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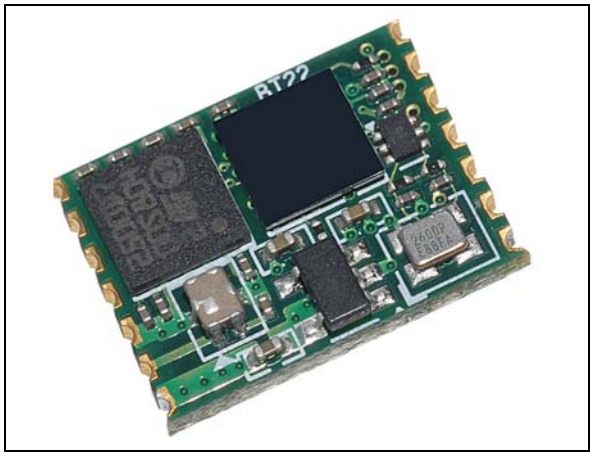
# SPBT2532C2.AT2

## Bluetooth® V2.1 + EDR module class 2 embedding SPP and AT commands

**Datasheet – production data**




## Features

- Bluetooth® radio
  - Fully embedded Bluetooth v2.1 + EDR with profiles
  - Class 2 module
  - Complete RF ready module
- ST micro Cortex-M3 microprocessor up to 72 MHz
- Memory
  - 256 kb Flash memory
  - 48 kb RAM memory
- Data rate
  - 1.5 Mbps maximum data rate
- Serial interface
  - UART up to 2.0 Mbps
- General I/O
  - 4 general purpose I/Os
- User interface
  - AT2 command set (abSerial)
  - Firmware upgrade over UART
- CE and Bluetooth qualified
- EPL (end product listing) fulfilled
- Single voltage supply: 3.3 V typical
- Micro-sized form factor: 10.5 x 13.5 x 2.5 mm
- Operating temperature range: -40 °C to 85 °C



This is information on a product in full production. www.st.com

# Contents

# List of tables

# List of figures

# 1 Description

The SPBT2532C2.AT2 is an easy to use Bluetooth module, compliant with Bluetooth v2.1 + EDR.

The module is the smallest form factor available which provides a complete RF platform. The SPBT2532C2.AT2 enables electronic devices with wireless connectivity, not requiring any RF experience or expertise for integration into the final product. The SPBT2532C2.AT2 module, being a certified solution, optimizes the time to market of the final application.

The module is designed for maximum performance in the minimum possible size including fast speed UART and 4 general purpose I/O lines, several serial interface options, and up to 1.5 Mbps data throughput.

The SPBT2532C2.AT2 is a surface mount PCB module that provides fully embedded, ready-to-use Bluetooth wireless technology. The reprogrammable Flash memory contains embedded firmware for serial cable replacement using the Bluetooth SPP profile. Embedded Bluetooth AT2 command firmware is a friendly interface, which realizes a simple control for cable replacement, enabling communication with most Bluetooth enabled devices, provided that the devices support the SPP profile. The SPBT2532C2.AT2, supporting iAP profile, provides communication with Android™, smartphones, and Apple® iOS Bluetooth enabled devices.

An Apple authentication IC is required to exchange data with an Apple device or access an Apple device application. The AT2 FW includes the Bluetooth SPP profile capable of recognizing the Apple authentication chip.

Customers using the Apple authentication IC must register as developers to become an Apple certified MFI member. License fees may apply, for additional information visit: http://developer.apple.com/programs/which-program/index.html.

Certified MFI developers developing electronic accessories that connect to the iPod®, iPhone®, and iPad® gain access to technical documentation, hardware components, technical support and certification logos.

Customized firmware for peripheral device interaction, power optimization, security, and other proprietary features may be supported and can be ordered pre-loaded and configured.

# 2 RoHS compliance

ST modules are RoHS compliant and comply with ECOPACK® norms.

# 3 Applications

- Serial cable replacement
- M2M industrial control
- Service diagnostic
- Data acquisition equipment
- Machine control
- Sensor monitoring
- Security system
- Mobile health.

# 4 Software architecture

## 4.1 Lower layer stack

- Bluetooth v2.1 + EDR
- Device power modes: active, sleep and deep sleep
- Wake-on Bluetooth feature optimized power consumption of host CPU
- Authentication and encryption
- Encryption key length from 8 bits to 128 bits
- Persistent Flash memory for BD address and user parameter storage
- All ACL (asynchronous connection less) packet types
- Point-to-point supported
- Master/slave switch supported during connection and post connection
- Dedicated inquiry access code for improved inquiry scan performance
- Dynamic packet selection channel quality driven data rate to optimize link performance
- Dynamic power control
- 802.11b co-existence AFH.

## 4.2 Upper layer stack: Amp'ed UP

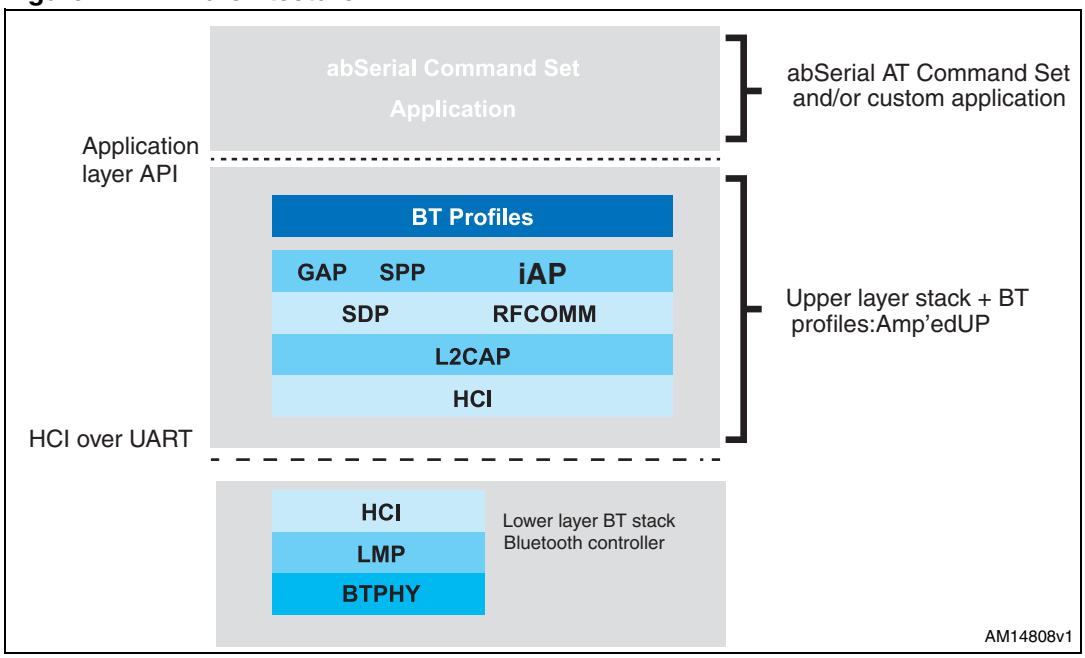
- SPP, IAP, SDAP and GAP protocols
- RFComm, SDP, and L2CAP supported
- Multipoint with simultaneous slaves.

## 4.3 AT command set: abSerial

The complete command list including the iAP commands is reported in the UM1547 user manual.

## 4.4 Bluetooth firmware implementation

**Figure 1. FW architecture**



# 5 Hardware specifications

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

## 5.1 Recommended operating conditions

**Table 1. Recommended operating conditions**

| Rating | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Operating temperature range(1) | -40 | - | 85 | °C |
| Supply voltage $V_{IN}$ | 2.8 | 3.3 | 3.6 | V |
| Signal pin voltage | - | 3.0 | - | V |
| RF frequency | 2400 | - | 2483.5 | MHz |

1. @ CPU 8MHz, @ CPU 32MHZ - 16 MHz max. operating temperature is 55 °C.

## 5.2 Absolute maximum ratings

**Table 2. Absolute maximum ratings**

| Rating | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Storage temperature range | -55 | - | +105 | °C |
| Supply voltage, $V_{IN}$ | -0.3 | | + 5.0 | V |
| I/O pin voltage, $V_{IO}$ | -0.3 | | + 5.5 | V |
| RF input power | - | | -5 | dBm |
| Input voltage on non-5 V tolerant pin | 0.3 | | +4.0 | V |

## 5.3 High speed CPU mode current consumption

- High speed CPU mode
  - CPU 32 MHz, maximum operating temperature 55 °C
  - UART supports up to 921 Kbps
  - Data throughput up to 1.5 Mbps
  - Shallow sleep enabled.

**Table 3. High speed CPU mode current consumption**

| Modes (typical power consumption) | Avg. | Unit |
|---|---|---|
| ACL data 115 K baud UART at max. throughput (master) | 41 | mA |
| ACL data 115 K baud UART at max. throughput (slave) | 41 | mA |
| Connection, no data traffic, master | 28.9 | mA |
| Connection, no data traffic, slave | 34.5 | mA |
| Standby, without deep sleep | 28 | mA |
| Standby, with deep sleep | 3.1 | mA |
| Bluetooth power down / CPU standby | 25 | µA |

## 5.4 Standard CPU mode current consumption

- Standard CPU mode
  - CPU 8 MHz, maximum operating temperature 85 °C
  - UART supports up to 115 Kbps
  - Data throughput up to 200 Kbps
  - Shallow sleep enabled.

**Table 4. Standard CPU mode current consumption**

| Mode (typical power consumption) | Avg. | Unit |
|---|---|---|
| ACL data 115 K baud UART at max. throughput (master) | 25.8 | mA |
| ACL data 115 K baud UART at max. throughput (slave) | 25.8 | mA |
| Connection, no data traffic, master | 11.9 | mA |
| Connection, no data traffic, slave | 16.9 | mA |
| Standby, without deep sleep | 11.2 | mA |
| Standby, with deep sleep | 2.6 | mA |
| Bluetooth power down / CPU standby | 25 | µA |

## 5.5 I/O operating characteristics

**Table 5. I/O operating characteristics**

| Symbol | Parameter | Min. | Max. | Unit | Conditions |
|---|---|---|---|---|---|
| $V_{IL}$ | Low-level input voltage | - | 0.9 | V | $V_{IN}$, 3.0 V |
| $V_{IH}$ | High-level input voltage | 2.1 | - | V | $V_{IN}$, 3.0 V |
| $V_{OL}$ | Low-level output voltage | - | 0.4 | V | $V_{IN}$, 3.0 V |
| $V_{OH}$ | High-level output voltage | 2.2 | - | V | $V_{IN}$, 3.0 V |
| $I_{OL}$ | Low-level output current | - | 4.0 | mA | $V_{OL}$ = 0.4 V |
| $I_{OH}$ | High-level output current | - | 4.0 | mA | $V_{OH}$ = 2.2 V |
| $R_{PU}$ | Pull-up resistor | 80 | 120 | kΩ | Resistor turned on |
| $R_{PD}$ | Pull-down resistor | 80 | 120 | kΩ | Resistor turned on |

## 5.6 Selected RF characteristics

**Table 6. Selected RF characteristics**

| Parameter | Conditions | Typ. | Unit |
|---|---|---|---|
| Antenna load | | 50 | ohm |
| **Radio receiver** | | | |
| Sensitivity level | BER < .001 with DH5 | -85 | dBm |
| Maximum usable level | BER < .001 with DH1 | +8 | dBm |
| Input VSWR | | 2.5:1 | |
| **Radio transmitter** | | | |
| Maximum output power | 50 Ω load | +2 | dBm |
| Initial carrier frequency tolerance | | ± 30 | kHz |
| 20 dB bandwidth for modulated carrier | | 935 | kHz |

## 5.7 Pin assignment

**Table 7. Pin assignment**

| Name | Type | Pin# | Description | ALT function(1) (2) | 5 V tolerant | Initial state |
|---|---|---|---|---|---|---|
| **UART interface** | | | | | | |
| RXD | I | 13 | Receive data | ADC 3 | Y | |
| TXD | O | 14 | Transmit data | ADC 2 | Y | |
| RTS | O | 12 | Request to send (active low) | ADC 0 $I^2C$ clock/aux UART Rx | Y | |
| CTS | I | 11 | Clear to send (active low) | ADC 1 $I^2C$ data/aux UART Tx | Y | |
| **Boot loader** | | | | | | |
| Boot 0 | I | 9 | Boot 0 | | | |
| **Power and ground** | | | | | | |
| Vin | | 8 | $V_{in}$ | | | |
| GND | | 5,7 | GND | | | |
| **Reset** | | | | | | |
| RESETN | I | 10 | Reset input (active low for 5 ms) | | | |
| **Antenna** | | | | | | |
| ANT | RF I/O | 6 | 50 Ω Rx/Tx antenna port | | | |
| **GPIO - general purpose input/output** | | | | | | |
| GPIO [1] | I/O | 1 | General purpose input/output | SPI MISO | Y | Input pull-down |
| GPIO [2] | I/O | 2 | General purpose input/output | SPI MOSI/I2S_SD | Y | Floating |
| GPIO [3] | I/O | 3 | General purpose input/output | SPI SCLK/ I2S_CK | Y | Input pull-down |
| GPIO [4] | I/O | 4 | General purpose input/output | SPI SS/I2S_WS | Y | Input pull-down |

1. ADC pin functions are not 5 V tolerant when used as ALT pin function. Otherwise the I/O pins are all 5 V tolerant.
2. Please note that the usage of ALT function is dependant upon the firmware that is loaded into the module, and is beyond the scope of this document. The AT command interface uses the main UART by default.

## 5.8 Pin placement

**Figure 2. Pin placement**

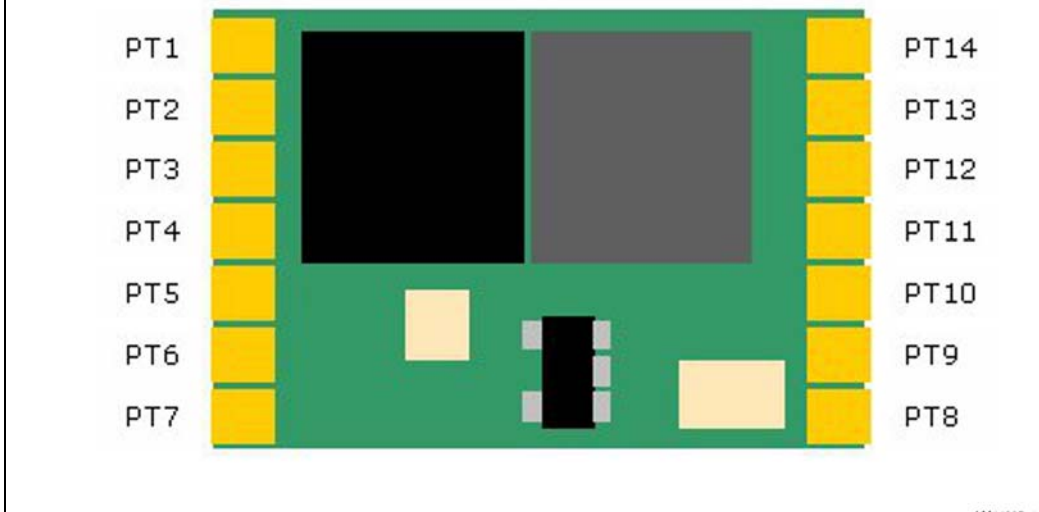
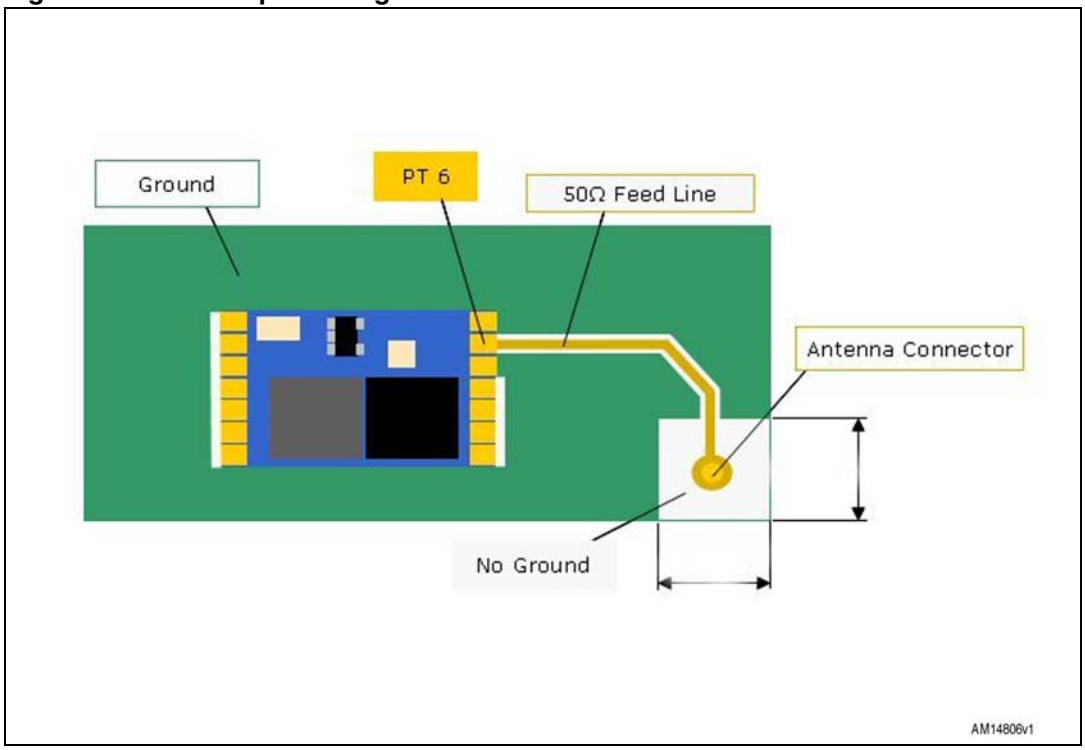
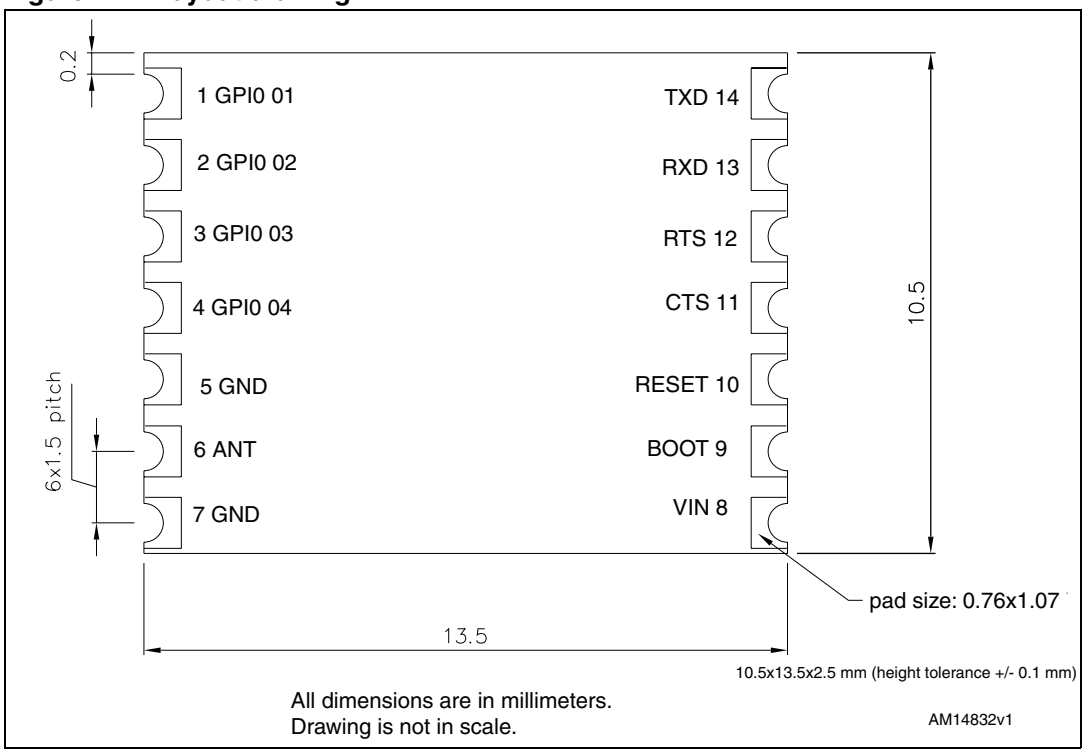



**Figure 3. Ground plane diagram**



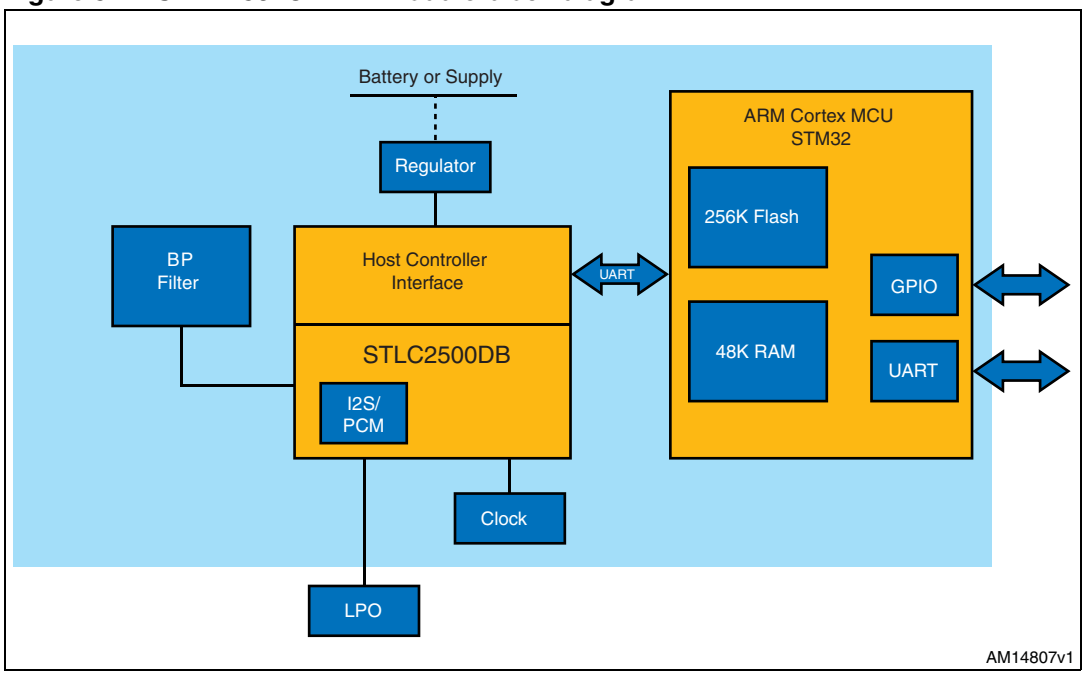
## 5.9 Layout drawing

**Figure 4. Layout drawing**



# 6 Hardware block diagram

**Figure 5. SPBT2532C2.AT2 module block diagram**



# 7 Hardware design

The SPBT2532C2.AT2 module with AT2 command embedded FW supports UAR and GPIO hardware interfaces. Note that the usage of these interfaces is dependent upon the firmware that is loaded into the module, and is beyond the scope of this document. The AT2 command interface uses the main UART by default.

*Note: 1 All unused pins should be left floating; do not ground.*

*2 All GND pins must be well grounded.*

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

*4 Traces should not be routed underneath the module.*

## 7.1 Module reflow installation

The SPB2532C2.AT2 is a surface mount Bluetooth module supplied on a 14-pin, 6-layer PCB. The final assembly recommended reflow profiles are indicated here below.

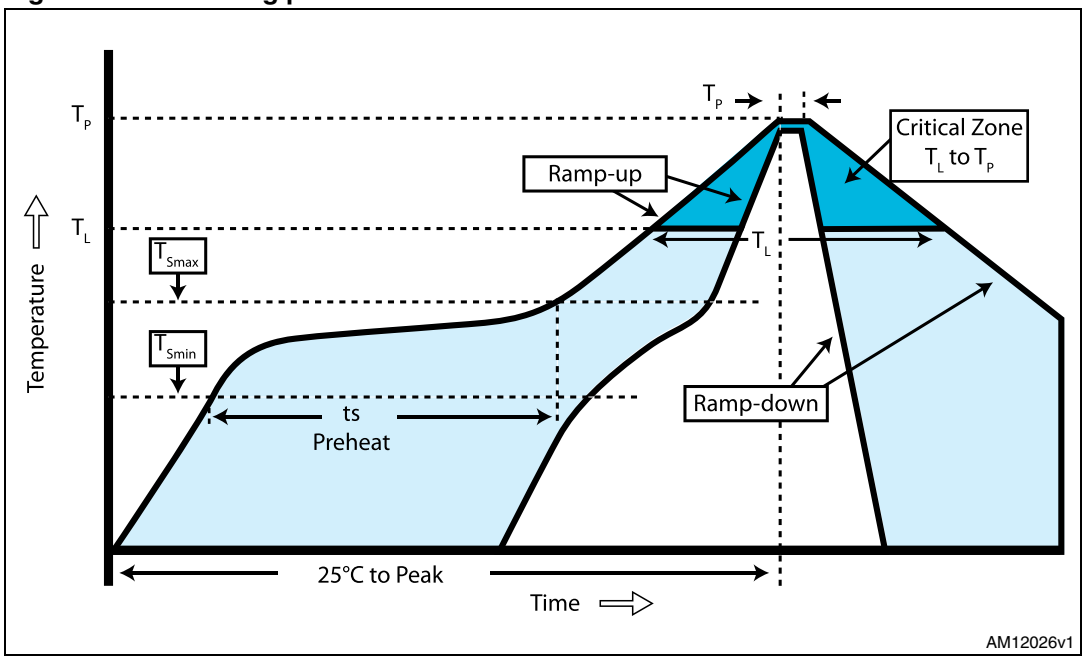
The soldering phase must be executed with care: in order to avoid undesired melting phenomenon, particular attention must be paid to the setup of the peak temperature.

The following are some suggestions for the temperature profile based on IPC/JEDEC J-STD-020C, July 2004 recommendations.

**Table 8. Soldering**

| Profile feature | PB-free assembly |
|---|---|
| Average ramp-up rate ($T_{SMAX}$ to $T_P$) | 3 °C/sec max. |
| Preheat:<br>– Temperature min. ($T_S$ min.)<br>– Temperature max. ($T_S$ max.)<br>– Time ($t_s$ min. to $t_s$ max.)($t_s$) | 150 °C<br>200 °C<br>60-100 sec |
| Time maintained above:<br>– Temperature $T_L$<br>– Temperature $T_L$ | 217 °C<br>60-70 sec |
| Peak temperature ($T_P$) | 240 + 0 °C |
| Time within 5 °C of actual peak temperature ($T_P$) | 10-20 sec |
| Ramp-down rate | 6 °C/sec |
| Time from 25 °C to peak temperature | 8 minutes max. |

**Figure 6. Soldering profile**




## 7.2 GPIO interface

All GPIOs are capable of sinking and sourcing 4 mA of I/O current. GPIO [1] is internally pulled down with 100 kΩ (nominal) resistors.

## 7.3 UART interface

The UART is compatible with the 16550 industry standard. Four signals are provided with the UART interface. The TXD and RXD pins are used for data while the CTS and RTS pins are used for flow control.

**Figure 7. Connection to host device**

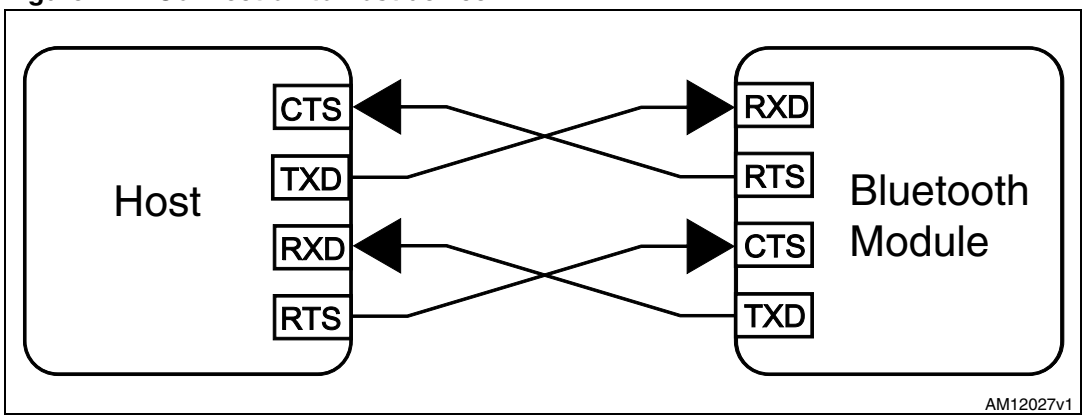
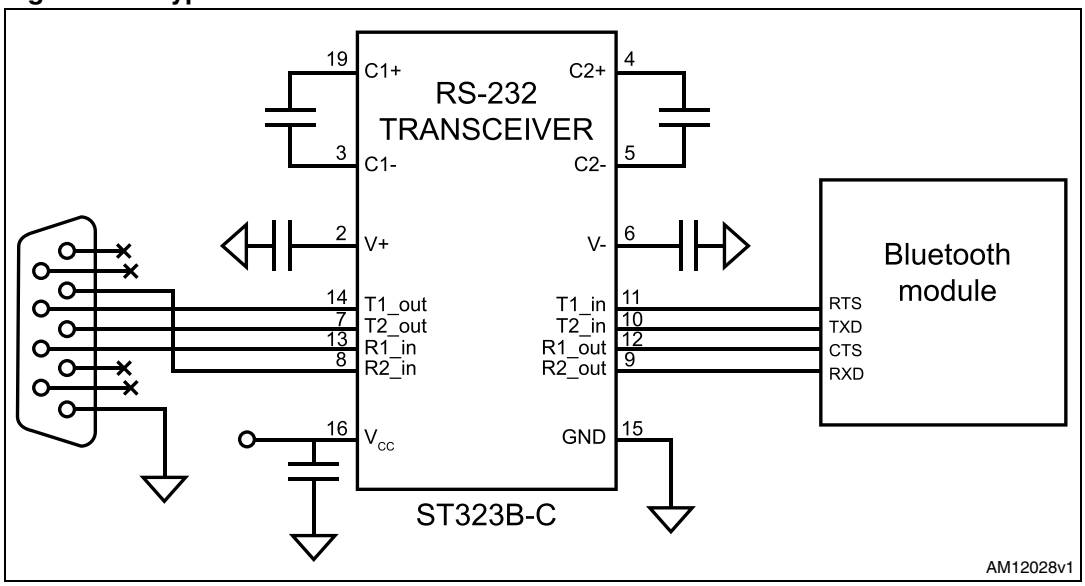


**Figure 8. Typical RS232 circuit**



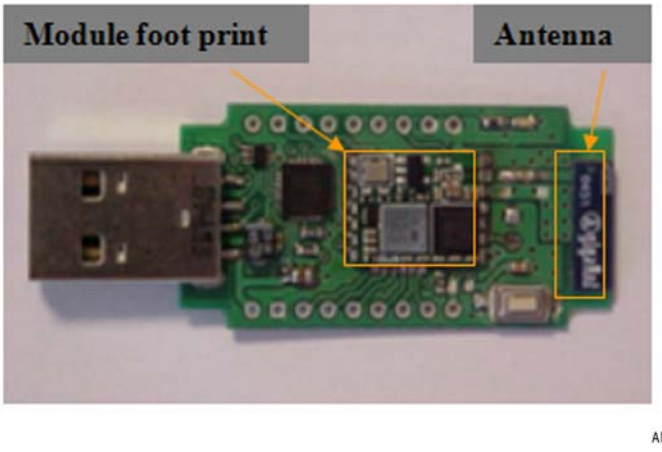
# 8 Application information

Here below there are some suggestions to better implement the module in the final application.

- Avoid that traces with switching signals are routed on the motherboard below the module. The best condition would be to have a ground plane underneath the module
- Connect the supply voltage ground of the module with the other grounds present on the motherboard in a star ground configuration.

Keep the RF ground separate from the module supply voltage ground; the two grounds are already connected inside the module in one point, a possible implementation can be seen in *Figure 9*.

**Figure 9. Example of antenna integration on the STEVAL-SPBT2ATV3**



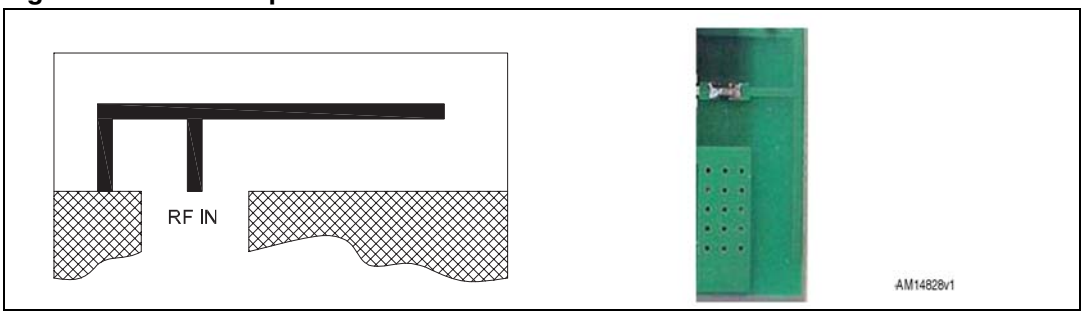

## 8.1 Antenna choice

The RF output pin must be connected to an antenna which may be:

- Antenna directly printed on the PCB (*Figure 10*)
- Integrated SMD antenna, including but not limited to the following examples (*Figure 11*):
  - Johanson Technology 2450T18A100S
  - Antenova 30-30-A5839-01
  - Murata ANCV12G44SAA127
  - Pulse W3008
  - Yageo CAN4311153002451K.

The external antenna connected by means of an SMA connector (*Figure 12*).

**Figure 10. Antenna printed on PCB**




*Note: This is an antenna design indication. Since antenna dimension depends on PCB material, thickness, ε r constant and design, among other parameters, to dimension it correctly, please refer to antenna calculator literature.*

**Figure 11. SMD antenna**

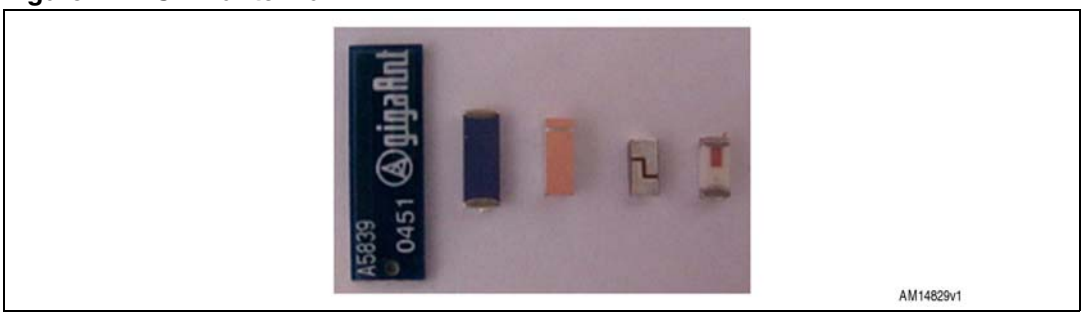
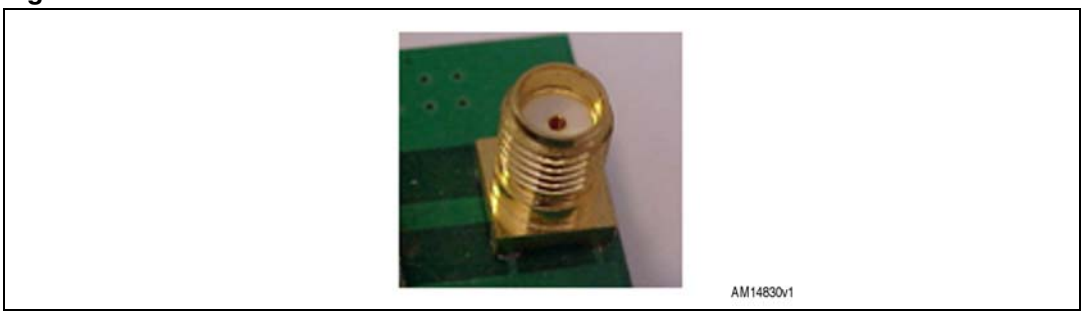



**Figure 12. SMA connector for external antenna**



## 8.2 Antenna coupling

Despite the type of antenna chosen, the connection between the RF out pin and the antenna must be realized to get the maximum power transfer.

As a general rule, the characteristic impedance (Z0) of the connection must be fixed at the value of 50 Ω The connection trace must be matched to respect such a condition.

50 Ω matching depends on various factors and elements that must be taken into consideration:

- Type of material, i.e. FR4 or others
- The electrical characteristics of the material, among them the electric constant, εr, at 2.4 GHz
- PCB and traces mechanical dimensions:
  - PCB thickness
  - Reference ground thickness
  - Trace width
  - Trace thickness.

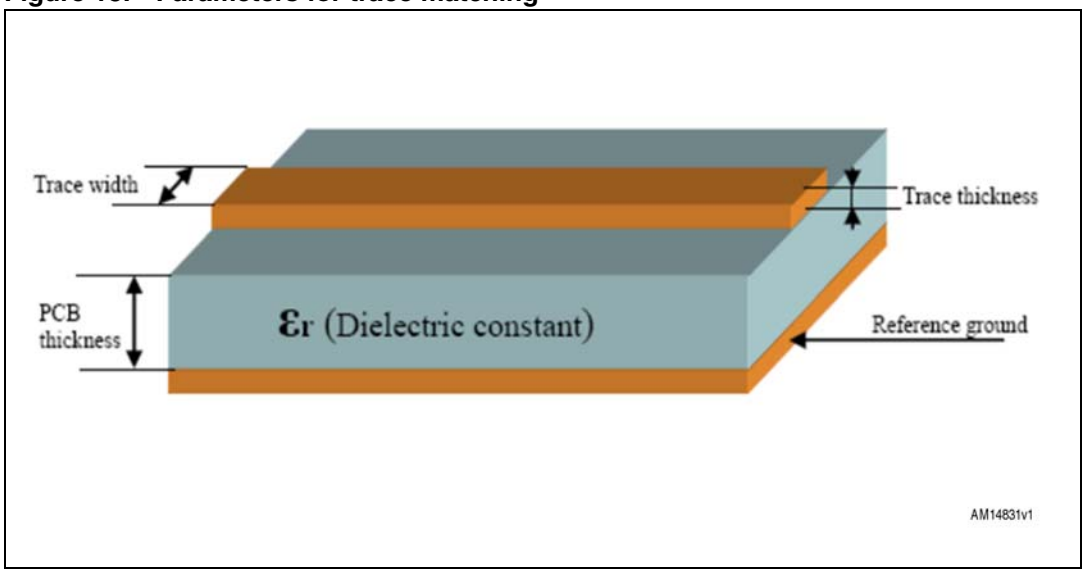
## 8.3 Example of trace calculation

Example of strip line calculation:

- To get a strip line of 50 Ω using a 1 mm thick FR4 board, with an εr = 4.3 at 2.4 GHz, with Cu thickness of 41 µm, the strip line width must be 1.9 mm (micro strip type calculation).

Tools for calculating the characteristic impedance, based on the physical and mechanical characteristics of the PCB, can be easily found online.

**Figure 13. Parameters for trace matching**

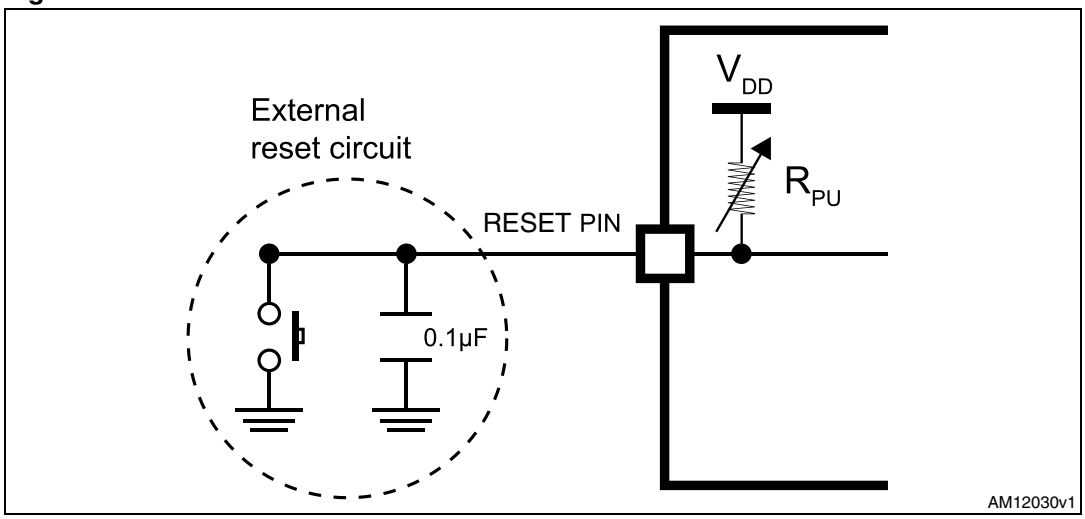


## 8.4 Reset circuit

Two types of system reset circuits are detailed below.

### 8.4.1 External reset circuit

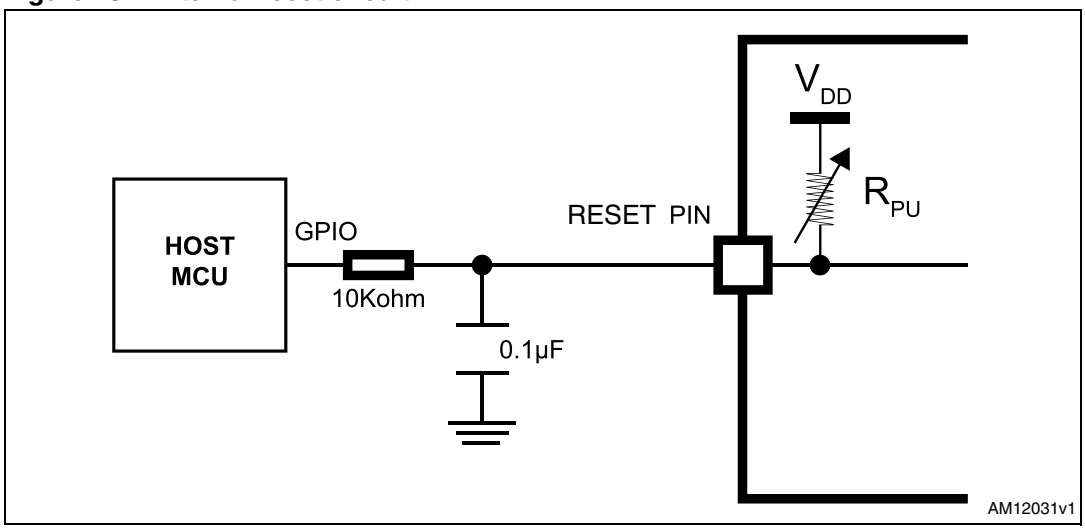
**Figure 14. External reset circuit**




*Note: RPU ranges from 30 kΩ to 50 kΩ internally.*

### 8.4.2 Internal reset circuit

**Figure 15. Internal reset circuit**




*Note: 1 $R_{PU}$ ranges from 30 kΩ to 50 kΩ internally.*

*2 $R_{RST}$ should be from 1 kΩ to 10 kΩ.*

# 9 Regulatory compliance

- BQB
  - BQB qualified design, QD ID: B016360
  - Product type: End Product
  - TGP version: Core 2.1/2.1 + EDR TCRL-2009-1
  - Core spec version: 2.1/2.1 + EDR
  - Product descriptions: Bluetooth module

- CE
  - CE Expert opinion: 307-ARAJ00079
  - Measurements have been performed in accordance with (report available on request):
  - EN 300 328 V 1.7.1 (2006-10) [a]
  - EN 301 489-17 V 2.1.1 (2009) [b]
  - EN60950-1:2006 +A11:2009+A1:2010 [c]

  CE certified:

CE 0051

a. EN 300 328 V 1.7.1 (2006-10): “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. EN 301 489-17 V 2.1.1 (2009): “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. EN60950-1:2006 +A11:2009+A1:2010: “Information technology equipment - safety”.

# 10 Ordering information

**Table 9. Ordering information**

| Order code | Description |
|---|---|
| SPBT2532C2.AT2 | Class 2 OEM Bluetooth antenna module |