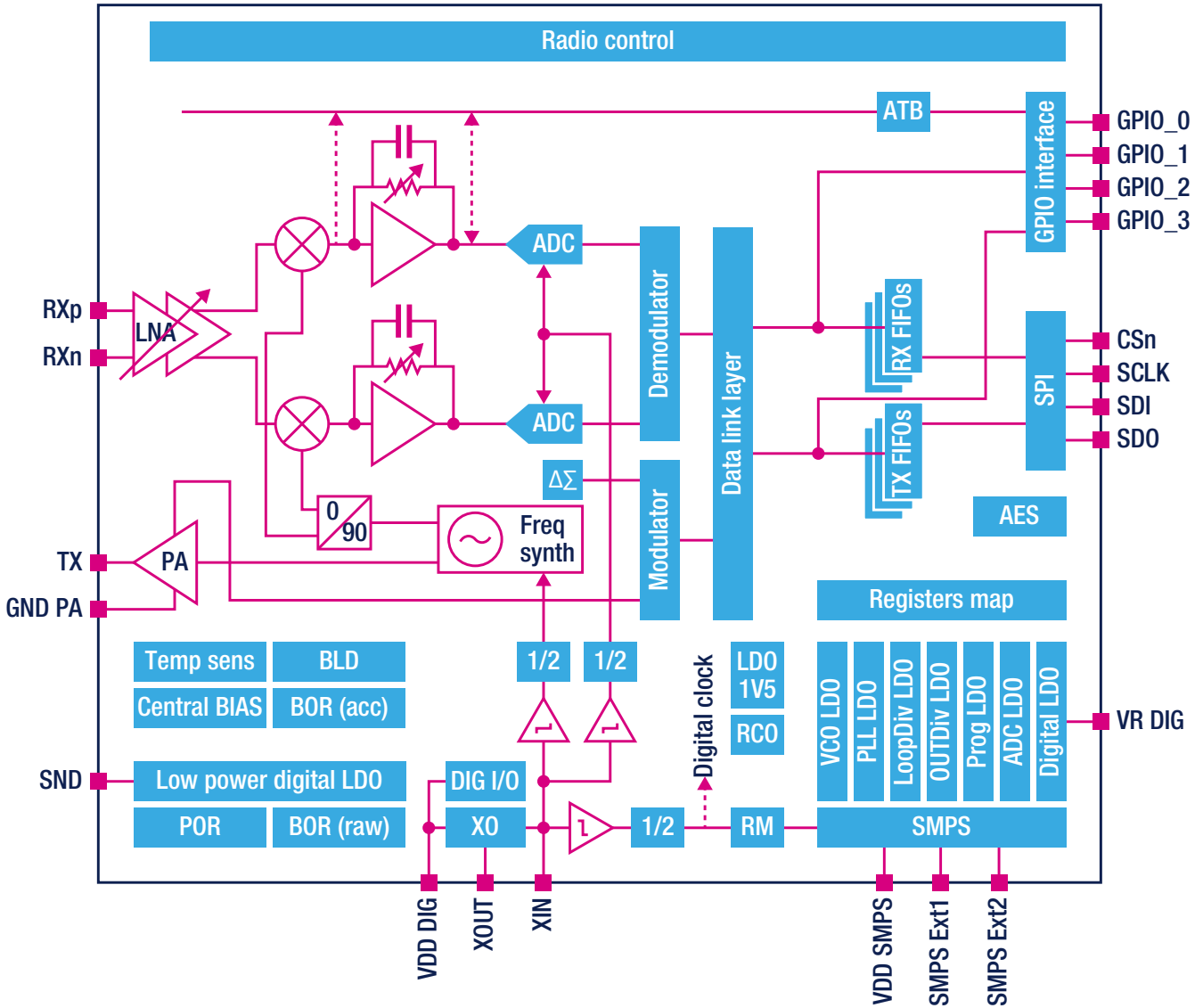
The SPIRIT1 combines excellent radio performance with unbeatable current consumption. Additional embedded features include a "listen-before-talk' (CSMA/CA) engine, AES-128 data encryption, error correction and detection, as well as a highly flexible and programmable data packet format which contributes to further reducing the computational load of the host microcontroller and the overall system current consumption. Moreover, the SPIRIT1 fully supports antenna diversity with an integrated antenna switching control algorithm.

Software stacks are available including the Wireless M-Bus protocol stack based on European standard 13757-4:2011.10, mainly addressing energy meter applications.

Key Features

- Frequency bands: 150-174 MHz, 300-348 MHz, 387-470 MHz, and 779-956 MHz
- Modulation schemes: FSK, GFSK, MSK, OOK and ASK
- Air data rate from 1 to 500 kbit/s
- Programmable output power: from -30 dBm to +16 dBm (Boost mode)
- RX sensitivity: -122 dBm
- Low current consumption:
  - Shutdown: 2.5 nA
  - Standby: 650 nA
  - Sleep: 950 nA
  - RX: 9 mA
  - TX: 21 mA @ +11 dBm
- Programmable channel spacing (12.5 kHz minimum).
- Frequency hopping, antenna diversity algorithm
- 128-bit AES encryption co-processor
- Automatic acknowledgement, retransmission, and timeout protocol engine
- Embedded packet handler
- Wireless M-Bus
- EN 300 220, FCC CFR47 15 (15.205, 15.209, 15.231, 15.247, 15.249), and ARIB STD T-67, T-108 compliant
- 4x4 mm, 20-pin QFN package

STS1TX RF TRANSMITTER

The STS1TX is a sub-GHz transmitter derived from the SPIRIT1, keeping pin-to-pin compatibility and the same characteristics, designed for alarm and security systems and automatic meter reading, as well as home and building automation.

It operates in the ISM and SRD frequency bands at 169, 315, 433, 868, and 915 MHz, but also in the 300-348 MHz, 387-470 MHz, and 779-956 MHz bands. The STS1TX supports programmable air data rates from 1 to 500 kbit/s and different modulation schemes: 2-FSK, GFSK, OOK, ASK, and MSK. Transmitted data bytes are buffered in three-level TX FIFOs, accessible via the SPI interface for host processing.

The output power is programmable from -30 up to +16 dBm in Boost mode. The STS1TX supports highly flexible and programmable data packet formats with dynamic payload length, and embeds additional features such as AES-128 data encryption, a forward error correction algorithm with interleaving, and data whitening

Available software stacks include among others the Wireless M-Bus protocol stack, mainly addressing energy meter applications.
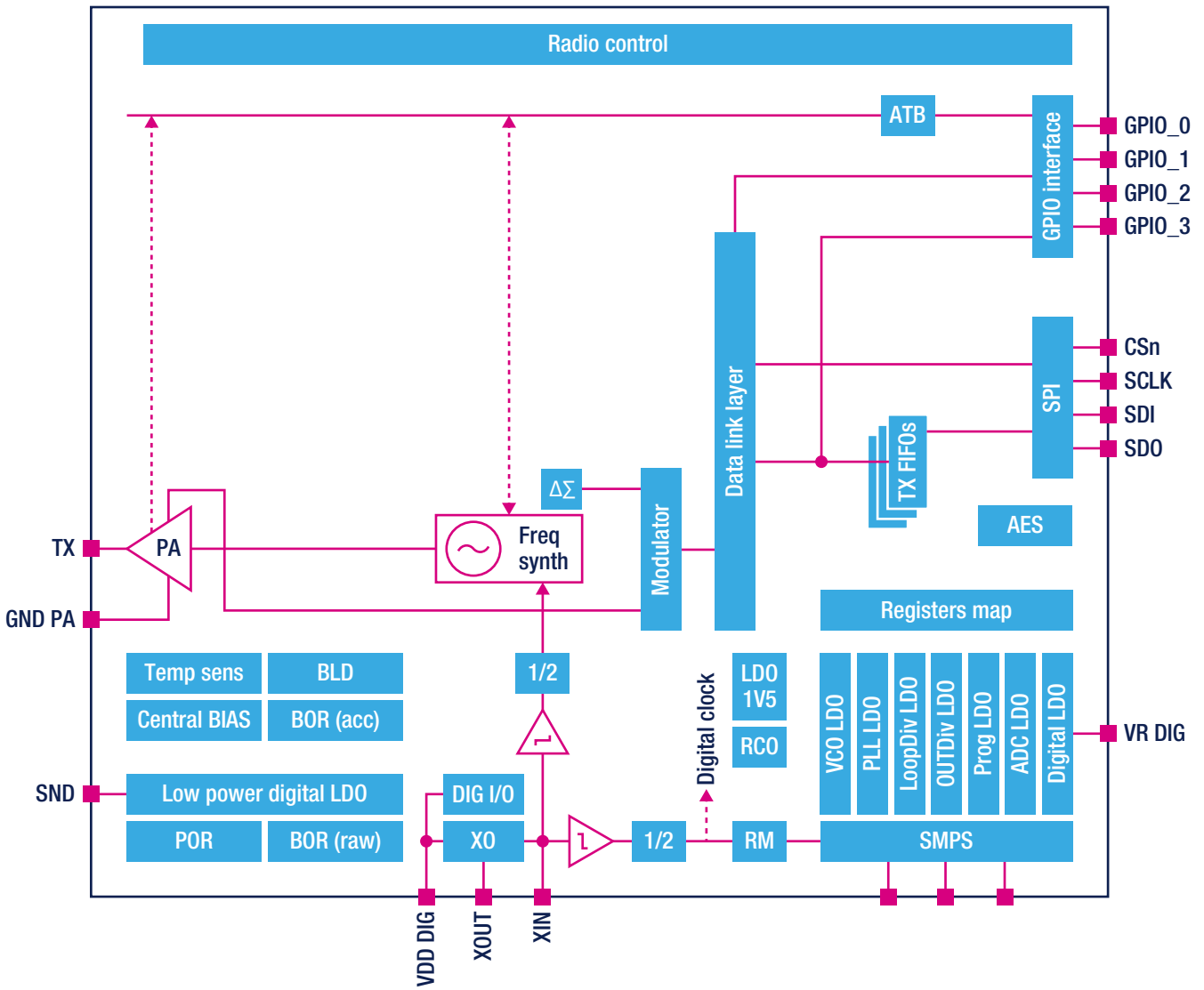
Key features

- Frequency bands: 150-174 MHz, 300-348 MHz, 387-470 MHz, and 779-956 MHz
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, and ASK
- Air data rate from 1 to 500 kbit/s
- Very low power consumption (21 mA TX at +11 dBm)
- Programmable channel spacing (12.5 kHz minimum)
- Programmable output power up to +16 dBm
- TX FIFO buffer (96 bytes each)
- Configurability via SPI interface
- 128-bit AES encryption co-processor
- Fully integrated ultra-low power RC oscillator
- Wakeup on internal timer and on external event
- Flexible packet length with dynamic payload length
- Automatic CRC handling
- FEC with interleaving
- Data whitening

BALF-SPI-01D3 SINGLE-CHIP SUB-GHZ BALUN

The BALF-SPI-01D3 is an ultra-miniature balun, integrating a matching network and harmonics filter. Matching impedance is customized for the SPIRIT1 transceiver in the 868 and 915 MHz bandwidth. It uses ST's IPD technology on a non-conductive glass substrate which optimizes RF performance.
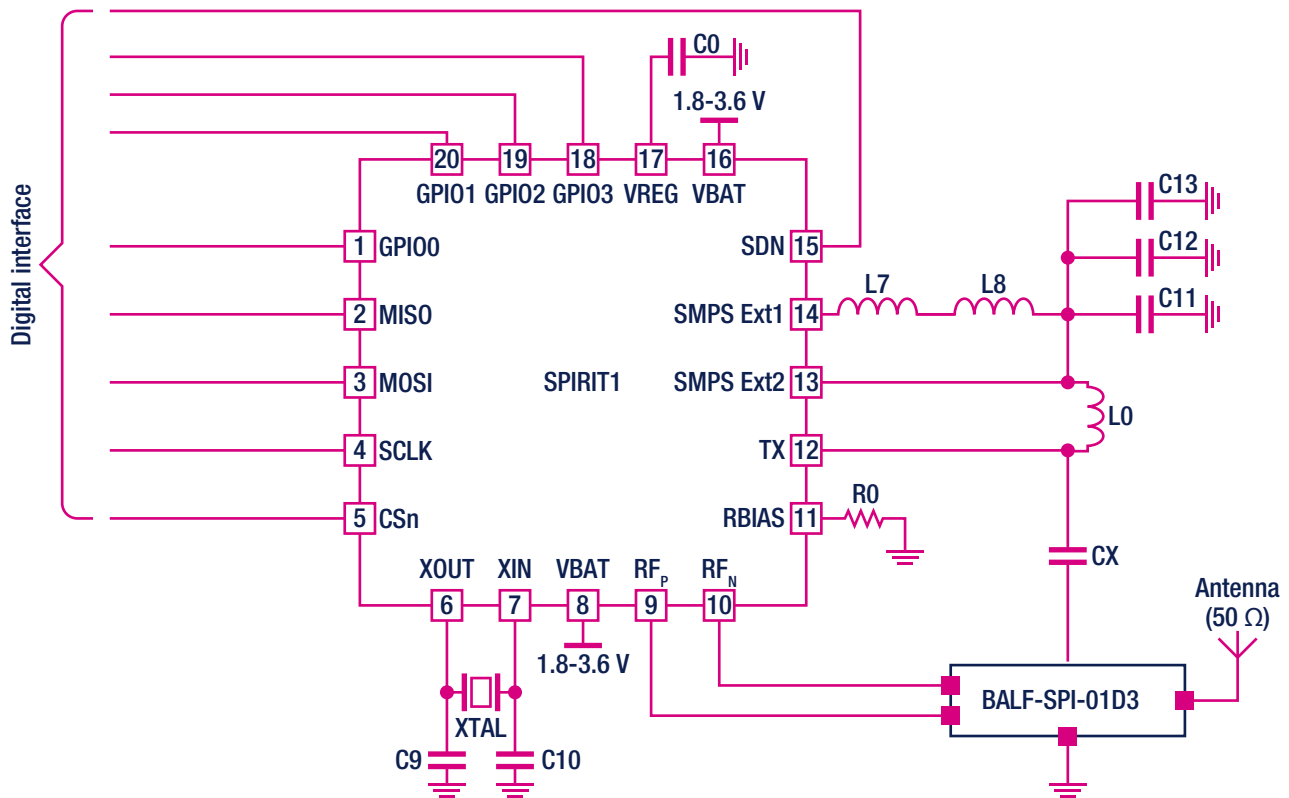

The BALF-SPI-01D3 is delivered in a 6-bump flip-chip package with a 2.8 mm² footprint.

BALF-SPI-02D3 SINGLE-CHIP SUB-GHZ BALUN

The BALF-SPI-02D3 is an ultra-miniature balun, integrating a matching network and harmonics filter. Matching impedance is customized for the SPIRIT1 transceiver in the 434 MHz bandwidth. It uses ST's IPD technology on a non-conductive glass substrate which optimizes RF performance.

The BALF-SPI-02D3 is delivered in a 6-bump flip-chip package with a 2.8 mm² footprint.
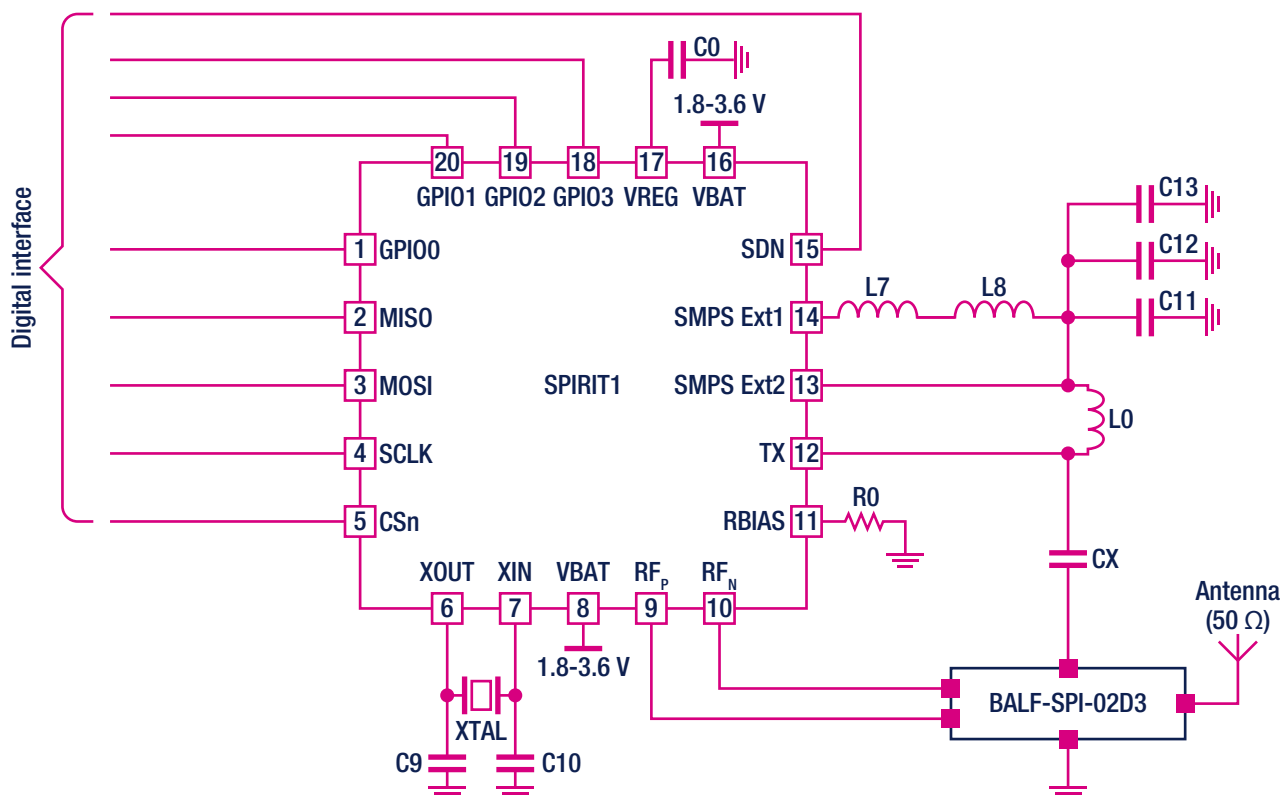
Sub-GHz modules overview

Gaining access to the sub-GHz band is really useful to increase radio range and decrease power consumption but it has one main drawback: it requires going through a certification process which is not as guided as with 2.4 GHz protocols such as Wi-Fi or Bluetooth. This means it requires in-depth RF expertise to successfully implementation a sub-GHz transceiver solution.

In order to facilitate this process, ST provides two different types of certified modules: one has a microcontroller (SP1ML) and the other does not (SPSGRF).

While both modules come with a tiny form factor, the SP1ML will allow you to build the smallest form factor device, embedding both an STM32L1 ultra-low-power MCU and SPIRIT1 transceiver. If only a SPIRIT1 RF solution is needed, the SPSGRF is for you.

SP1ML-868 / SP1ML-915 MODULES WITH ON-BOARD STM32 MCU

The SP1ML-868 and SP1ML-915 are ultra-low-power and fully integrated RF modules operating respectively in the 868 MHz SRD and 915 MHz ISM bands.

Thanks to their small compact size, on-board antenna and easy-to-use interface, these modules let you easily add wireless connectivity to your design without requiring in-depth RF experience. They also come with the necessary FCC modular approvals and CE compliance, reducing your time to market.

These modules embed a SPIRIT1 RF transceiver with integrated SMPS, an STM32L1 ultra-low-power microcontroller, an integrated filter/balun and a chip antenna.

The UART host interface ensures a simple connection to an external microcontroller using standard firmware with an AT command set for easy RF configuration, data transmission and reception.
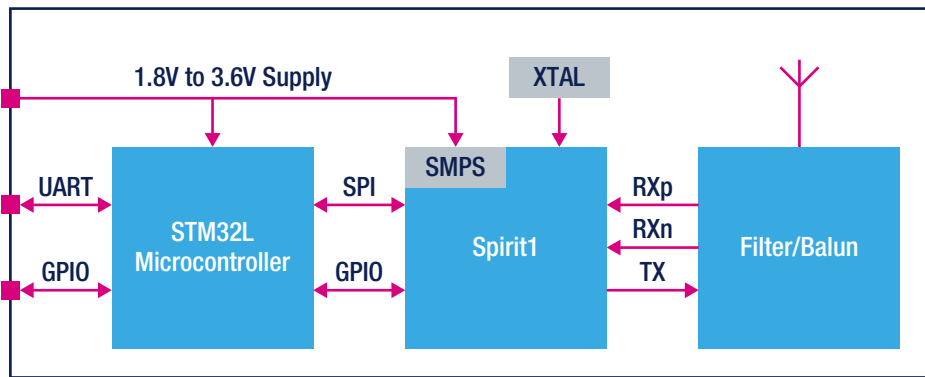
The Serial Wire Debug (SWD) interface is also available to the user. Standard firmware can be replaced by user applications running on the STM32L MCU with full access to SPIRIT1 features.

Key Features:

- Module based on:
  - SPIRIT1 low-data-rate, low-power sub-GHz transceiver STM32L ultra-low-power microcontroller at 32 MHz
  - 32 Kbytes of RAM and 128 Kbytes of Flash memory
  - BALF-SPI-01D3 868/915 MHz balun with integrated harmonic filter
  - Integrated antenna and crystal oscillator
- 863 to 870 MHz operation (SP1ML-868)
- 902 to 928 MHz operation (SP1ML-915)
- 1.8 V to 3.6 V supply - Low power consumption
- Output power up to +11.6 dBm
- Air data rates up to 500 kbit/s
- Operating temperature: -40 to 85 °C
- Standard firmware with AT command set, interface via UART for configuration and point-to-point RF data communication

Benefits:

- Add wireless capability to any electronic device without requiring RF experience
- Compact size: 14 x 13.5 mm
- CE-compliant and FCC-certified (FCC ID: S9NSP1ML)
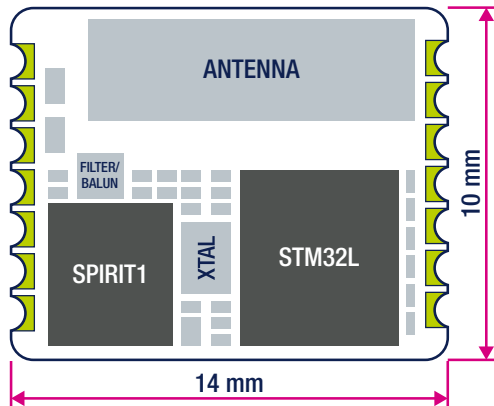
Applications

- Internet of Things
- Home & building automation
- Wireless sensor network
- P2P serial data link
- Industrial monitor and control
- Wireless metering, Wireless M-Bus
- Mobile health and medical

Evaluation boards

- STEVAL-SP1ML868 USB dongle for SPIRIT1 low-power RF modules
- STEVAL-SP1ML915 USB dongle for SPIRIT1 low-power RF modules

SPSGRF-868 AND SPSGRF-915 MODULES

The SPSGRF-868 and SPSGRF-195 are easy-to-use, low-power RF sub-GHz modules based on the SPIRIT1 RF transceiver. The modules provide a complete and certified RF platform in a tiny form factor.
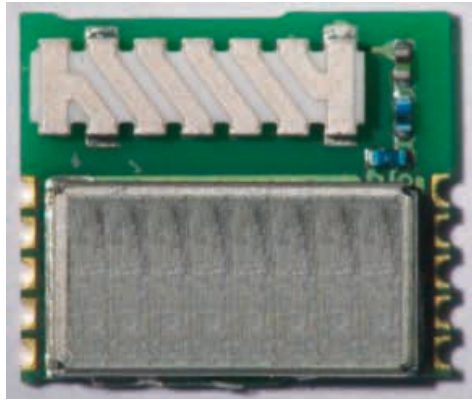
The SPSGRF modules enable wireless connectivity in your design without requiring RF experience or expertise for integration into the final product. As an FCC-, IC-, and CE-certified solution, the SPSGRF series optimizes the time to-market of end applications. The SPSGRF-915 is an FCC-certified module (FCC ID: S9NSPSGRF) while the SPSGRF-868 is CE-compliant. The modules are designed for maximum performance in minimal space and include 4 programmable I/O pins and SPI serial interfaces.

Features

- Module based on:
  - SPIRIT1 low-data-rate, low-power sub-GHz transceiver
  - BALF-SPI-01D3 868/915 MHz balun with integrated harmonic filter
  - On-board antenna and crystal oscillator
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOk, and ASK
- Air data rate from 1 to 500 kbit/s
- Operating temperature range from -40 to 85°C
- Tiny size: 13.5 x 11.5 mm
- SPSGRF-868 with 868-MHz tuned antenna (SPSGRF-868)
- SPSGRF-195 with 915-MHz tuned antenna (SPSGRF-915)
- Receiver sensitivity: -118 dBm
- Programmable RF output power up to +16 dBm
- 1.8 V to 3.6 V supply - Low power consumption
- RX: 9 mA, Tx: 21 mA @ +11 dBm
- Shutdown: 2.5 nA
- SPI host interface
- Up to 32 programmable I/O functions with 4 programmable GPIO pins
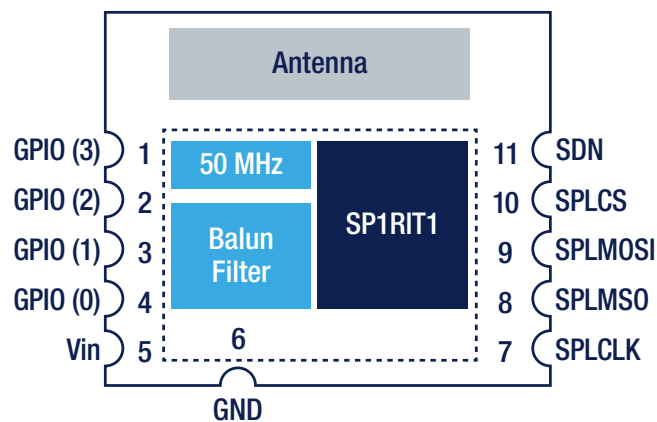
Applications

- AMR (automatic meter reading)
- Home and building automation
- WSN (wireless sensor network)
- Industrial monitoring and control
- Wireless fire and security alarm systems
- Point-to-point wireless links

Benefits:

- Add wireless capability to any electronic device without requiring RF experience
- Compact size
- CE compliant
- SPSGRF-915 is an FCC-certified module (FCC ID: S9NSPSGRF)

Tools and resources

Wi-Fi evaluation kits

WI-FI EVALUATION BOARD BASED ON SPWF01SA.11 MODULE

The STEVAL-IDW001V1 provides a platform for evaluating ST's SPWF01SA.11 Wi-Fi module. This evaluation board integrates connectors for use in conjunction with the STM32F051 discovery kit (STM32F0DISCOVERY) or with the UART-to-USB bridge board (STEVAL-PCC018V1).

With the STEVAL-PCC018V1, it can be used as a USB dongle on a PC to evawluate the AT commands that are available in the Wi-Fi module firmware. This can be done using a PC utility such as HyperTerminal or similar.

When integrated with the STM32F051 discovery kit, the STEVAL-IDW001V1 uses the Wi-Fi module as a network co-processor for the STM32F0 microcontroller. In this case it is necessary to write an application for the microcontroller to pilot the Wi-Fi module capabilities.
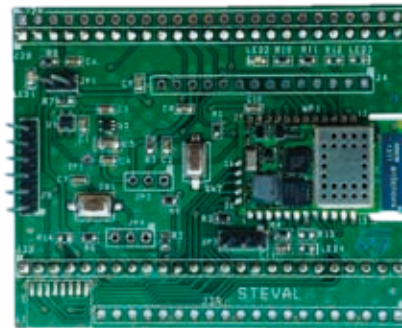
Key features

- Integrated SPWF01SA.11 Wi-Fi module
- Used as daughterboard for the STM32F051 discovery kit (STM32F0DISCOVERY)
- Can be used with the UART-to-USB bridge board (STEVAL-PCC018V1)
- Integrated reset button
- Integrated power LED
- Dimensions: 53 x 65 mm
- RoHS compliant

Development documentation

- STWS-WIFI001 (http://www.st.com/web/en/catalog/tools/PF260799) Latest firmware for SPWF01Sx.11.
- STWS-WIFI002 (http://www.st.com/web/en/catalog/tools/PF260801) Latest firmware for SPWF01Sx.21.
- STWS-IDW002 (http://www.st.com/web/en/catalog/tools/PF261605).
  - Hands-on documents: Discover SPWF01S module capabilities with STEVAL-PCC018V1 and STEVAL-IDW001V1.
  - STWS-IDW001 (http://www.st.com/web/en/catalog/tools/PF260583 Software example for STM32F0DISCOVERY motherboard and STEVAL-IDW001 daughterboard

Product name	On-board module	Web link
STEVAL-IDW001V1	SPWF01SA.11	http://www.st.com/web/en/catalog/tools/PF260012

Bluetooth 3.0 evaluation kits

SPBT2632C2A.AT2 / SPBT2632C1A.AT2 USB DONGLE EVALUATION TOOLS

The **STEVAL-SPBT3ATV3** and **STEVAL-SPBT4ATV3** demonstration boards are design tools for quickly and easily evaluating the SPBT2632C2A.AT2 and SPBT2632C1A.AT2 modules based on STLC2690 and STM32F MCU. The dongle includes the module under evaluation with an on-board RF antenna and USB connector.

The USB connector is used to connect the dongle with a PC to access the Bluetooth® module and to power the dongle.

The STEVAL-SPBT3ATV3 and STEVAL-SPBT4ATV3 are boards with downloaded firmware that enable the user to create a Bluetooth® link using simple AT commands. The AT command list is described in User Manual UM1547. Application note AN4127 describes how to get started with the STEVAL-SPBT3ATV3 board while application note AN4127 is the getting start guide for the STEVAL-SPBT4ATV3 board.

Features

- STEVAL-SPBT3ATV3 evaluation board based on SPBT2632C2A.AT2 Bluetooth 3.0 Class 2 module
- STEVAL-SPBT4ATV3 evaluation board based on SPBT2632C1A.AT2 Bluetooth 3.0 Class 1 module
- CE- and FCC-certified
- Simple AT command set
- Supports re-programmability via USB interface
- USB interface and power supply
- Reset button
- On-board antenna
- RoHS compliant

Order numbers

Product name	Onboard module	Web link
STEVAL-SPBT3ATV3	SPBT2632C2A.AT2	http://www.st.com/web/en/catalog/tools/PF253878
STEVAL-SPBT4ATV3	SPBT2632C1A.AT2	http://www.st.com/web/en/catalog/tools/PF253879

For documentation and more information related to SPBT2632C2A.AT2 and SPBT2632C1A.AT2 modules, visit www.st.com/bluemodules

34

Bluetooth Low Energy evaluation kit

STEVAL-IDB002V1/STEVAL-IDB005V1 EVALUATION KIT (BLUENRG DAUGHTERBOARD AND STM32L MOTHERBOARD)

The STEVAL-IDB002V1/STEVAL-IDB005V1 is an evaluation board based on the BlueNRG, a Bluetooth Low Energy 4.0/4.1 compliant low-power network coprocessor. The STEVAL-IDB002V1/STEVAL-IDB005V1 is composed of an RF daughterboard and a microcontroller motherboard. The RF daughterboard features the BlueNRG device, an SMA connector for an antenna or measuring instruments and an SPI connector for the external microcontroller. The motherboard is based on the STM32L ultra-low-power MCU, acting as external microcontroller driving the BlueNRG device. A JTAG connector lets users develop firmware on the microcontroller.
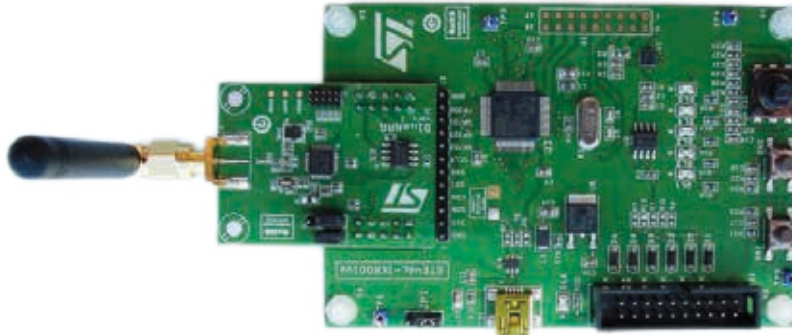
Key Features

- BlueNRG low-power Bluetooth Low Energy network coprocessor
- External STM32L ultra-low-power microcontroller
- Associated BlueNRG development kit including documentation, firmware for STM32L and GUI
- JTAG debug connector
- Bluetooth Low Energy 4.0/4.1 master and slave compliant
- Very low power consumption:7.3 mA (RX) and 8.3 mA (TX) at +0 dBm
- Maximum transmission power: +8 dBm
- Excellent receiver sensitivity (-88 dBm)
- SPI interface for external microcontroller
- ITunes app available (app name: BlueNRG)
- Google Play app available (app name: BlueNRG)
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers

Product name	Operating band	Web link
STEVAL-IDB002V1	2.4 GHz	http://www.st.com/web/en/catalog/tools/PF259562
STEVAL-IDB005V1	2.4 GHz	htpp://www.st.com/web/catalog/tools/FM116/SC1075/PF261924

BLUENRG USB DONGLES

The STEVAL-IDB003V1 is an evaluation board based on BlueNRG, a low power Bluetooth® Smart IC, compliant with Bluetooth® 4.0 specifications and supporting both master and slave roles. The STEVAL-IDB003V1 features an on-board STM32L ultra-low-power microcontroller. It is primarily meant to interface with BlueNRG but is also available for custom application development. The STEVAL-IDB003V1 has a USB connector for PC GUI interaction and firmware updates. The footprint for a JTAG connector is available on the STEVAL-IDB003V1. When a JTAG connector is soldered (the connector is not mounted on the STEVAL-IDB003V1) it lets users develop custom firmware on the STM32L microcontroller. For a detailed explanation on how to use the STEVAL-IDB003V1, please refer user manual UM1686: BlueNRG development kit.

Key features

- BlueNRG based Bluetooth® Smart USB dongle based for direct PC connection
- Maximum transmission power: +8 dBm.
- STM32L ultra-low-power host microcontroller
- Major features of BlueNRG: 7.3mA (RX mode), 8.2mA (TX mode at 0 dBm) maximum peak current, programmable output power from -18 dBm to +8 dBm, and RF link budget up to 96 dB USB interface
- Bluetooth® Low Energy 4.0 compliant, supports both master and slave roles.
- JTAG footprint connector for custom firmware development (JTAG connector not mounted)
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers

| Product name	Operating band	Web link
STEVAL-IDB003V1	2.4 GHz	http://www.st.com/web/en/catalog/tools/PF260386

SPBTLE-RF MODULE-BASED EXPANSION BOARD FOR STM32 NUCLEO

The X-NUCLEO-IDB05A1 is a Bluetooth Smart v4.1 evaluation board based on SPBTLE-RF module, to allow the expansion of STM32 Nucleo boards.

The X-NUCLEO-IDB05A1 is designed to operate with the ecosystem tool available for the BlueRNG-MS network processor, which is the core of the SPBTLE-RF module.

Compatible with both the ST Morpho and Arduino UNO R3 connector layouts, the X-NUCLEO-IDB05A1 board interfaces with the STM32 microcontroller via SPI connections and GPIO pins.

The different expansion boards can be easily stacked in order to evaluate different devices with Bluetooth Smart connectivity.
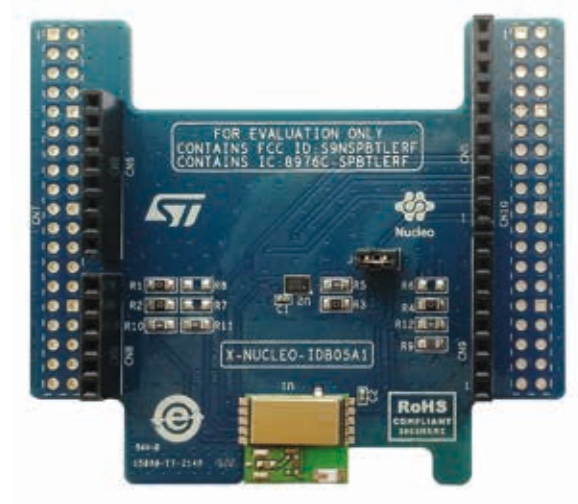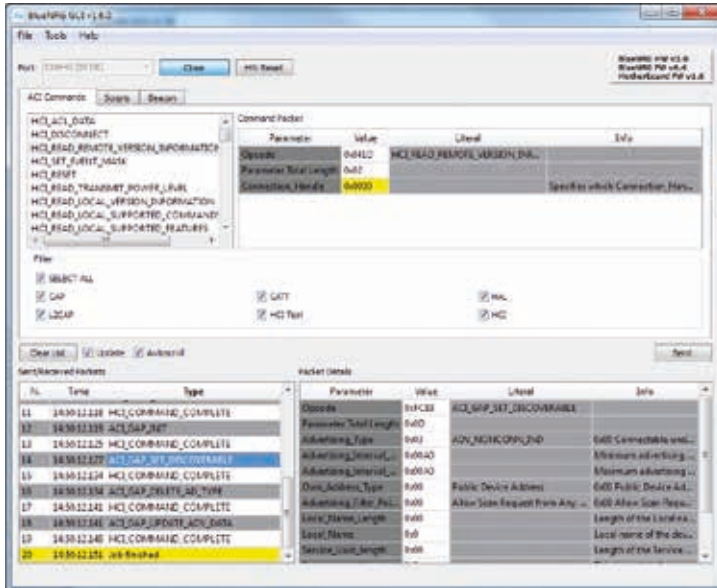
Key Features

- X-NUCLEO-IDB05A1 is an STM32 Nucleo expansion board based on the SPBTLE-RF, module FCC and IC certified (FCC ID: S9NSPBTLERF and IC: 8976C-SPBTLERF)
- Compatible with STM32 Nucleo boards
- Equipped with Arduino UNO R3 connectors
- Scalable solution; can cascade multiple boards for larger systems
- Example firmware for BlueNRG-MS, compatible with STM32Cube firmware
- RoHS compliant

Order numbers

Product name	Web link	Web link
X-NUCLEO-IDB05A1	STM32 Nucleo expansion board based on SPBTLE-RF	http://www.st.com/web/catalog/tools/FM146/CL2167/SC2006/PF262191

Bluetooth Low Energy software development kit

The BlueNRG development kit is a comprehensive package including all the necessary hardware and software information to develop applications based on BlueNRG.

Key features

- Complete software package to support BlueNRG/BlueNRG-MS evaluation and development
- Comprehensive graphical user interface to support detailed device evaluation and configuration
- Script language to support device evaluation
- Supports all the BlueNRG hardware evaluation kits
- Firmware libraries for STM32L MCU to allow development of BlueNRG/BlueNRG-MS applications
- Rich set of firmware and application examples to facilitate customer development
- Beacon demonstration
- Over-the-air firmware upgrade demonstration

Part numbers:

Product name	Web link
STSW-BLUENRG-DK	http://www.st.com/web/en/catalog/tools/PF261967

Bluetooth Low Energy support tools

BLUENRG/BLUENRG-MS CURRENT CONSUMPTION ESTIMATION TOOL

The BlueNRG/BlueNRG-MS current consumption estimation tool provides a means to predict the current consumption of the BlueNRG/BlueNRG-MS Bluetooth® low energy wireless network processor under different conditions as defined by the Bluetooth Low Energy specification. This application provides an accurate estimation of BlueNRG/BlueNRG-MS power consumption and related battery life under various operating conditions. Nevertheless, as a pure simulation it should not be considered as a substitute for measurements taken on the actual silicon device, which would provide real figures.
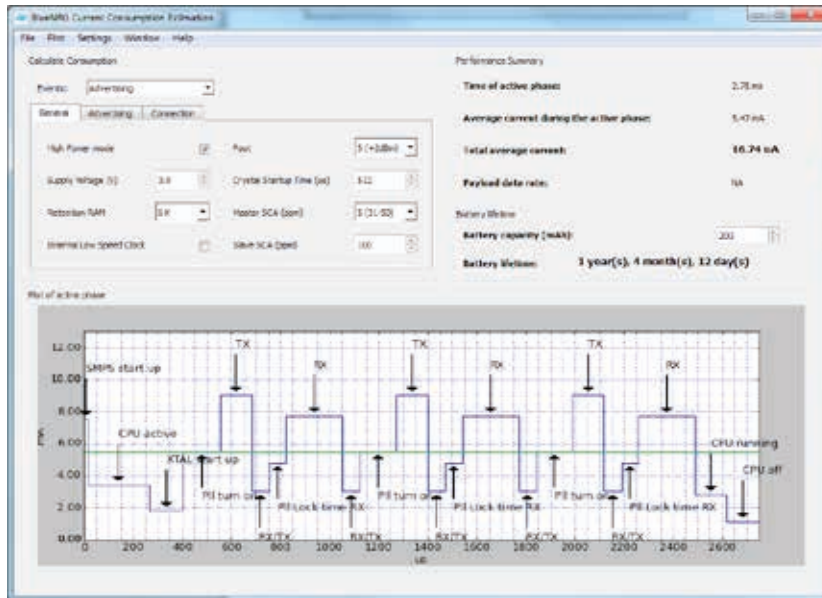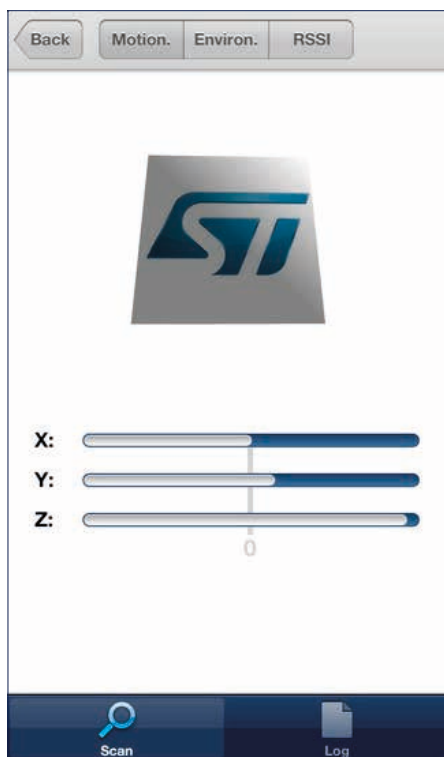
Key Features

- Allows measurement of average current consumption for various use cases
- Excellent correlation with real measurements
- User-friendly and easy to parameterize
- Available input parameters:
  - Advertising/Connected as Slave or Master
- General settings: power, payload, intervals, and battery capacity
- Available output data:
  - Average current estimation
  - Battery life estimation
  - Data rate estimation
  - PC-based application
  - Output report in PDF
  - Save/restore configuration
  - Graphical plot of the current consumption during active phase
  - Save plot in PNG format

Order numbers

Product name	Web link
STSW-BNRG001	http://www.st.com/web/en/catalog/tools/PF260405

BLUENRG IOS AND ANDROID SMARTPHONE APP

Used in conjunction with ST's BlueNRG evaluation kit (STEVAL-IDB002V1), the BlueNRG app allows you to access all the sensor data directly from your mobile device via the Bluetooth® Low Energy protocol.

Key features

- Access all the sensor data directly from your mobile device via the Bluetooth® Low Energy protocol.
- Available for iOS
- Available for Android
- Source code available from third-party editor upon registration

Order numbers

Product name	OS	Web link
BlueNRG	iOS	https://itunes.apple.com/us/app/bluenrg/id705873549?l=it&ls=1&mt=8
BlueNRG	Android	https://play.google.com/store/apps/details?id=com.st.bluenrg
BlueNRG (Apple iOS)	iOS source code	http://software.g-maps.it/bluenrg-ios/
BlueNRG (Google Android)	Android source code	http://software.g-maps.it/bluenrg-android/

Sub-GHz evaluation kits

SPIRIT1 SUB-GHZ TRANSCEIVER DEVELOPMENT KIT

The STEVAL-IKR002V1 development kit includes 2 RF daughterboards based on the SPIRIT1 low-power, sub-GHz low-data-rate transceiver suitable for ISM bands and wireless M-Bus systems, and 2 motherboards based on the STM32L ultra-low-power microcontroller for controlling the daughterboard. Each motherboard features a USB connector for PC GUI interaction and firmware updates. A JTAG connector is available for developing specific firmware on the microcontroller.

Key features
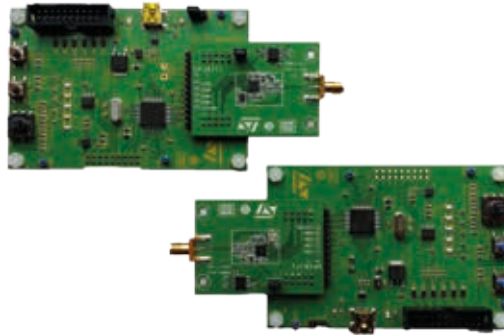
- Two SPIRIT1 low-power, sub-GHz RF transceiver daughterboards
- Two STM32L microcontroller-based motherboards
- Suitable for wireless M-Bus systems
- Associated SPIRIT1 software development kit with documentation, STM32L firmware and GUI
- Debug connector
- USB interface
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, and ASK
- Air data rate from 1 to 500 kbit/s
- Very low power consumption (9 mA (RX) and 21 mA (TX) at +11 dBm)
- Excellent performance of receiver sensitivity (up to -120 dBm)
- Low duty cycle RX/TX operation mode
- Automatic acknowledgment, retransmission, and timeout protocol engine
- 128-bit AES encryption co-processor
- SPI interface for microcontroller
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers

Product name	Operating band	Web link
STEVAL-IKR002V1	169 MHz	http://www.st.com/web/en/catalog/tools/PF259022
STEVAL-IKR001V2	315 MHz	http://www.st.com/web/en/catalog/tools/PF253894
STEVAL-IKR002V3	433 MHz	http://www.st.com/web/en/catalog/tools/PF259024
STEVAL-IKR002V4	868 MHz	http://www.st.com/web/en/catalog/tools/PF259025
STEVAL-IKR002V5	915/920 MHz	http://www.st.com/web/en/catalog/tools/PF259026

SPIRIT1 DAUGHTERBOARDS (WITHOUT EXTERNAL POWER AMPLIFIER)

The STEVAL-IKR00 product evaluation boards are based on the SPIRIT1, a very low-power RF transceiver intended for RF wireless applications in the sub-GHz frequency band.
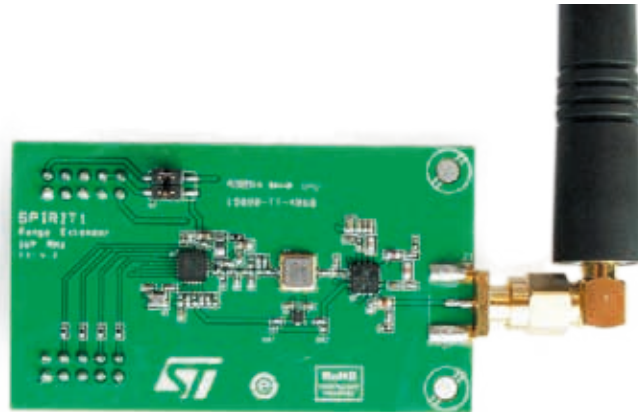
Key features

- SPIRIT1 low-power sub-GHz transceiver in a standalone RF module
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, and ASK
- Suitable for wireless M-Bus applications
- Programmable air data rate from 1 to 500 kbit/s
- Very low power consumption: 9.2 mA (RX) and 19.5 mA (TX) at +11 dBm
- Excellent receiver sensitivity (down to -120 dBm)
- Low duty cycle RX/TX operation mode
- Automatic acknowledgment, retransmission, and timeout protocol engine
- 128-bit AES encryption co-processor
- SPI interface for microcontroller
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers

Product name	Operating band	Web link
STEVAL-IKR002V1D	169 MHz	http://www.st.com/web/en/catalog/tools/PF259057
STEVAL-IKR001V2D	315 MHz	http://www.st.com/web/en/catalog/tools/PF259233
STEVAL-IKR002V3D	433 MHz	http://www.st.com/web/en/catalog/tools/PF259236
STEVAL-IKR002V4D	868 MHz	http://www.st.com/web/en/catalog/tools/PF259237
STEVAL-IKR002V4B	868/915 MHz with integrated balun	http://www.st.com/web/en/catalog/tools/PF259555
STEVAL-IKR002V5D	915/920 MHz	http://www.st.com/web/en/catalog/tools/PF259238

SPIRIT1 169 MHZ DAUGHTERBOARD (WITH EXTERNAL POWER AMPLIFIER)

The STEVAL-IKR002V7D product evaluation board is based on the SPIRIT1, a very low-power RF transceiver intended for RF wireless applications in the sub-GHz frequency band. The STEVAL-IKR002V7D also features an on-board external front-end module from Skyworks®

(SKY66100-11), which can reach a maximum output power of +27 dBm (500 mW).
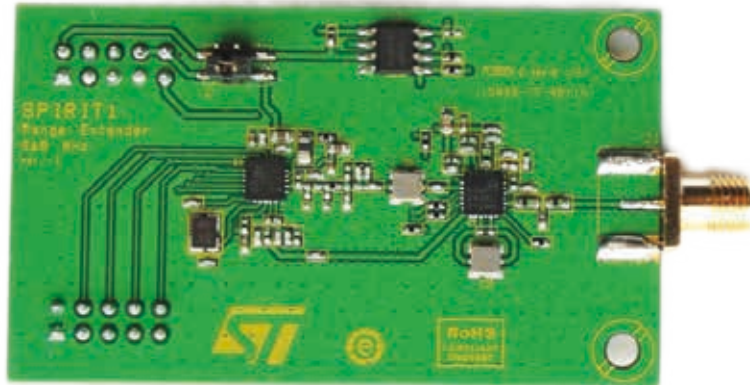
Key features

- SPIRIT1 low-power sub-GHz transceiver in a standalone RF module tuned for 169 MHz, with an external Skyworks® front-end module (SKY66100-11)
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, and ASK
- Suitable for wireless M-Bus applications
- Programmable air data rate from 1 to 500 kbit/s
- Maximum output power: +27 dBm
- Excellent receiver sensitivity (-123 dBm)
- Meets the tight narrow-band system requirements
- Low duty cycle RX/TX operation mode
- Automatic acknowledgment, retransmission, and timeout protocol engine
- 128-bit AES encryption co-processor
- SPI interface for microcontroller
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers

Product name	Operating band	Web link
STEVAL-IKR002V7D	169 MHz	http://www.st.com/web/en/catalog/tools/PF259552

SPIRIT1 868 MHZ DAUGHTERBOARD (WITH EXTERNAL POWER AMPLIFIER)

The STEVAL-IKR001V8D demonstration board is based on the SPIRIT1, a sub-GHz low-power, low-data-rate transceiver suitable for ISM bands and wireless M-Bus systems. The STEVAL-IKR001V8D includes an external power amplifier from SkyWorks®, which allows the application to reach +27 dBm (500 mW) output power.
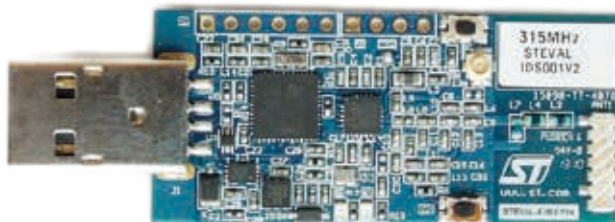

Key features

- SPIRIT1 low-power sub-GHz transceiver in a standalone RF module tuned for 868 MHz band with external power amplifier
- Associated SPIRIT1 development kit, including documentation, firmware for STM32L and GUI
- Suitable for wireless M-Bus systems
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, and ASK
- Air data rate from 1 to 500 kbit/s
- TCXO for narrow band requirements
- Maximum output power: +27 dBm
- Excellent receiver sensitivity (up to -123 dBm)
- TX power consumption @ +27 dBm: 350 mA
- SAW filter in reception path to prevent interference from out-of-band signals
- SkyWorks® SE2435L power amplifier
- Low duty cycle RX/TX operation mode
- Automatic acknowledgment, re-transmission and timeout protocol engine
- 128-bit AES encryption co-processor
- SPI interface for microcontroller
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers

Product name	Operating band	Web link
STEVAL-IKR001V8D	868 MHz	http://www.st.com/web/en/catalog/tools/PF258319

SPIRIT1 USB DONGLES WITH EMBEDDED STM32L MICROCONTROLLER

The STEVAL-IDS001 demonstration boards are based on the SPIRIT1, a sub-GHz low-power, low-data-rate transceiver suitable for ISM bands. The board is equipped with an STM32L low-power microcontroller for controlling the SPIRIT1. The board also features a USB connector for PC GUI interaction and firmware updates. An optional JTAG connector (not mounted) lets you develop specific firmware on the microcontroller.

Key Features

- SPIRIT1 low-power sub-GHz transceiver integrated in a USB dongle for direct PC connection
- STM32L microcontroller
- External components tuned for 315 MHz band
- Associated SPIRIT1 development kit includes: documentation, firmware for STM32L and GUI
- Optional debug connector (not mounted)
- USB interface
- Modulation schemes: 2-FSK, GFSK, MSK, GMSK, OOK, and ASK
- Air data rate from 1 to 500 kbit/s
- Very low power consumption (9 mA (RX) and 21 mA (TX) at +11 dBm)
- Excellent receiver sensitivity performance (up to -118 dBm)
- Low duty cycle RX/TX operation mode
- Automatic acknowledgment, retransmission, and timeout protocol engine
- 128-bit AES encryption co-processor
- SPI interface for microcontroller
- Schematics, BOM, and Gerber files available
- RoHS compliant

Order numbers:

Product name	Operating band	Web link
STEVAL-IDS001V2	315 MHz	http://www.st.com/web/en/catalog/tools/PF258710
STEVAL-IDS001V3	433 MHz	http://www.st.com/web/en/catalog/tools/PF258711
STEVAL-IDS001V4	868 MHz	http://www.st.com/web/en/catalog/tools/PF258712
STEVAL-IDS001V5	915/920 MHz	http://www.st.com/web/en/catalog/tools/PF258713

SPIRIT1 868 MHZ / 915 MHZ USB DONGLE (WITH EMBEDDED STM32L1 MCU)

The STEVAL-SP1ML868 and STEVAL-SP1ML915 demonstration boards are design tools for quickly and easily evaluating the SP1ML-868 and SP1ML-915 modules, based on the SPIRIT1 RF transceiver and STM32L1 MCU.

The dongle includes the module under evaluation, with an on-board RF antenna, and USB connector.

The USB connector is used to connect the dongle with a PC to access the sub-GHz module and to power the dongle.

The STEVAL-SP1ML868 and STEVAL-SP1ML915 are boards with downloaded firmware that enables the user to create a sub-GHz SPIRIT1 link using simple AT commands to create point-to-point communication.

Key features

- STEVAL-SP1ML868 USB dongle based on SP1ML-868
- STEVAL-SP1ML915 USB dongle based on SP1ML-915
- On-board SP1ML-868 or SP1ML-915 module:
  - 868 MHz ETSI-certified and 915 MHz FCC-certified modules based on SPIRIT1 sub-GHz RF transceiver
  - STM32L1 ultra-low-power microcontroller
  - Integrated balun (BALF-SPI-01D3)
  - Chip antenna
- Simple AT command set
- USB interface and power supply
- Reset button
- On-board antenna
- RoHS compliant

Order numbers

Product name	Operating band	Web link
STEVAL-SP1ML868	868 MHz	http://www.st.com/web/en/catalog/tools/PF261272
STEVAL-SP1ML915	915 MHz	http://www.st.com/web/catalog/tools/PF261273

SPIRIT1 MODULE-BASED EXPANSION BOARD FOR STM32 NUCLEO

The X-NUCLEO-IDS01A4 and X-NUCLEO-IDS01A5 are evaluation boards based on the SPIRIT1 RF modules, respectively SPSGRF-868 for 868MHz and SPSGRF-915 for 915MHz, to allow the expansion of STM32 Nucleo boards. The SPSGRF-868 module operates in the 868 MHz ISM band and is ETSI certified; while the SPSGRF-915 module operates in the 915 MHz ISM band and is FCC certified.

The operating frequency of each board is configured through two resistors (R14 and R15). Compatible with both the Morpho and Arduino UNO R3 connector layouts, the X-NUCLEO-IDS01Ax boards interface with the STM32 microcontroller via SPI connections and GPIO pins. The user can easily configure certain GPIOs by mounting or removing resistors.
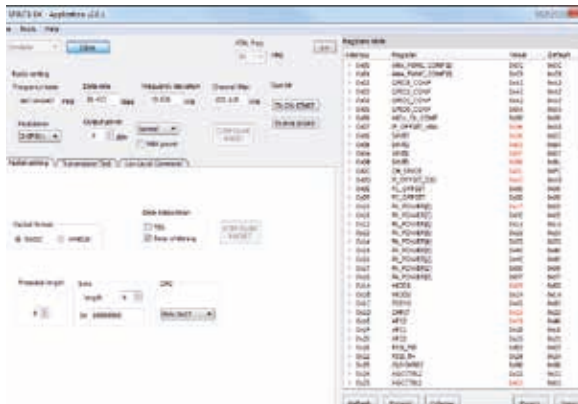
Key features

- X-NUCLEO-IDS01A4 is an STM32 Nucleo expansion board based on the SPSGRF-868, 868 MHz ETSI-certified module
- X-NUCLEO-IDS01A5 is an STM32 Nucleo expansion board based on the SPSGRF-915, 915MHz FCC certified module (FCC ID: S9NSPSGRF)
- SPGRF-868 and -915 boards contain:
  - Certified module based on low-power, low-rate sub-1 GHz SPIRIT1 transceiver
  - Integrated balun (BALF-SPI-01D3)
  - Chip antenna
- Compatible with STM32 Nucleo boards
- Equipped with Arduino UNO R3 connectors
- LED for user interface
- Jumper at 3V3 for checking the current consumption of the expansion board
- Scalable solution; can cascade multiple boards for larger systems
- Example firmware for point-to-point communication, compatible with STM32Cube firmware

Evaluation boards	Identification resistors	RF communication frequency	Description
X-NUCLEO-IDS01A4	R14 mounted	868 MHz	868 MHz RF expansion board based on ETSI certified module SPSGRF-868 for STM32 Nucleo
X-NUCLEO-IDS01A5	R15 mounted	915 MHz	915 MHz RF expansion board based on FCC certified module SPSGRF-915 for STM32 Nucleo

Sub-GHz software development kit

The SPIRIT1 development kit is a comprehensive package including all the necessary hardware and software information to develop applications based on the SPIRIT1 RF transceiver.

Key features

- Complete software package to support SPIRIT1 RF evaluation and development
- Comprehensive graphical user interface (SPIRIT1 DK - GUI) to support detailed device evaluation
- Supports all SPIRIT1 hardware evaluation kits
- SPIRIT1 firmware libraries for STM32L and STM8L MCUs for developing SPIRIT1 applications
- Rich set of firmware and application examples to facilitate customer development
- Wireless M-Bus dedicated GUI for evaluation and demonstration purposes
- Dedicated wireless M-Bus library with documentation and example applications for developing applications based on the SPIRIT1 RF transceiver

Order numbers

Product name	Web link
STSW-CONNECT009	http://www.st.com/web/en/catalog/tools/PF258102

Useful links

- Wi-Fi modules: www.st.com/wifimodules
- Bluetooth ICs: www.st.com/bluetooth
- Bluetooth low energy ICs: www.st.com/bluetoothlowenergy
- Bluetooth modules: www.st.com/bluemodules
- Sub 1Ghz ICs: www.st.com/spirit
- Sub 1Ghz modules: www.st.com/subghzmodules

Online support

For technical support or questions about product availability, pricing, where-to-buy, or other related issues, please visit www.st.com/onlinesupport.

To participate in our forums about RF and wireless solutions, please visit: https://my.st.com/public/STe2ecommunities/interface/default.aspx

life.augmented