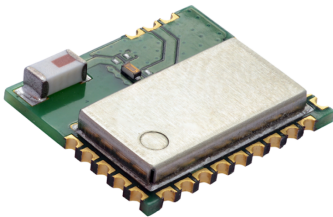# Very low power application processor module for Bluetooth® Low Energy v4.2

Features

- Bluetooth v4.2 compliant
  - Supports master and slave modes
  - Multiple roles supported simultaneously
- High performance, ultra-low power Cortex-M0 32-bit based architecture core
- Programmable embedded 160 kB Flash
- 24 kB embedded RAM with data retention
- Interfaces:
  - 1 x UART, 1 x I²C, 1xSPI, 14 x GPIO, 2 x multifunction timer, 10-bit ADC, Watchdog and RTC, DMA controller, PDM stream processor, SWD debug interface
- Bluetooth radio performance:
  - Max. Tx power: + 4 dBm
  - Excellent link reliability
- On-board chip antenna
- Small form factor: 11.5 mm x 13.5 mm
- Complemented with Bluetooth low energy protocol stack library (GAP, GATT, SM, L2CAP, LL)
- AES security co-processor
- Bluetooth low energy SDK with wide range of profile available
- Certifications:
  - EU (RED) type certificate
  - FCC, IC modular approval certification
  - SRRC Chinese certification
  - BT SIG end product QDID
- Pre-programmed UART bootloader
- Operating supply voltage: from 1.7 to 3.6 V
- Operating temperature range: -40 °C to 85 °C

Applications

- Internet of Things
- Smart Home
- Building and industrial automation
- Smart lighting
- Remote and access control
- Fitness, wellness and sports
- Consumer medical
- Security and proximity
- Assisted living
- PC and smart phone peripherals

Product status link
SPBTLE-1S

Description

The SPBTLE-1S is a Bluetooth® low energy system-on-chip application processor certified module, compliant with BT specifications v4.2 and BQE qualified. The SPBTLE-1S module supports multiple roles simultaneously and can act at the same time as Bluetooth smart master and slave device.

The SPBTLE-1S is based on BlueNRG-1 system-on-chip and entire Bluetooth low energy stack and protocols are embedded into module.

The SPBTLE-1S module provides a complete RF platform in a tiny form factor. Radio, embedded antenna and high frequency oscillators are integrated to offer a certified solution to optimize the time to market of the final applications.

The SPBTLE-1S can be powered directly with a pair of AAA batteries or any power source from 1.7 to 3.6 V.

1 General description

The SPBTLE-1S is a Bluetooth low energy application processor module compliant with Bluetooth® specifications v4.2 with embedded ceramic antenna.

The SPBTLE-1S module has been designed around the ST BlueNRG-1 SoC where its Cortex-M0 core can execute both Bluetooth protocols and customer application. A complete power-optimized Bluetooth stack library provides:

- Master, slave, multiple roles support
- GAP: central, peripheral, observer or broadcaster roles
- Simultaneous advertising and scanning
- capability of being slave of up to two masters simultaneously
- ATT/GATT: client and server
- SM: privacy, authentication and authorization
- L2CAP
- Link Layer: AES-128 encryption and decryption

The SPBTLE-1S has 160 kB embedded Flash and 24 kB embedded RAM memory.

In the module are available 32 MHz and 32 kHz crystal oscillators. It has been designed to leverage the BlueNRG-1 integrated DC-DC step down converter in order to achieve best power consumption in active mode.

It can be configured to support both application processor (host-less) and network processor (hosted) modes.

Being based on the BlueNRG-1 SoC, the SPBTLE-1S module leverages all the tools and documentation of its ecosystem: development kit, application notes, user manuals, design notes and tips. A wide set of sample programs are also available in C source code.

The SPBTLE-1S module has a wide set of peripherals available for customer application (1 x UART interface, 1 x SPI interface, 1 x I^2C interface, 14 GPIO, 2 x multifunction timer, 10-bit ADC, watchdog and RTC, DMA controller, PDM stream processor).

The SPBTLE-1S module enables wireless connectivity into electronic devices, not requiring any RF experience or expertise for integration into the final product. The SPBTLE-1S module provides a complete RF application platform in a tiny form factor (11.5 x 13.5 x 2.0 mm) and being a certified solution optimizes the time to market of the final applications.

The SPBTLE-1S module allows applications to meet the tight advisable peak current requirements imposed with the use of standard coin cell batteries. Optimized results are obtained with the embedded high-efficiency DC-DC step-down. SPBTLE-1S can be powered directly with a standard 3 V coin cell battery as with a pair of AAA batteries or any power source from 1.7 to 3.6 V.

2 Block schematic

Figure 1. Block diagram
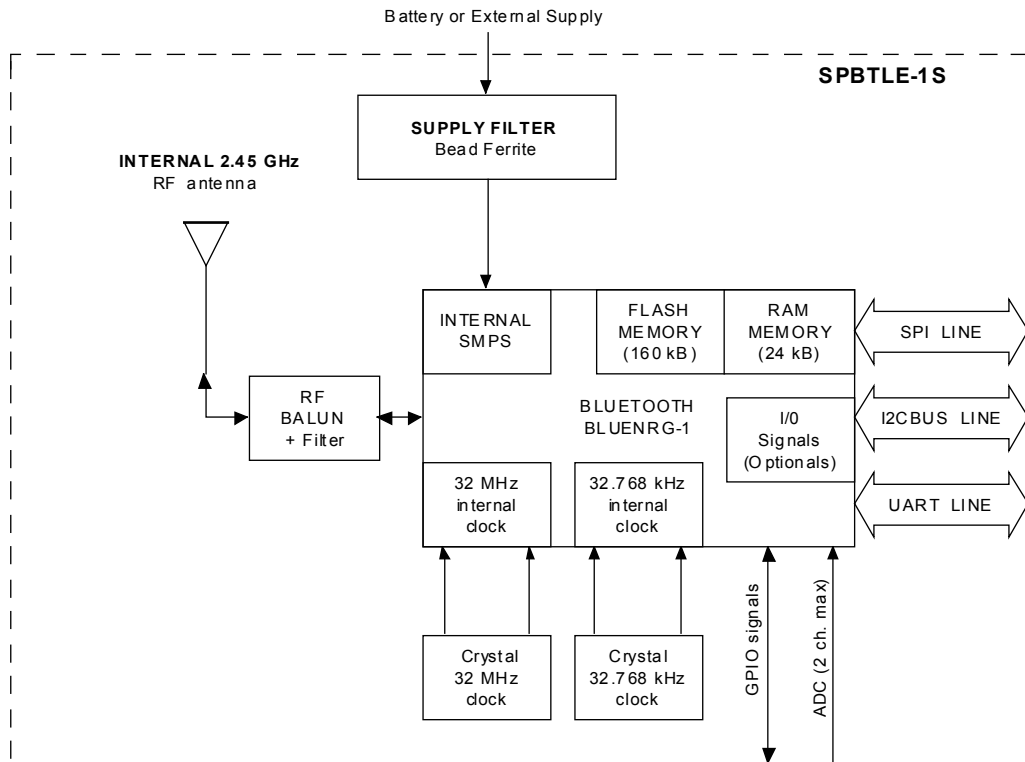
3 Software development

3.1 Software development kit

The SPBTLE-1S module embeds the BlueNRG-1 application processor. Refer to the BlueNRG-1 web page (https://www.st.com) to get access to:

- BlueNRG-1 datasheet
- development kit
- application notes
- user manuals
- tools and software
- design note and tips

Software and firmware should be configured taking into account the SPBTLE-1 specific configuration as described in the block diagram chapter. In particular the SPBTLE-1 module has:

- 32 MHz crystal oscillator
- 32 kHz crystal oscillator
- SMPS DC-DC converter
- 10 µH SMPS inductor

The projects provided with the development kit should be customized defining as following:

- HS_SPEED_XTAL=HS_SPEED_XTAL_32MHZ
- LS_SOURCE=LS_SOURCE_EXTERNAL_32KHZ
- SMPS_INDUCTOR=SMPS_INDUCTOR_10µH

3.2 Software architecture

There are two possible software architectures:

- Host-less mode (application processor): customer application runs on the SPBTLE-1S module. Many sample projects are available in the development kit

Figure 2. SPBTLE-1S BLE application processor
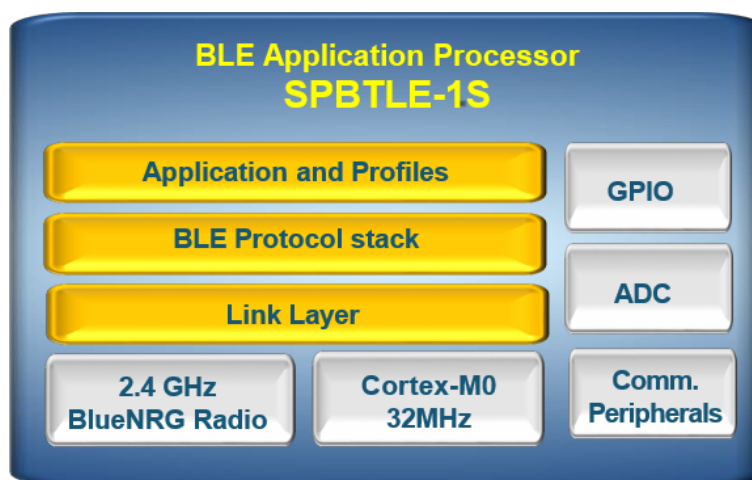
- Hosted mode (network processor): the module is configured as network module controlled by an external host connected via SPI or UART. A project named DTM is available in the development kit that configures the SPBTLE-1S module as a network module.

Figure 3. SPBTLE-1S as BLE network processor
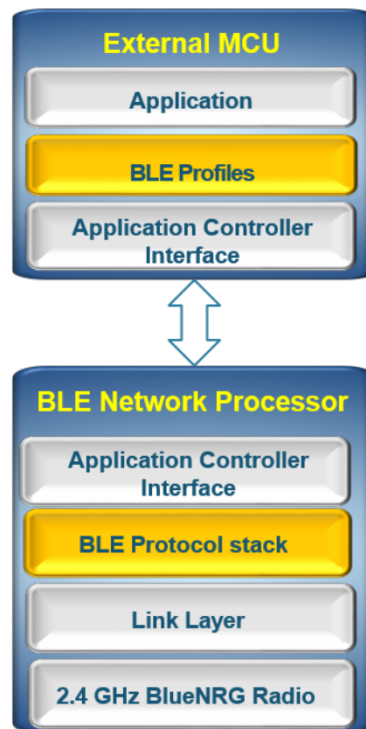
4 Hardware specifications

General conditions (V_{IN} = 3.3 V and 25 °C)

Table 1. Absolute maximum ratings

Ratings	Min.	Typ.	Max.	Unit
Storage temperature range	- 40		+ 95	°C
Supply voltage, V_{IN}	- 0.3		+ 3.9	V
I/O pin Voltage (V_{IO} five-volt tolerant pin)	- 0.3		+ 3.9	V
RF saturation input power		8		dBm

Table 2. Recommended operating conditions

Ratings	Min.	Typ.	Max.	Unit
Operating temperature range	- 40		+ 85	°C
Supply voltage, V_{IN}	1.7	3.3	3.6	V
Signals and I/O pin voltage (according supply voltage)	1.7		3.6	V

Table 3. Radio features

Ratings	Min.	Typ.	Max.	Unit
Bluetooth version		4.2		
Radiated transmit power			+ 4.48	dBm
Receiver sensitivity		- 84		dBm
RF frequency	2402		2480	MHz
HS_Startup_Time [1]		512		µs

1. The HS_Startup_Time has been measured according to the "Bringing up the BlueNRG-1 device" (AN4818). The HS_Startup_Time parameter is important because it permits minimization of the current consumption. A value that is too short prevents the SPBTLE-1S from correctly sending/receiving packets. Users should set the typical value as indicated in *Table 3. Radio features* .

4.1 Current consumption

Characteristics measured over recommended operating conditions unless otherwise specified. Typical value are referred to T_A = 25 °C, V_{IN} = 3.0 V.

Current consumption values has been taken using the "BlueNRG current consumption estimation tool", configured to match the SPBTLE-1S configuration.

The tool is available on ST.com at:

http://www.st.com/en/embedded-software/stsw-bnrg001.html

Reported values have been taken configuring the tool as shown in the follow figure:

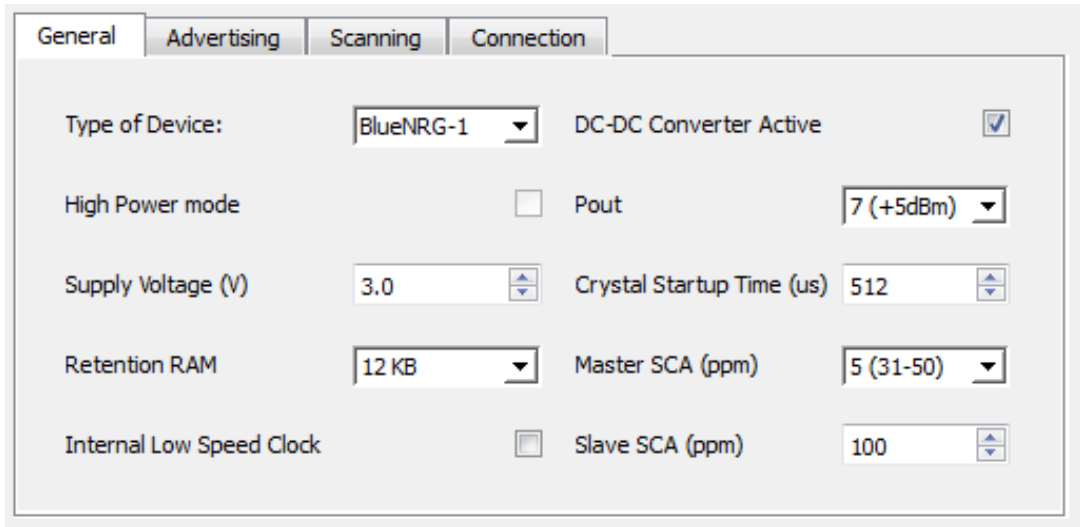**Figure 4. Configuration of the "BlueNRG current consumption estimation tool"**

Table 4. Current consumption

Symbol	Parameter	Test conditions	Typ.	Unit
I_{DD}	Supply current	Reset	5	nA
		Standby	500	
		Sleep mode	0.9	µA
		Active mode	1.9	mA
		RX	7.7	
		TX: +5 dBm	15	
		TX: 0 dBm	11	

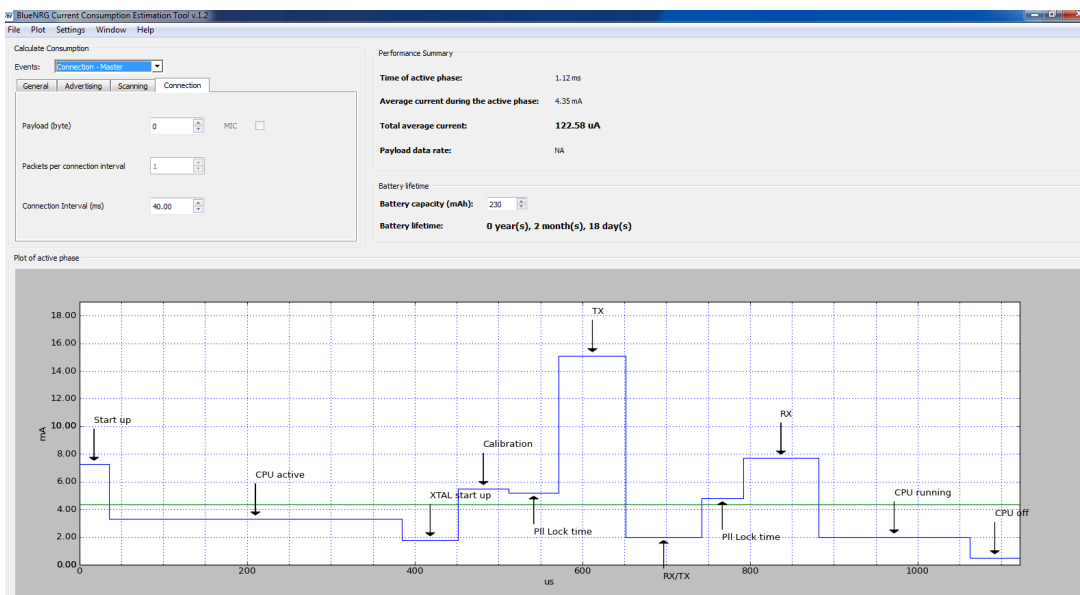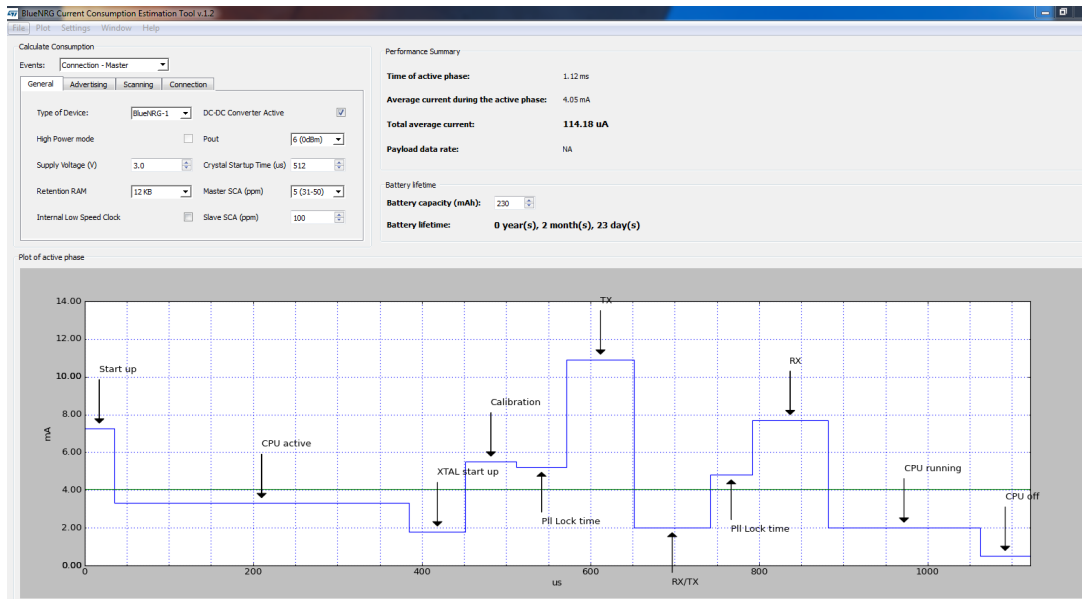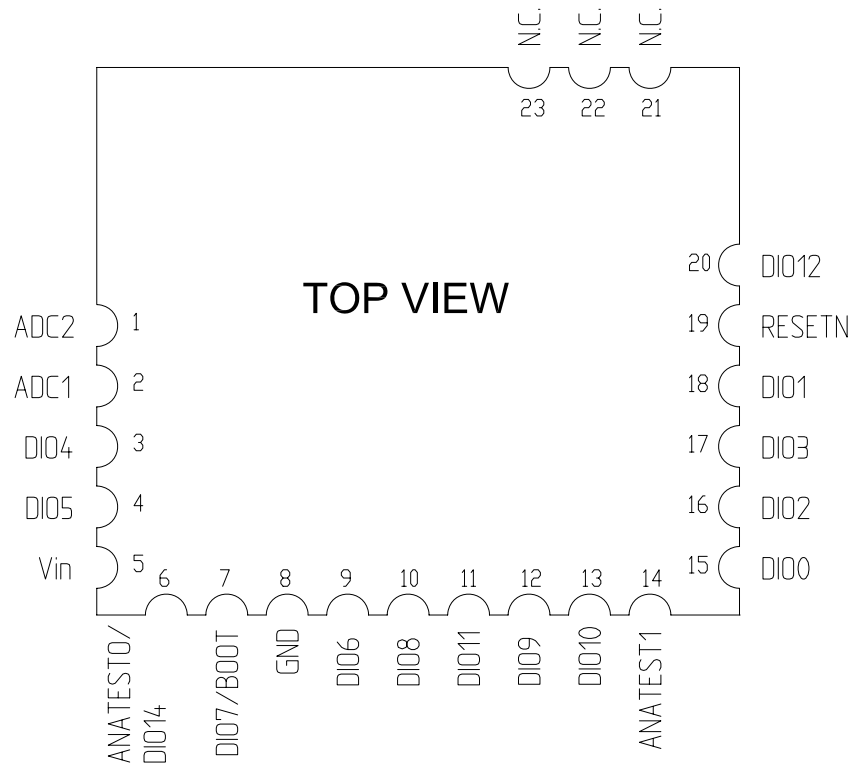**Figure 5. Typical current consumption profile at +5 dBm**

Figure 6. **Typical current consumption profile at 0 dBm**

4.2 Pin assignment

Figure 7. **Pin assignment**

As described in the previous picture the SPBTLE-1S module is using exposed pad in order to allow a full optical visual inspection in order to fulfill the needs of industrial grade applications.

The follow table provides the association between SPBTLE-1S module pin and the related BlueNRG-1 pin. Refer to the BlueNRG-1 datasheet for detailed description.

Table 5. Pinout description

Module pin #	Name	BlueNRG-1 Pin (CSP package)	Function			
			Mode: "000"	Mode: "001"	Mode: "100"	Mode: "010"
1	ADC2	D5	ADC input 2			
2	ADC1	B4	ADC input 1			
3	DIO4	C3	GPIO4	UART_RXD	I2C2_CLK	PWM0
4	DIO5	C2	GPIO5	UART_TXD	I2C2_DAT	PWM1
5	Vin	A3, E6	Supply pin			
6	ANATEST0/ DIO14/	A5	GPIO14		SPI_CLK	ADC_DATA
7	DIO7/BOOT[1]	D2	GPIO7	UART_CTS	I2C2_DAT	PDM_CLK
8	GND	A4, B6, C1, F5	Ground			
9	DIO6	D1	GPIO6	UART_RTS	I2C2_CLK	PDM_DATA
10	DIO8	D3	GPIO8	UART_TXD	SPI_CLK	PDM_DATA
11	DIO11	E2	GPIO11	UART_RXD	SPI_CS1	
12	DIO9	E1	GPIO9	SWCLK	SPI_IN [2]	
13	DIO10	F1	GPIO10	SWDIO	SPI_OUT [3]	
14	ANATES1	D4	Anatest1			
15	DIO0	A2	GPIO0	UART_CTS	SPI_CLK	
16	DIO2	A1	GPIO2	PWM0	SPI_OUT	PDM_CLK
17	DIO3	B1	GPIO3	PWM1	SPI_IN	ADC_CLK
18	DIO1	B2	GPIO1	UART_RTS	SPI_CS1	PDM_DATA
19	RESETN	B3	Reset Pin			
20	DIO12	F2	GPI12 [4]			
21	N.C.	N/A	Must be left floating			
22	N.C.	N/A	Must be left floating			
23	N.C.	N/A	Must be left floating			

1. The pin DIO7/BOOT is monitored by bootloader after power up or hardware Reset and it should be low to prevent unwanted bootloader activation
2. The function SPI_IN indicates that the pin is always an input when configured for SPI. Thus in case of SPI master role, it acts as MISO pin. In case of SPI slave role, this pin act as MOSI. See Table 5.
3. The function SPI_OUT indicates that the pin is always an output when configured for SPI. Thus in case of SPI master role, it acts as MOSI pin. In case of SPI slave role, this pin act as MISO. See Table 5.
4. DI012 can only be General Purpose Input pins (not output).

Table 6. SPI pin function

| SPI function	SPBTLE-1S SPI role = master	SPBTLE-1S SPI role = Slave
SPI_IN	SPI MISO	SPI MOSI
SPI_OUT	SPI MOSI	SPI MISO

5 Hardware design

Note:
- *All unused pins should be left floating; do not ground*
- *GND pin must be well grounded*
- *Traces should not be routed underneath the module*

The area around the module should be free of any ground planes, power planes, trace routings, or metal for 6 mm from the module antenna position, in all directions.

5.1 Reset circuitry

The SPBTLE-1S module requires an external pull-up reset circuitry to ensure proper operation at power on. Refer to the "Reset management" chapter of the BlueNRG-1 datasheet for details.

Figure 8. Reset circuitry
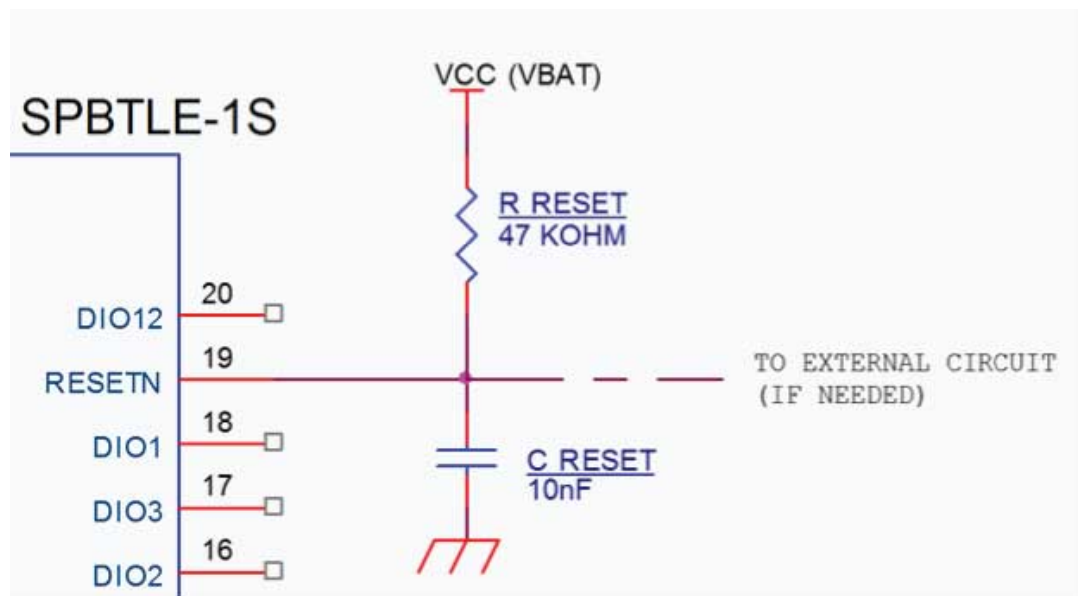
5.2 Debug interface

The SPBTLE-1S embeds the ARM serial wire debug (SWD) port. It is two pins (clock and single bi-directional data) debug interface, providing all the debug functionality plus real time access to system memory without halting the processor or requiring any target resident code.

Table 7. Debug interface pin

Pin functionality	Module PIN	Pin description
SWCLK	12	SWD clock signal
SWDIO	13	SWD data signal

For more information refer to the BlueNRG-1 technical documentation
(http://www.st.com/en/wireless-connectivity/bluenrg-1.html)

5.3 Reflow soldering

The SPBTLE-1S is a high temperature strength surface mount Bluetooth® module supplied on a 23 pin, 4-layer PCB.

Module is assembled with special soldering paste that allow to make the additional reflow with no changes in the module original characteristic. It's important to respect the parameter listed in the follow table.

The final assembly recommended reflow profiles are indicated here below.

Soldering phase has to be executed with care: in order to avoid undesired melting phenomenon, particular attention has to be taken on the set up of the peak temperature. Here following some suggestions for the temperature profile based on following recommendations.

Table 8. Soldering

Profile feature	Pb-free assembly
Average ramp up rate (T_{SMAX} to T_p)	3 °C / s max.
Preheat	
Temperature min. (T_S min.)	150 °C
Temperature max. (T_S max.)	200 °C
Time (t_S min. to t_S max.) (t_S))	60 - 100 s
Time maintained above	
Temperature T_L	217 °C
Time t_L	60 - 70 s
Peak temperature (T_P)	245 (-0) °C
Time within 5 °C of peak temperature (T_P-5 °C)	min. 30 s
Ramp down rate	6 °C / s
Time from 25 °C to peak temperature	8 minutes max.

Figure 9. Soldering profiles
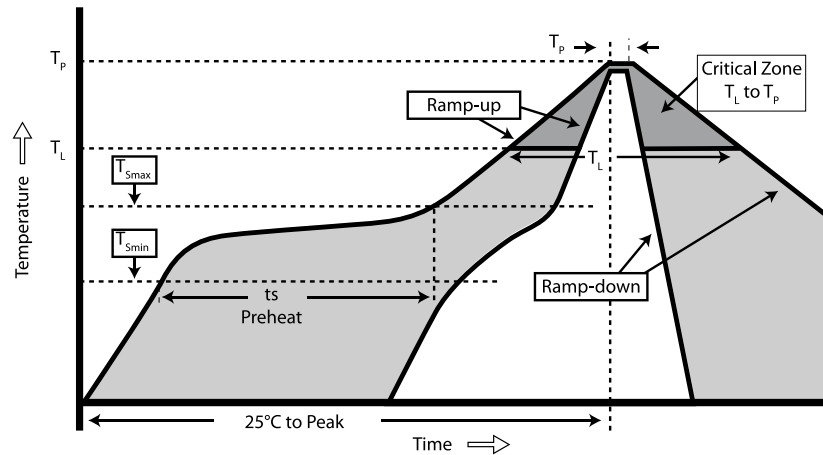
6 Regulatory compliance

6.1 FCC certification

This module has been tested and found to comply with the FCC part 15 rules. These limits are designed to provide reasonable protection against harmful interference in approved installations. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference may not occur in a particular installation.

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference,

    and

2. this device must accept any interference received, including interference that may cause undesired operation.

Modifications or changes to this equipment not expressly approved by STMicroelectronics may render void the user's authority to operate this equipment.

Modular approval

FCC ID: S9NSPBTLE1S

In accordance with FCC part 15, the SPBTLE-1S is listed as a modular transmitter device.

This module is evaluated for stand-alone use only. Finished products incorporating multiple transmitters must comply with colocation and RF exposure requirements in accordance with FCC multi-transmitter product procedures. Collocated transmitters operating in portable RF Exposure conditions (e.g. <20 cm from persons including but not limited to body worn and hand held devices) may require separate approval.

6.1.1 Labeling instructions

When integrating the SPBTLE-1S into the final product, the OEM must ensure that the FCC labeling requirements are satisfied. A statement must be included on the exterior of the final product which indicates the product includes a certified module. The label should state the following (or similar wording that conveys the same meaning):

This product uses SRRC approved Radio modular. CMIIT ID: 2017DJ5956

6.1.2 Product manual instructions

This section applies to OEM final products containing the SPBTLE-1S module, subject to FCC compliance. The final product manual must contain the following statement (or a similar statement that conveys the same meaning)

Note: *Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. (Part. 15.21)*

In the case where an OEM seeks Class B (residential) limits for the final product, the following statement must be included in the final product manual:

Note: *This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna*
- *Increase the separation between the equipment and receiver*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected*
- *Consult the dealer or an experienced radio/TV technician for help*

In the case where an OEM seeks the lesser category of a Class A digital device for the final product, the following statement must be included in the final product manual:

Note: *This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his expense.*

6.2 IC certification

The SPBTLE-1S module has been tested and found compliant with the IC RSS-210 rules. These limits are designed to provide reasonable protection against harmful interference in approved installations. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference may not occur in a particular installation.

This device complies with RSS-210 of the IC rules. Operation is subject to the following two conditions:

- this device may not cause harmful interference

  and

- this device must accept any interference received, including interference that may cause undesired operation

Modifications or changes to this equipment not expressly approved by STMicroelectronics may render void the user's authority to operate this equipment.

Modular approval

IC: 8976C-SPBTLE1S

In accordance with IC RSS-210, the SPBTLE-1S is listed as a modular transmitter device.

This module is evaluated for stand-alone use only. Finished products incorporating multiple transmitters must comply with colocation and RF exposure requirements in accordance with IC multi-transmitter product procedures. Collocated transmitters operating in portable RF Exposure conditions (e.g. < 20 cm from persons including but not limited to body worn and hand held devices) may require separate approval.

6.2.1 Labeling instructions

When integrating the SPBTLE-1S into the final product, the OEM must ensure that the IC labeling requirements are satisfied. A statement must be included on the exterior of the final product which indicates that the product includes a certified module. The label should state the following (or similar wording that conveys the same meaning):

Contains IC: 8976C-SPBTLE1S

OR

This product contains IC: 8976C-SPBTLE1S

The OEM must include the following statements on the exterior of the final product unless the product is too small (e.g. less than 4 x 4 inches):

This device complies with RSS-210 of the IC Rules. Operation is subject to the following two conditions:

- this device may not cause harmful interference

  and

- this device must accept any interference received, including any interference that may cause undesired operation

6.2.2 Product manual instructions

This section applies to OEM final products containing the SPBTLE-1S module, subject to IC compliance. The final product manual must contain the following statement (or a similar statement that conveys the same meaning):

Warning:
> *Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. (RSS-210)*

In the case where an OEM seeks Class B (residential) limits for the final product, the following statement must be included in the final product manual:

Note: *This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to RSS-210 of the IC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna*

- *Increase the separation between the equipment and receiver*

- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected*

- *Consult the dealer or an experienced radio/TV technician for help*

In the case where an OEM seeks the lesser category of a Class A digital device for the final product, the following statement must be included in the final product manual:

Note: *This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to RSS-210 of the IC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his expense.*

6.3 SRRC

6.3.1 Modular approval

The SPBTLE-1S module complies with Chinese SRRC certification.
– SRRC CMIIT ID: 2017DJ5956

6.3.2 Labeling instructions

When integrating the SPBTLE-1S into the final product, the OEM must ensure that the FCC labeling requirements are satisfied. A statement must be included on the exterior of the final product which indicates the product includes a certified module. The label should state the following (or similar wording that conveys the same meaning):

This product uses SRRC approved Radio modular. CMIIT ID: 2017DJ5956

6.4 Bluetooth certification

The module with embedded stack and profile has been qualified in accordance with SIG qualification rules:

- Declaration ID: D034470
- Qualified design ID: 92838
- Product type: End Product
- Core spec version: 4.2
- Product description: Bluetooth Smart v4.2 module

7 CE certification

The SPBTLE-1S module has been certified according to the following certification rules :

- ETSI EN 300 328 V 2.1.1 (2016-11) (a)
- ETSI EN 301 489-17 V3.1.1 (2017-02) (b)
- ETSI EN 301 489-1 V2.1.1 (2017-02) (c)
- EN 62368-1:2020/A11:2020 (d)
- EN 62479:2010

a) ETSI EN 300 328 V 2.1.1 (2016 11): "electromagnetic compatibility and radio spectrum Matters (ERM); Wideband transmission systems; data transmission equipment operating in the 2.4 GHZ ISM band and using wideband modulation techniques; harmonized EN covering essential requirements under article 3.2 of the R&TTE directive".

b) ETSI EN 301 489-17 V 3.1.1 (2017 02): "electromagnetic compatibility and radio spectrum Matters (ERM); electromagnetic compatibility (EMC) standard for radio equipment and services; part 17: specific condition for 2.4 GHz wideband transmission systems and 5 GHz high performance RLAN equipment".

c) ETSI EN 301 489-1 V2.1.1 (2017 02): "electromagnetic compatibility and radio spectrum Matters (ERM); electromagnetic compatibility (EMC) standard for radio equipment and services; part 1: Common technical requirements".

d) EN 62368-1:2020/A11:2020: "Audio/video, information and communication technology equipment - Part 1: Safety requirements".

The module is provided by CE marking:

Figure 10. CE marking

The module has obtained the RED certificate: No. 0051-RED-0010

The certified module production firmware release is:

2.X

For additional information please refer to:

STMicroelectronics Via C. Olivetti , 2 Agrate Brianza 20864 (ITALY)

8 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

8.1 SPBTLE-1S package information
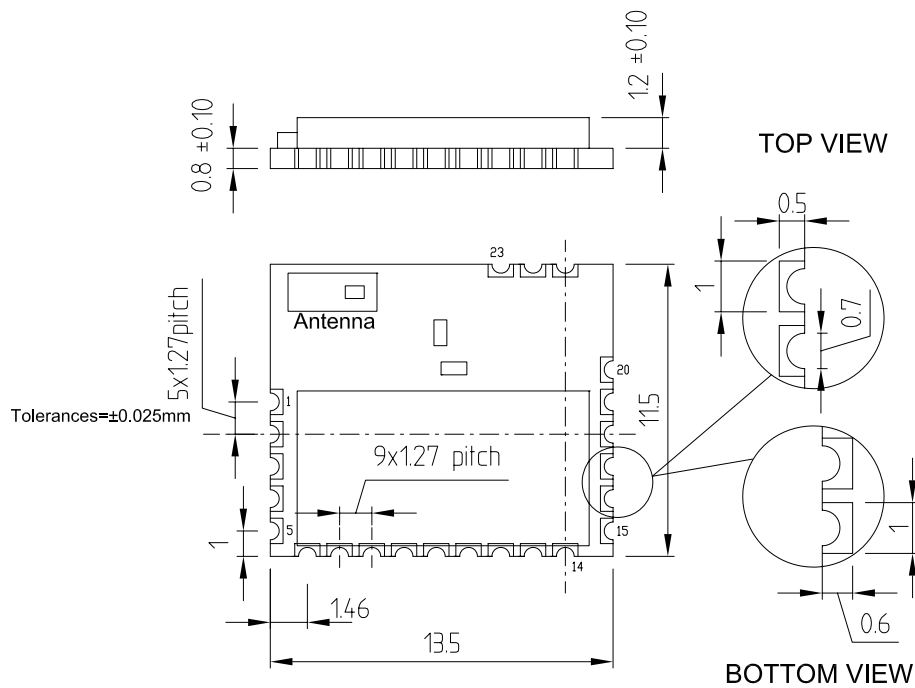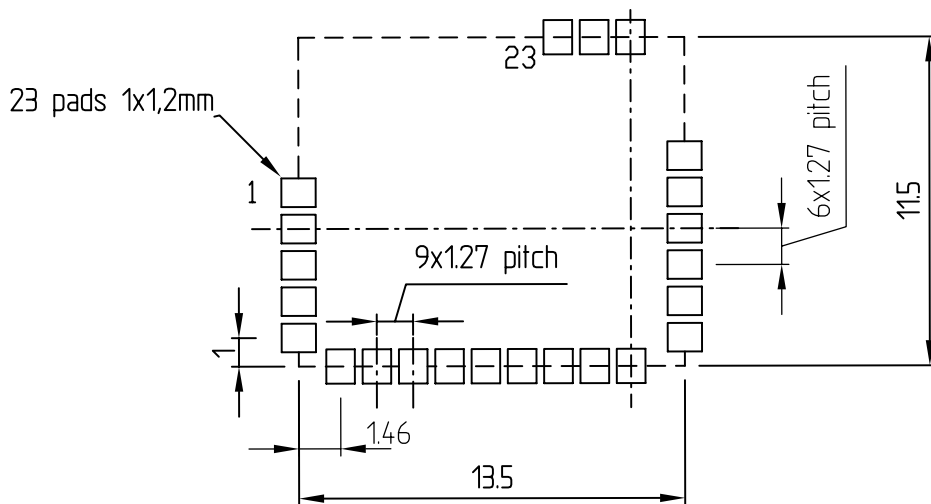
Figure 11. SPBTLE-1S package outline

Figure 12. Recommend land pattern

RECOMMENDED LAND PATTERN
TOP VIEW
All Dimensions are in millimeters

9 Traceability

Each module is univocally identified by serial number stored in a 2D data matrix laser marked on the bottom side of the module itself or on top of the module shieldThe serial number has the following format:

Table 9. **Traceability information**

Letter	Meaning
WW	Week
YY	Year
D	Product ID family
FF	Production panel coordinate identification
NNN	Progressive serial number

Each module bulk is identified by a bulk ID.

BULK ID and module 2D data matrix are linked by a reciprocal traceability link.

The module 2D data matrix traces the lot number of any raw material used.

10 Ordering information

Table 10. Ordering information

Order code	Description	Packing	MOQ
SPBTLE-1S	Bluetooth® V4.2 smart module	Tray	2448

Revision history

Table 11. Document revision history

Date	Version	Changes
03-Jul-2017	1	Initial release.
12-Jul-2017	2	Updated Table 10. Ordering information. Document status promoted from preliminary to production data. Minor text changes.
16-Oct-2017	3	Removed section EU type approval for SPBTLE-1S module. Updated Table 1. Absolute maximum ratings. Added Section 7 CE certification and text updated. Added Section 6.3 SRRC , Section 6.3.1 Modular approval and Section 6.1.1 Labeling instructions. Updated Table 5. Pinout description. Minor text changes.
03-Jun-2019	4	Updated features, Section 1 General description, Section 4.2 Pin assignment, Table 8. Soldering.
23-Jul-2019	5	Updated features and minor text changes.
13-Jan-2021	6	Updated Section 7 CE certification.

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