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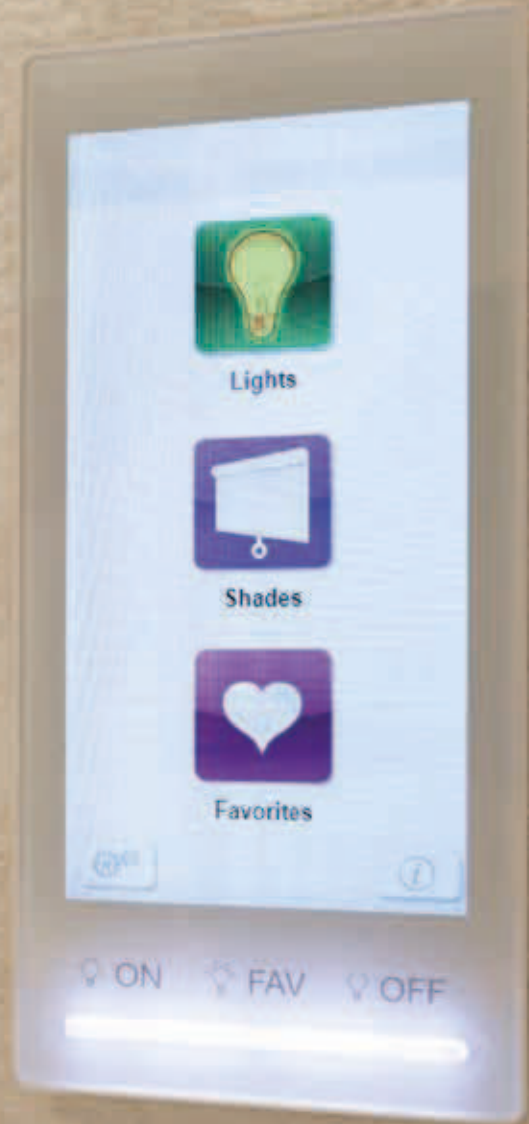
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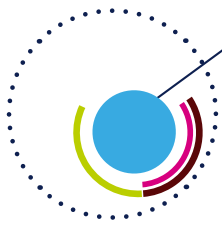


life.augmented

Wireless connectivity for IoT applications



Wi-Fi
Bluetooth®
Bluetooth® Smart
Sub 1 GHz

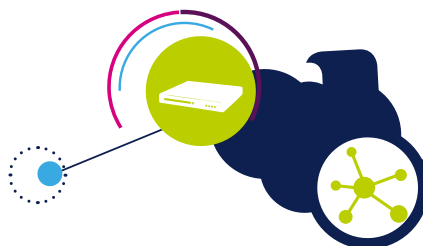


Content

Wireless connectivity for IoT applications	4
Overview.....	4
Introducing IoT.....	4
ST's eco-system for IoT.....	4
Building valuable applications in the age of IoT.....	4
ST's wireless connectivity portfolio.....	5
What are the main reasons for choosing ST's connectivity devices?.....	5
How to select the ideal wireless technology for your IoT network....	6
Wireless solution ICs and modules.....	7
Selecting the right connectivity solution: ICs or modules.....	7
IP networking and mesh solutions	9
Wi-Fi / IEEE 802.11 communication interface.....	9
Wi-Fi overview.....	9
SPWF01S module with STM32 MCU on-board.....	11
6LoWPAN	13
6LoWPAN and MESH network.....	13
Wireless personal area networks	15
Bluetooth® overview.....	15
SPBT2632C2A.AT2 / SPBT2632C1A.AT1 Bluetooth®3.0 modules with embedded stack and profiles (UART interface).....	16
Bluetooth® 4.0 / 4.1 Low Energy.....	18
BlueNRG network processor.....	18
BlueNRG-MS network processor.....	19
BALF-NRG-01D3 single-chip 2.4 GHz balun.....	19
SPBTLE-RF very low power module for Bluetooth® Smart v4.1....	20
Proprietary RF communication systems	23
Sub-1 GHz communication interfaces.....	23
Sub-1 GHz overview.....	23
SPIRIT1 low-power transceiver.....	24
STS1TX RF transmitter.....	26
BALF-SPI-01D3 single-chip sub-GHz balun.....	27
BALF-SPI-02D3 single-chip sub-GHz balun.....	28



Sub-GHz modules overview	29
SP1ML-868 / SP1ML-915 modules with on-board STM32 MCU...	29
SPSGRF-868 and SPSGRF-915 modules	31
Tools and resources	33
Wi-Fi evaluation kits.....	33
Wi-Fi evaluation board based on SPWF01SA.11 module	33
Bluetooth 3.0 evaluation kits.....	34
SPBT2632C2A.AT2 / SPBT2632C1A.AT2 USB dongle	
evaluation tools	34
Bluetooth Low Energy evaluation kit.....	35
STEVAL-IDB002V1/STEVAL-IDB005V1 evaluation kit (BlueNRG	
daughterboard and STM32L motherboard)	35
BlueNRG USB dongles	36
SPBTLE-RF module-based expansion board for STM32 Nucleo ..	37
Bluetooth Low Energy software development kit	38
Bluetooth Low Energy support tools	39
BlueNRG/BLUENRG-MS current consumption estimation tool ..	39
BlueNRG iOS and Android smartphone app	40
Sub-GHz evaluation kits	41
SPIRIT1 sub-GHz transceiver development kit	41
SPIRIT1 daughterboards (without external power amplifier)	42
SPIRIT1 169 MHz daughterboard	
(with external power amplifier)	43
SPIRIT1 868 MHz daughterboard	
(with external power amplifier)	44
SPIRIT1 USB dongles with embedded STM32L microcontroller ..	45
SPIRIT1 868 MHz / 915 MHz USB dongle	
(with embedded STM32L1 MCU).....	46
SPIRIT1 module-based expansion board for STM32 NUCLEO.....	47
Sub-GHz software development kit.....	48
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).

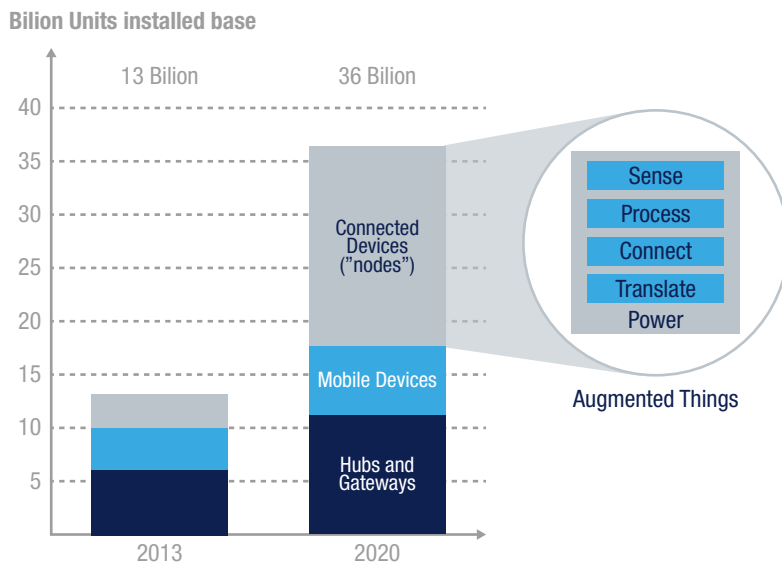


Fig.1 – Connected nodes in 2020 (*) Source ABI research

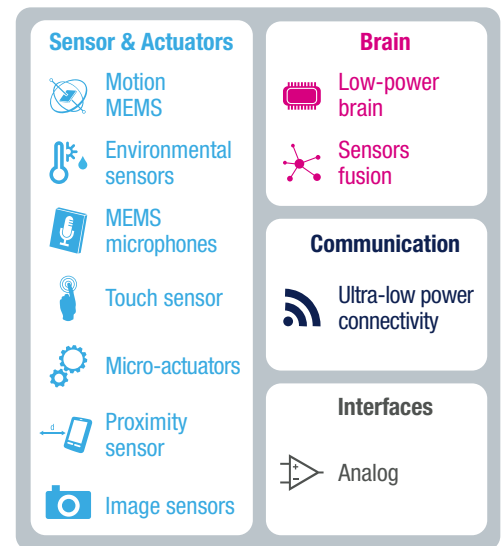


Fig.2 – STMicroelectronics building blocks for IoT

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

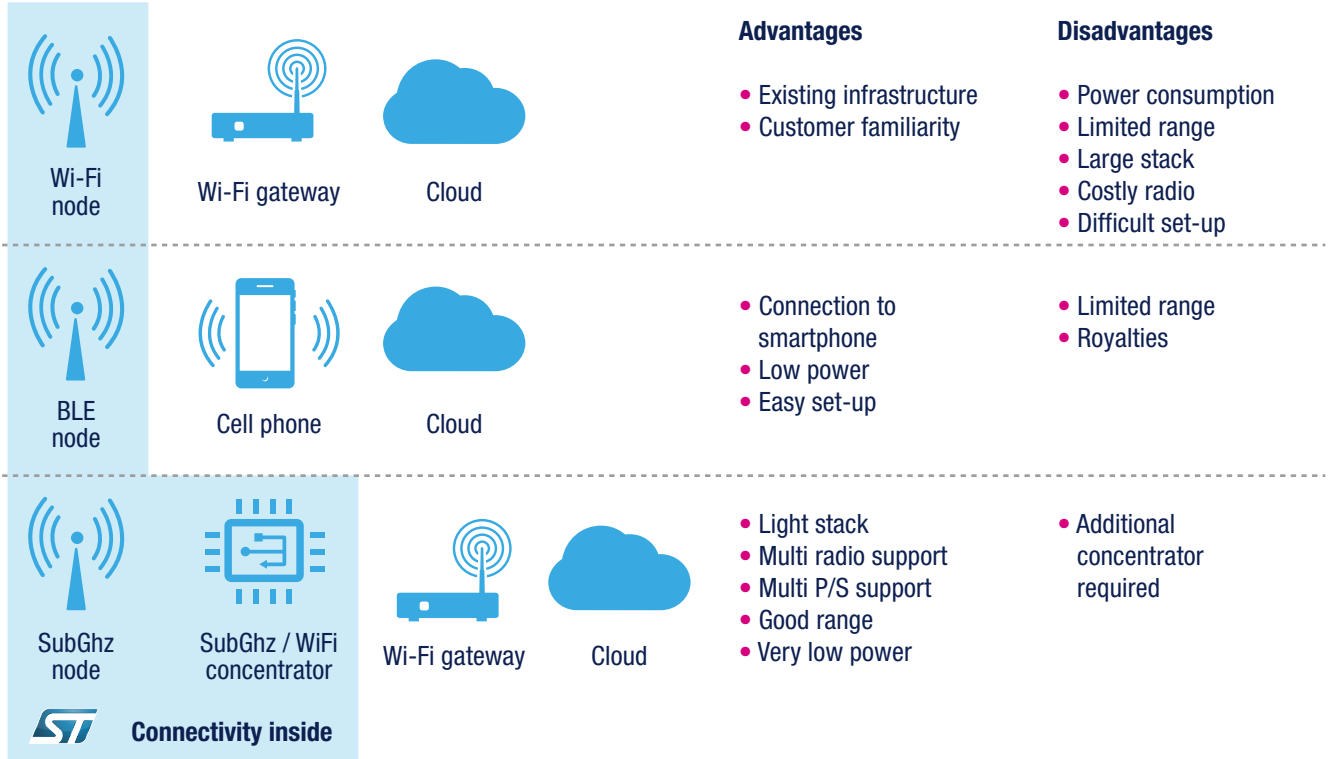
Regulation and lifestyle are driving the change: the need to conserve energy, increase efficiency and use technology to work for us and improve how we live. These trends push connectivity in applications such as:

- 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

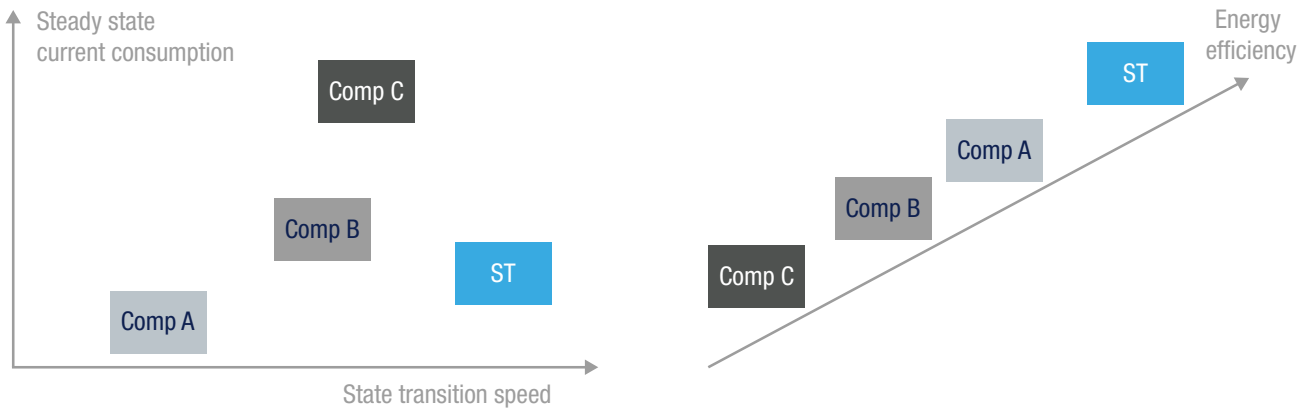
Low-power wireless connectivity represents the key technology for connecting smart objects to the internet and the cloud. As a matter of fact, wireless connectivity is not dominated by one single technology. Depending on application needs or technology constraints, different hardware and software integration 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



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 unmatched 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.



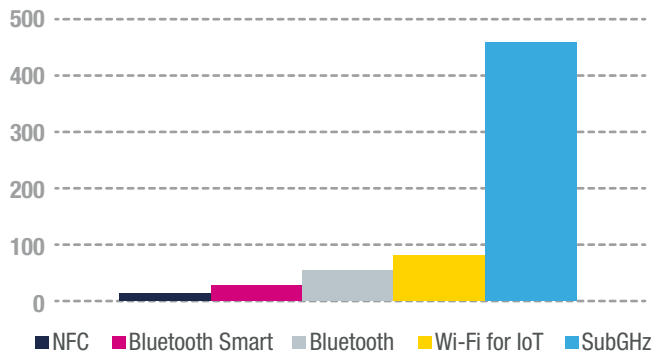
How to select the ideal wireless technology for your IoT network

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:

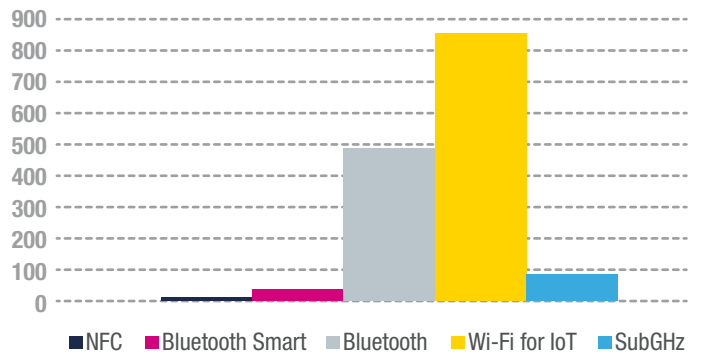
- Maximum throughput
- Power consumption
- Maximum distance range
- Web access: gateway connecting the device to the internet (e.g. Wi-Fi, ADSL router, Mobile network)

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

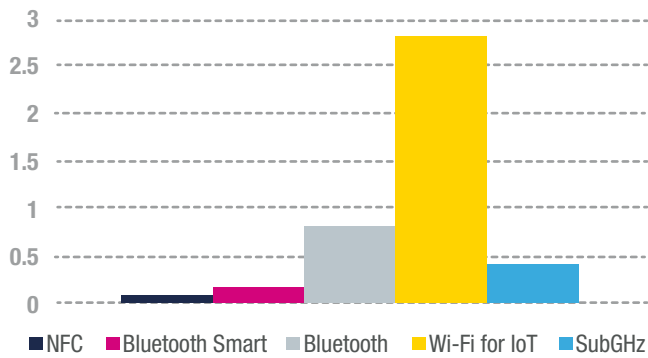
TYPICAL DISTANCE RANGE [m]



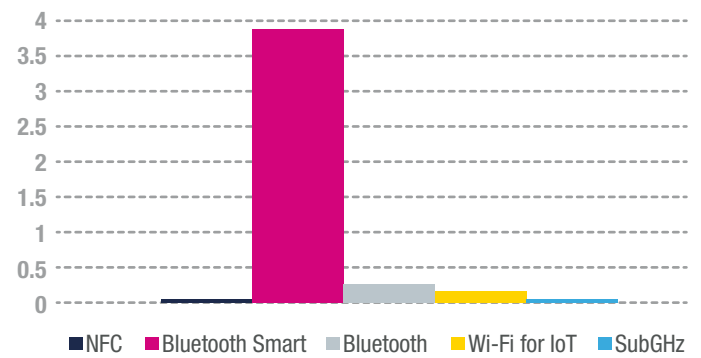
SLEEP CURRENT [uA]



MAXIMUM THROUGHPUT [Mbps]



BATTERY LIFE [years]



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

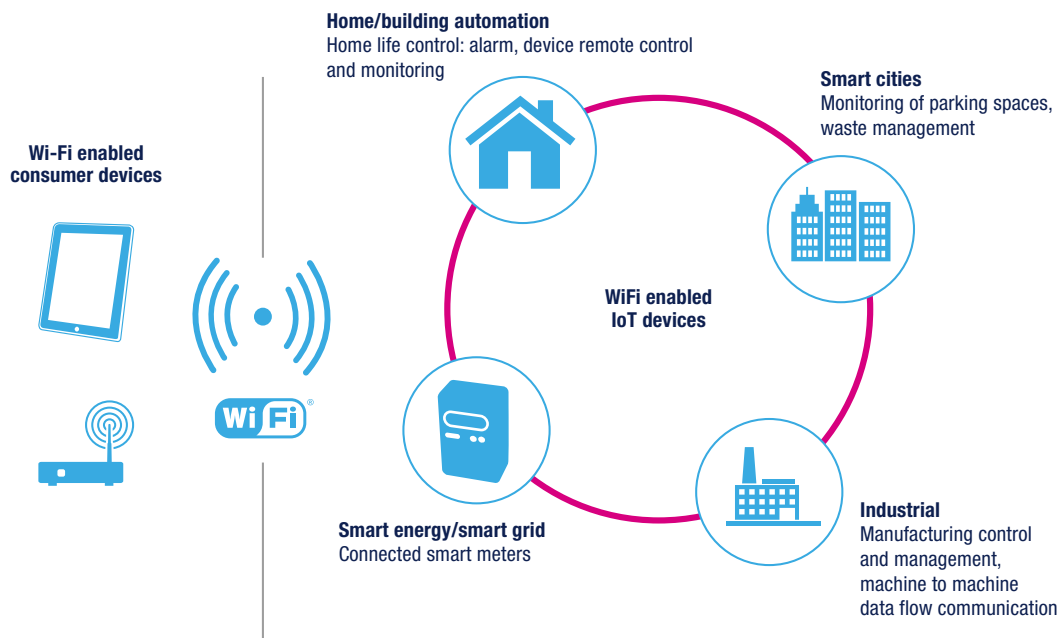
Wi-Fi / IEEE 802.11 communication interface

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.



Wi-Fi technology

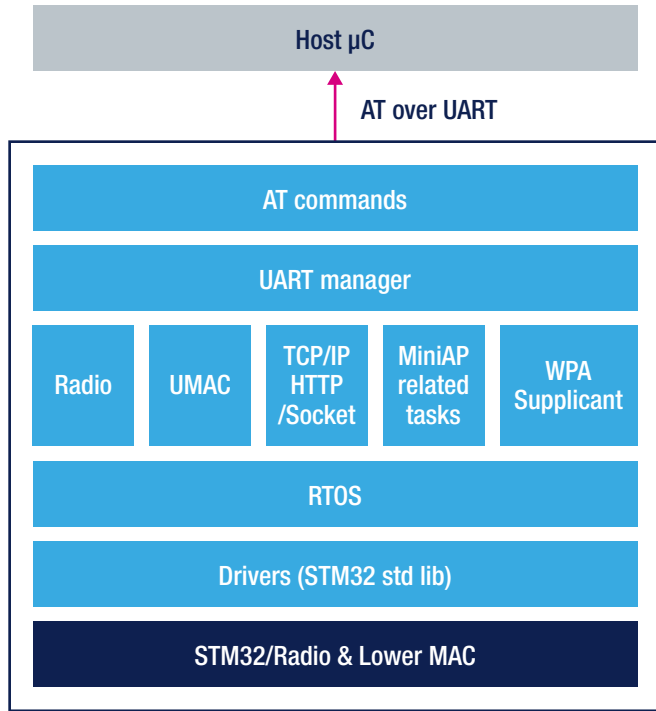
Wi-Fi technology was designed to connect electronic devices in a wireless local area network (WLAN). Devices within the WLAN can exchange data or connect to the Internet at a data rate of 54 Mbit/s or more. Wi-Fi is based on the IEEE 802.11 family of standards operating in the 2.4 GHz (IEEE 802.11b/g/n) 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



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.

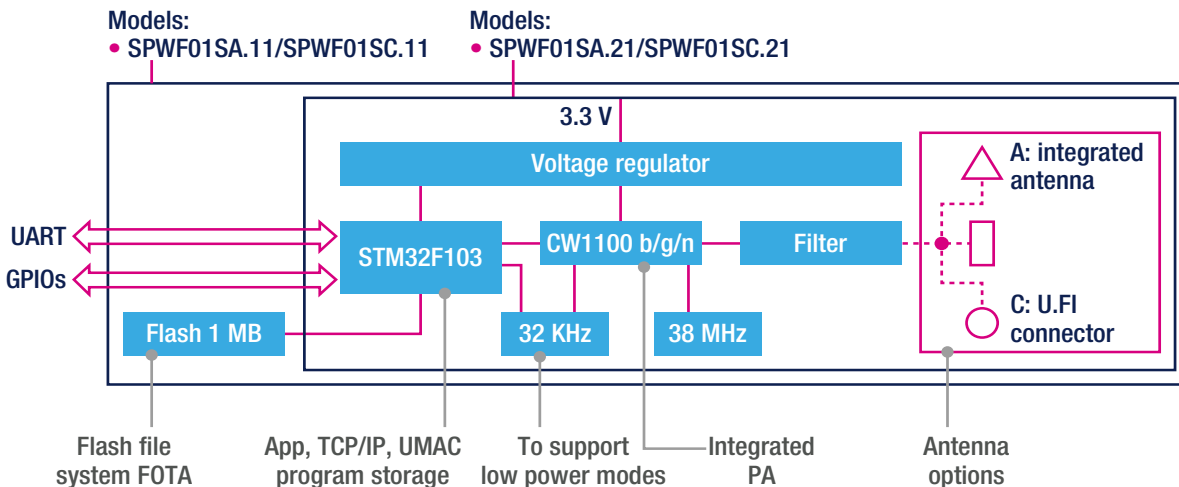
CE, IC, FCC certifications are available, meaning the module can be added on top of an existing design to easily add Wi-Fi functionality without having to get in touch with a certification lab.

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 mm²). 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.



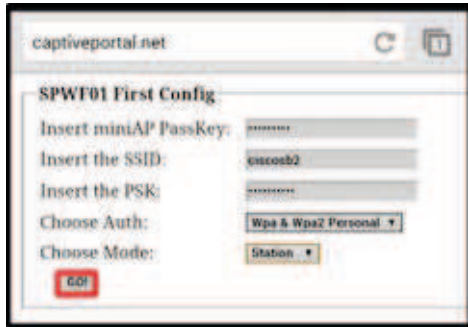
To further facilitate hardware integration, 16 GPIOs, a serial port and JTAG debug port are available.



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).

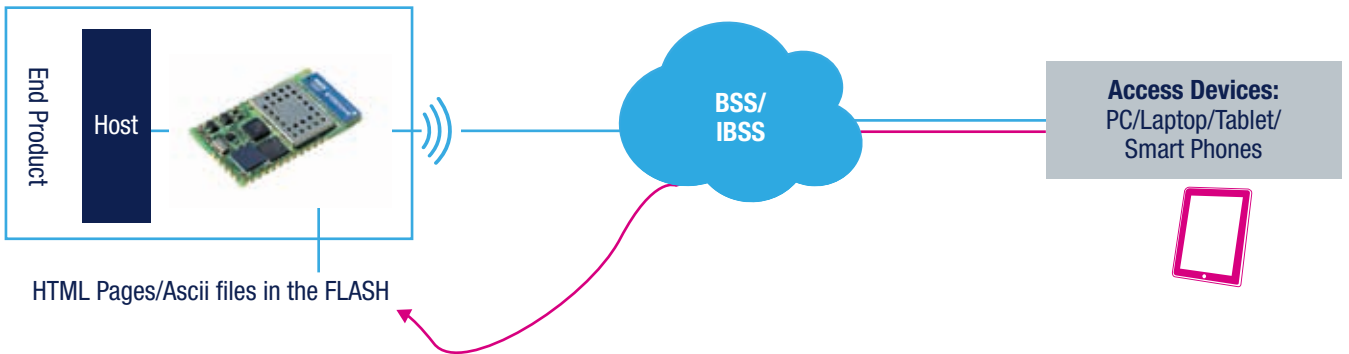


The miniAP function offers an easy method for configuring the module with the access point credentials at first association, i.e. SSID, password and security. A Wi-Fi-equipped smartphone or tablet can easily configure the module without the need for any specific software being pre-loaded or updated.

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



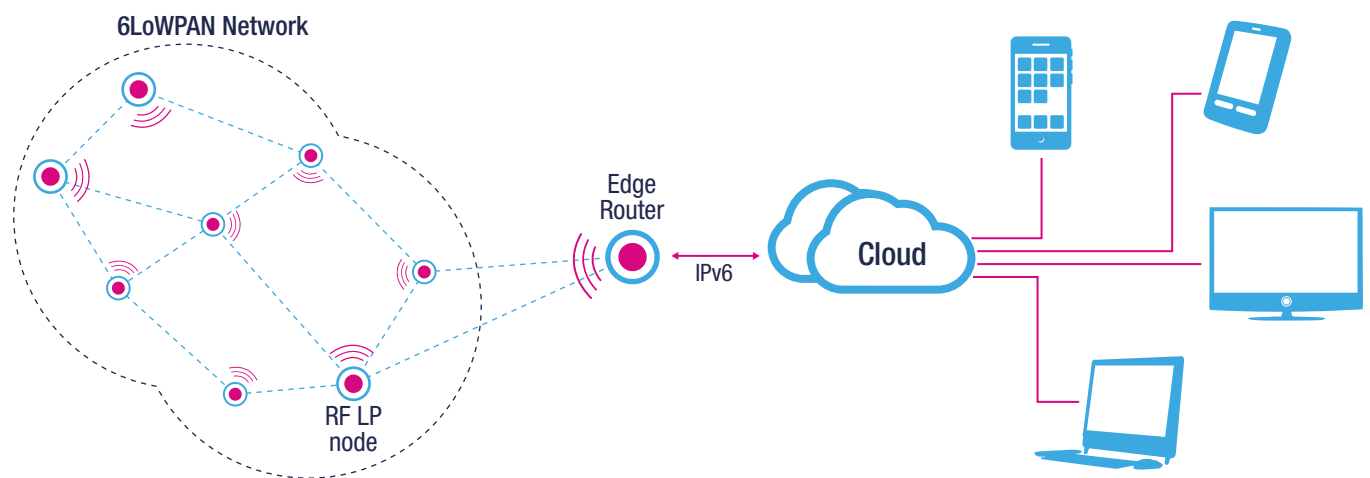
The module also implements a REST API (get, post) used to read remote pages over the serial port or to post data on a remote server. Modules equipped with 1 Mbyte of Extended Flash memory allow over-the-air firmware updates (FOTA).



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.



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.

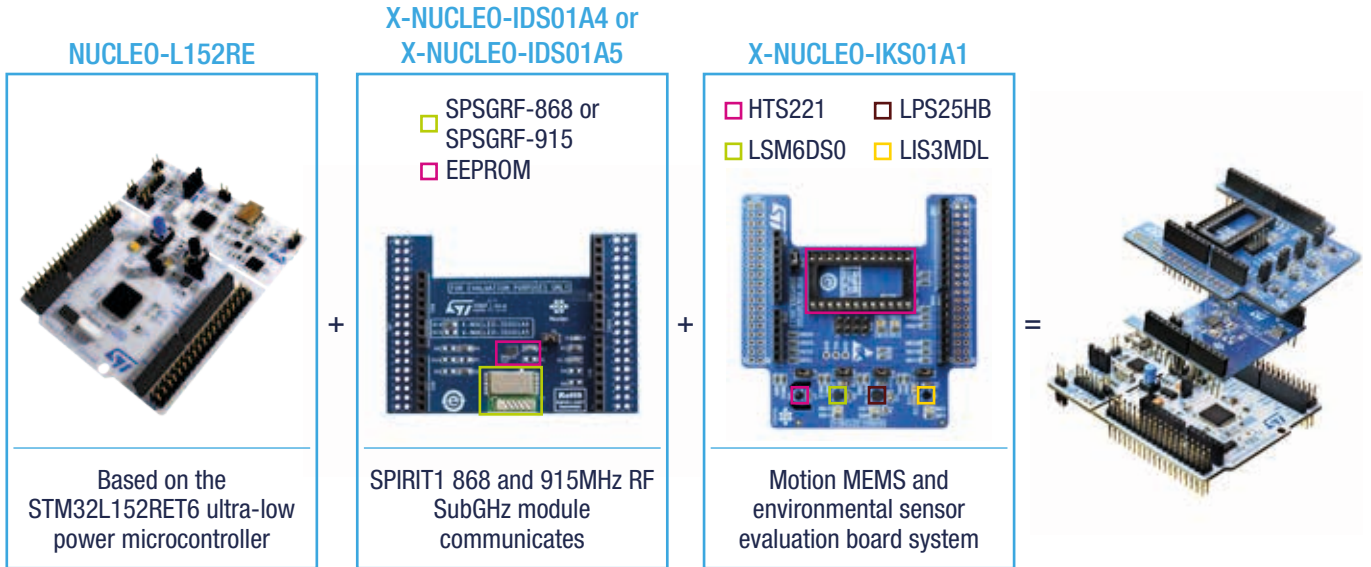
The Data Link layer implements carrier sense multiple access with collision avoidance (CSMA/CA) and ContikiMAC, a radio duty cycling mechanism. ContikiMAC includes a sleepy router feature which extends the battery life of a mesh network's low-power nodes. To save power, nodes are switched off most of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



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.

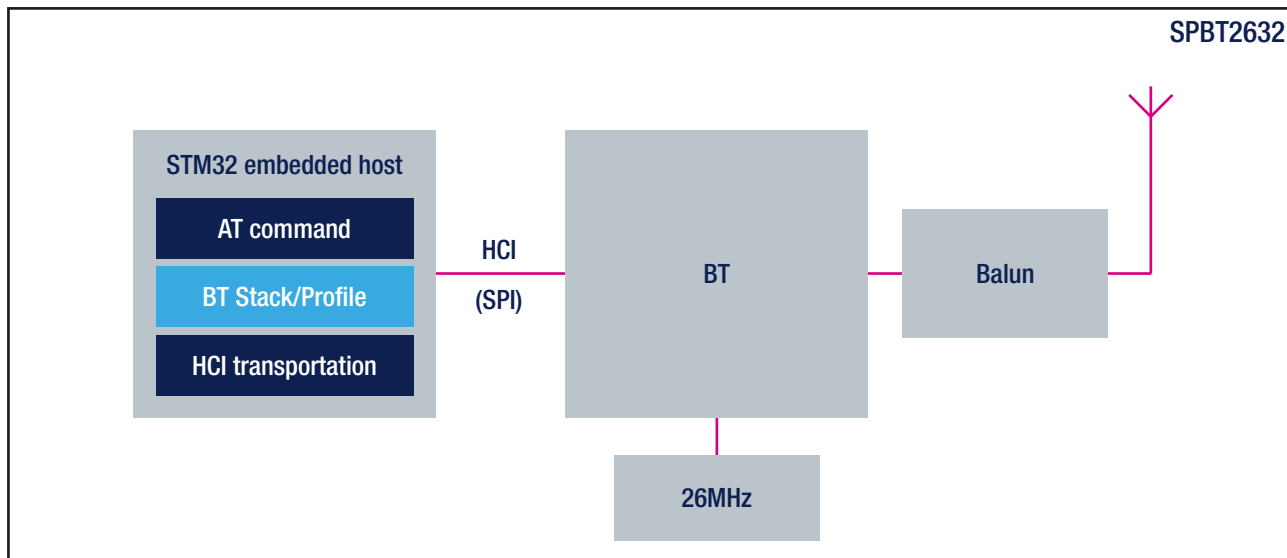
16

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 “accessories” 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 μ A
 - 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.

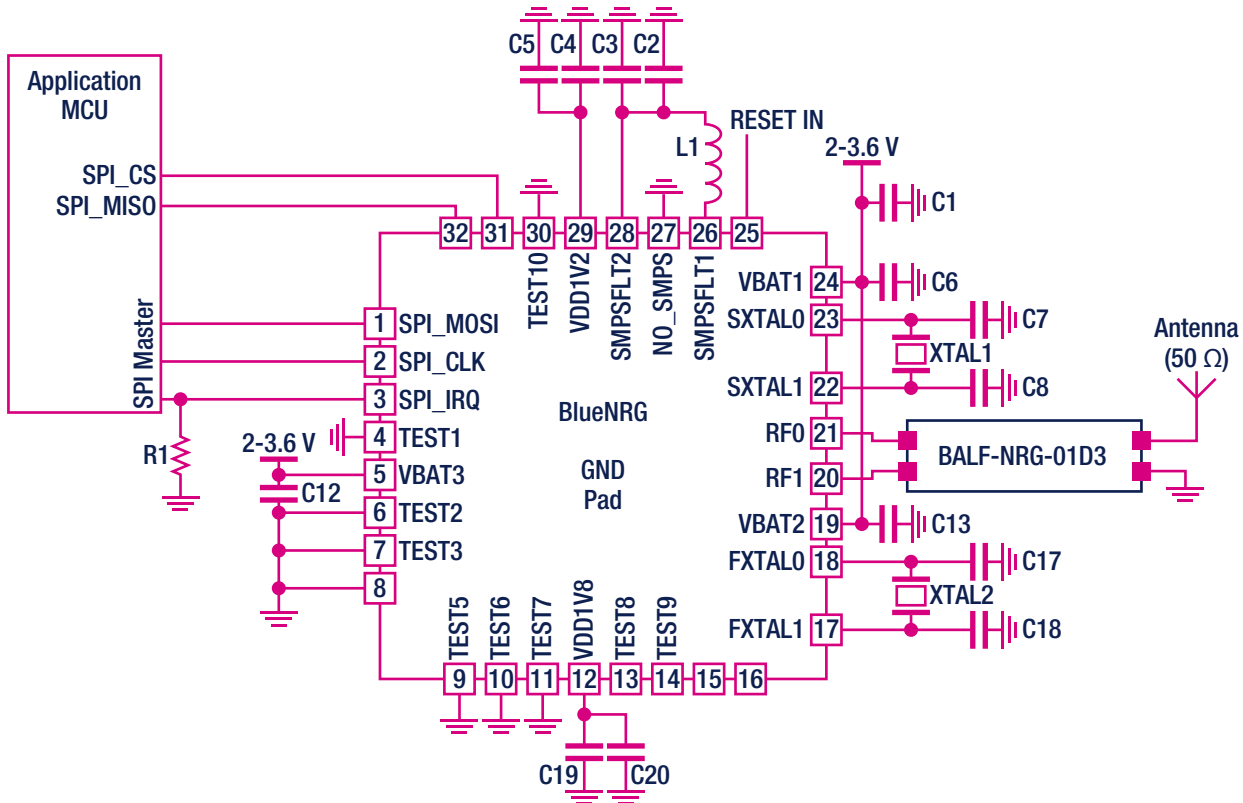
The BlueNRG-MS network processor can power devices such as a hub capable of collecting sensor data and subsequently acting as a peripheral to transfer the data to a smartphone supporting both master and slave roles simultaneously. It can also allow very large sensor networks with an unlimited communication 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 WLCSF 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

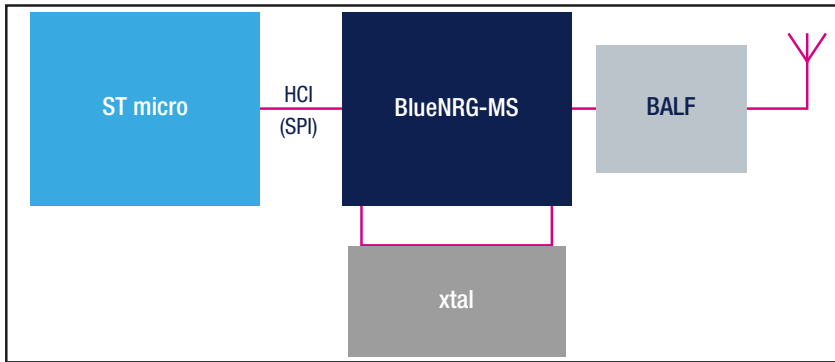
Moreover, the BlueNRG-MS radio embeds a non-volatile Flash memory which allows upgrading the stack when the device is deployed in the field.

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

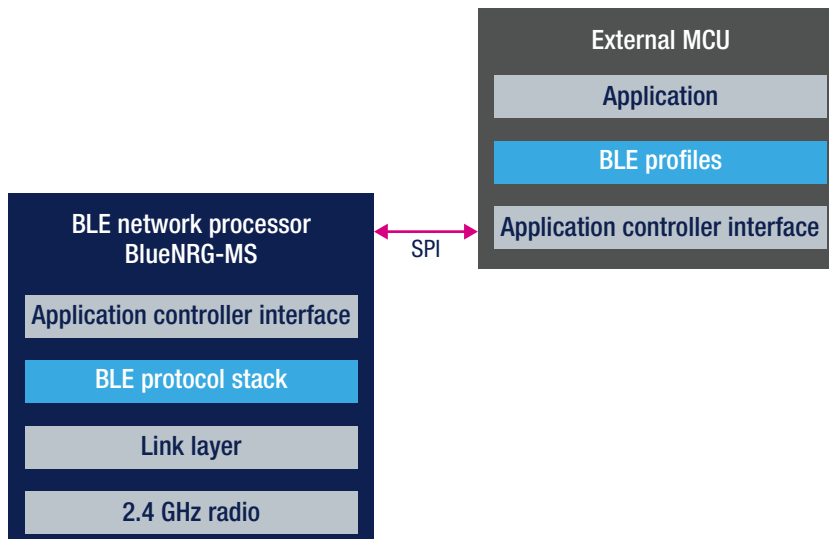
What's more is that the SPBTLE-RF module is available in a micro-sized form factor: 11.6 x 13.5 x 2.0 mm.

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

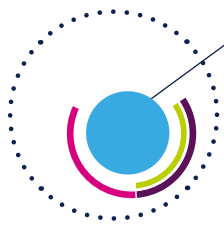
STEVAL-IDB006V1M USB dongle based on SPBTLE-RF

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

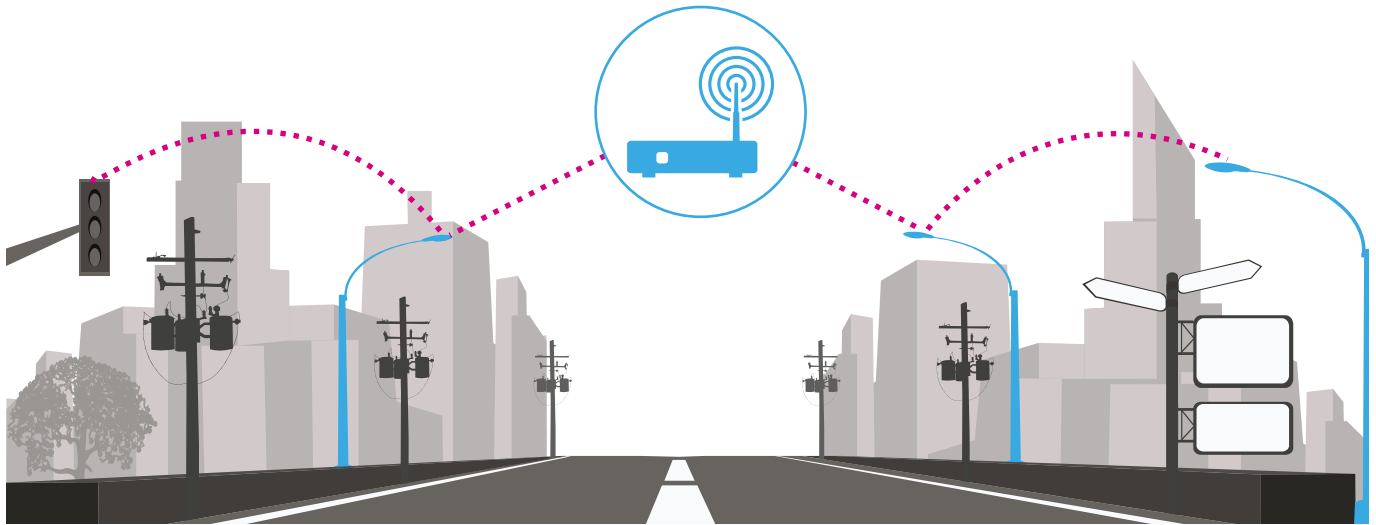
SUB-1 GHZ OVERVIEW

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 unmatched 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.

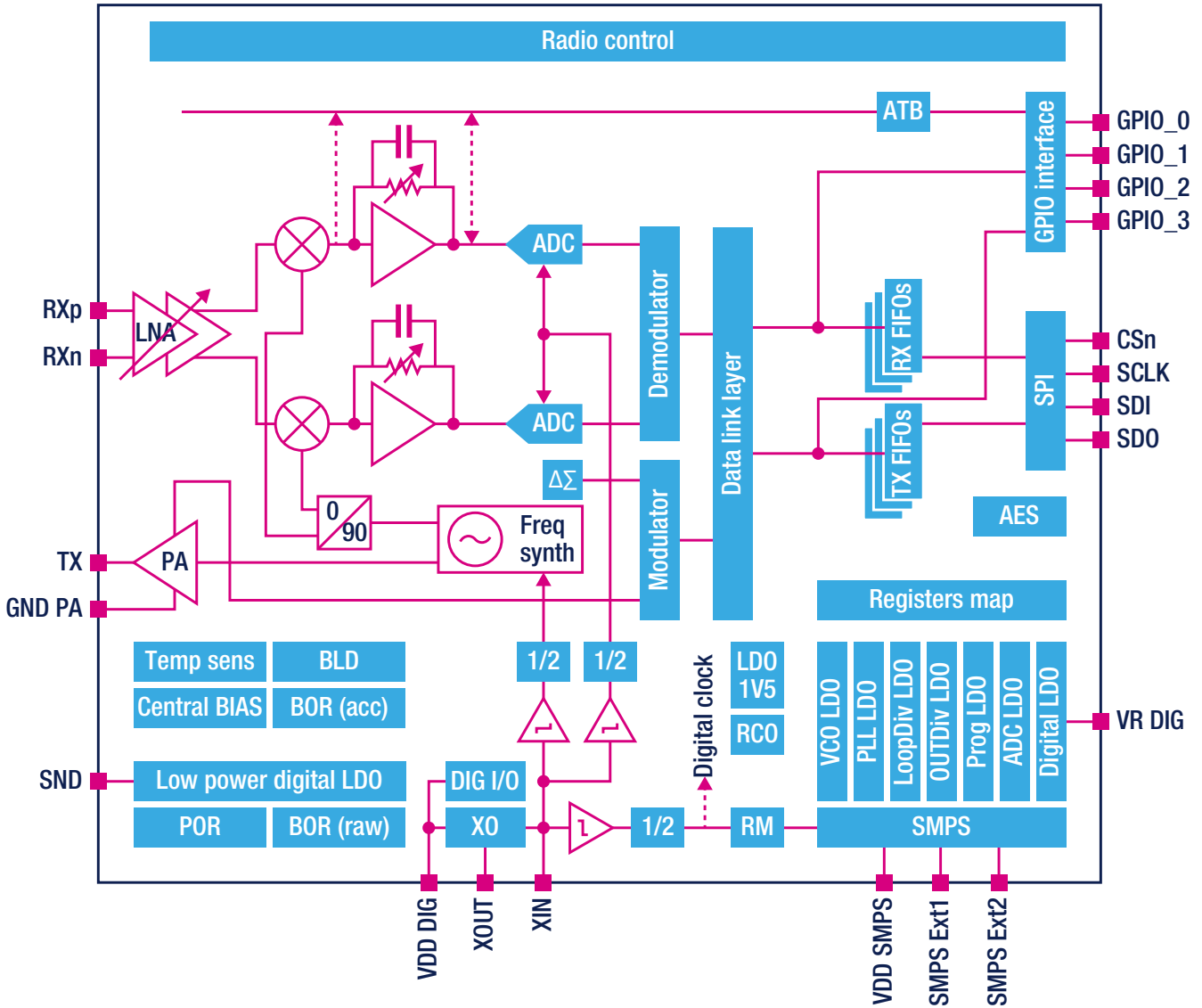


SPIRIT1 LOW-POWER TRANSCEIVER

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

