

# TR003nano Bluetooth Module

## User Manual

### 1. Product Instruction

**TR003nano** series is a powerful, highly flexible, ultra low power **Bluetooth® 5.1** module based on world-leading **Nordic® Semiconductor nRF52833 SoC** solution, which has a 32bit Arm® Cortex™-M4 CPU with floating point unit running at 64MHz. **MK07** series is capable of the latest and greatest features of **Bluetooth® 5.1**, the most prominent being Direction Finding<sup>1</sup>, taking Bluetooth positioning to new heights.

**TR003nano** series brings out all nRF52833 hardware features and capabilities including USB access, up to +8 dBm transmit power up to 5.5V supply considerations, and NFC tag (type 2 / 4) implementation.

TR003nano supports an extensive range of wireless protocols. It supports BLE® (Bluetooth Low Energy) , and is capable of Bluetooth® Direction Finding in addition Long Range and 2 Mbps. Bluetooth mesh, 802.15.4, Thread, Zigbee, proprietary 2.4 GHz protocols and NFC-A are also supported.

#### 1.1 Model Classification

There are two models of **TR003nano** series Bluetooth module —

The difference between TR003ANANO and TR003BNANO is the antenna design.

**TR003ANANO** integrates a high-performance antenna.

TR003BNANO uses a u.FL connector and requires an external 2.4Ghz antenna.

FCC& IC Radiation Exposure Statement:

This equipment complies with FCC and Canada radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Déclaration d'IC sur l'exposition aux radiations:

Cet équipement est conforme aux limites d'exposition aux radiations définies par le Canada pour des environnements non contrôlés. Cet équipement doit être installé et utilisé à une distance minimum de 20 cm entre l'antenne et votre corps.

Cet émetteur ne doit pas être installé au même endroit ni utilisé avec une autre antenne ou un autre émetteur.

## 1.2 Key Features

- Bluetooth® 5
  - Direction Finding
  - 2Mbps
  - CSA#2
  - Advertising Extensions
  - Long Range
- IEEE 802.15.4 radio support
  - Thread
  - Zigbee
- Supported data rates
  - Bluetooth®: 2 Mbps, 1 Mbps, 500 kbps, and 125 kbps
  - IEEE 802.15.4-2006: 250 kbps
  - Proprietary 2.4 GHz: 2 Mbps, 1 Mbps
- Wide supply voltage range: 1.7 V to 5.5V
- 518kB Flash and 128kB RAM
- Full set of digital interfaces including: SPI, TWI, UART, PDM, PWM, QDEC
- 12-bit, 200ksps ADC
- 128-bit AES ECB/CCM/AAR co-processor
- Individual power management for all peripherals
- On-chip DC/DC buck converter
- Dimension: 21.0 x 13.8 x 2.3mm (with shield)
- 40 GPIOs

### 1.3 Applications

- **Internet of things (IoT)**
  - Smart home sensors and controllers
  - Industrial IoT sensors and controllers
- **Advanced wearables**
  - Health/fitness sensor and monitor devices
  - Wireless payment enabled devices
- **Advanced computer peripherals and I/O devices**
  - Mouse
  - Keyboard
  - Multi-touch trackpad
- **Interactive entertainment devices**
  - Remote controls
  - Gaming controllers

### 1.4 Product Specifications

Detail	Description
<b>Bluetooth</b>	
Feature	Bluetooth® Low Energy Bluetooth® Mesh Bluetooth® Direction Finding 1M LE PHY 2M LE PHY Coded LE PHY (Long Range) Advertising Extensions CSA #2
Security	AES-128
LE connections	Concurrent central, observer, peripheral, and broadcaster roles with up to twenty concurrent connections along with one observer and one broadcaster
<b>Radio</b>	
Frequency	2360MHz - 2500MHz
Modulations	GFSK at 1 Mbps/2 Mbps 250kbps (IEEE 802.15.4-2006) and Long range (125kbps and 500kbps) data rates
Transmit power	+8 dBm maximum Configurable down to -40dBm
Receiver sensitivity	-103 dBm sensitivity in 125 kbps Bluetooth® LE mode -98 dBm sensitivity in 500 kbps Bluetooth® LE mode -96 dBm sensitivity in 1 Mbps Bluetooth® LE mode -92 dBm sensitivity in 2 Mbps Bluetooth® LE mode -94 dBm sensitivity in 1 Mbps ANT mode -94 dBm sensitivity in 1 Mbps 2.4 GHz mode -91 dBm sensitivity in 2 Mbps 2.4 GHz mode
Antenna	MK07A - PCB trace antenna MK07B - External 2.4Ghz antenna
<b>Current consumption</b>	
TX only (DCDC enabled, 3V) @ +8dBm / +4dBm / 0dBm / -4dBm/-20dBm/-40dBm	14.2mA / 9.6mA / 4.9mA / 3.8mA / 2.7mA / 2.3mA
TX only @ +8dBm / +4dBm / 0dBm / -4dBm / -20dBm / -40dBm	30.4mA / 20.7mA / 10.3mA / 8.0mA / 5.5mA / 4.5mA
RX only (DCDC enabled, 3V) @1Msps / 1Msps BLE	4.6mA
RX only @ 1Msps / 1Mbps BLE	9.6mA
RX only (DCDC enabled, 3V) @2Msps / 2Msps BLE	5.2mA
RX only @ 2Msps / 2Mbps BLE	10.7mA
System OFF mode (3V)	0.6uA
System OFF mode with full 64 kB RAM retention (3V)	1.3uA
System ON mode, no RAM retention, wake on RTC (3V)	1.5uA

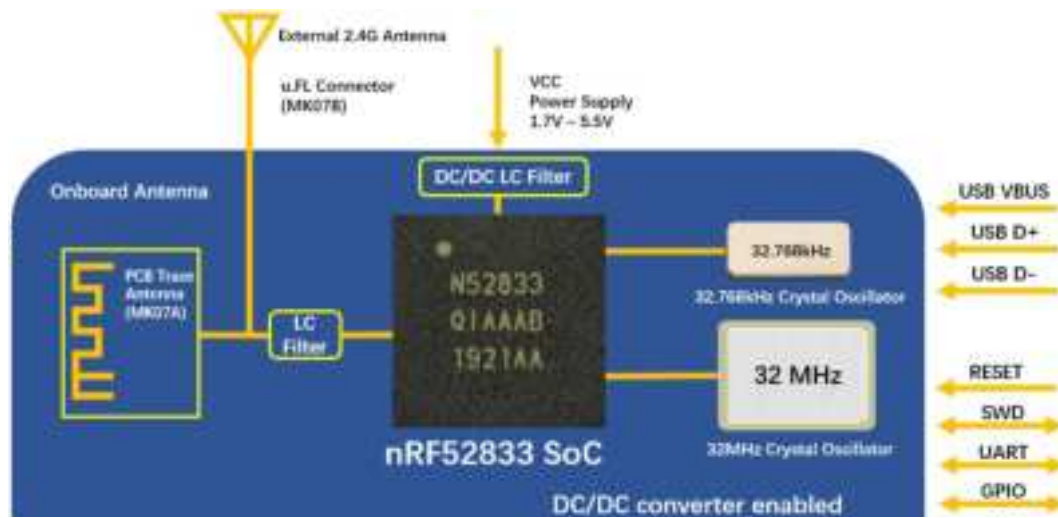
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Detail	Description
<b>Mechanical design</b>	
Dimensions	Length: 21mm±0.2mm Width: 13.8mm±0.2mm Height: 2.3mm+0.1mm/-0.15mm
Package	34 diameters of Half-holes + 20 LGA pads
PCB material	FR-4
Impedance	50Ω
<b>Hardware</b>	
CPU	ARM® Cortex®-M4 32-bit processor with FPU, 64 MHz
Memory	512kB flash, 128kB RAM
Interfaces	4x SPI master/3x SPI slave with EasyDMA 2x I <sup>2</sup> C compatible two-wire master/slave 2x UART (CTS/RTS) with EasyDMA 3x real-time counter (RTC) 5x 32-bit timer with counter mode 4x 4-channel pulse width modulator (PWM) unit with EasyDMA 40 GPIOs 8x 12bit, 200ksps ADC Audio peripherals – I <sup>2</sup> S, digital microphone interface (PDM)
Power supply	1.7V to 5.5V
Operating temperature range	-40 to 85 °C (-40 to +105 °C can be customized)
Clock control	32.768 kHz +/-20 ppm crystal oscillator
Power regulator	DC/DC regulator setup
<b>Certifications</b>	
USA (FCC)	FCC part 15 modular certification 47 CFR Part 15, Subpart C FCC ID: 2AO94-TR003nano
Europe (CE)	EN 300 328 V2.2.2      3.2: Effective use of spectrum allocated EN 301 489-1 V2.2.3      3.1(b): Electromagnetic Compatibility EN 301 489-17 V3.2.4 EN 62368-1: 2014+A11:2017      3.1(a): Health and Safety of the user EN 62479: 2010
Canada (ISED)	Industry Canada RSS-247 and RSS-Gen certification IC: 26442-TR003nano
Japan (MIC)	Ministry of Internal Affairs and Communications (MIC) of Japan pursuant to the Radio Act of Japan MIC: 217-204181
Australia/New Zealand (RCM)	AS/NZS 4268: 2017, Radio equipment and systems-short range devices

## 2. Circuit Design

### 2.1 Block Diagram



## 2.2 Reference Circuitry

### 2.2.1 Normal Voltage Mode

## **2.2.2 High Voltage Mode**

## **2.2.3 USB Voltage Mode**

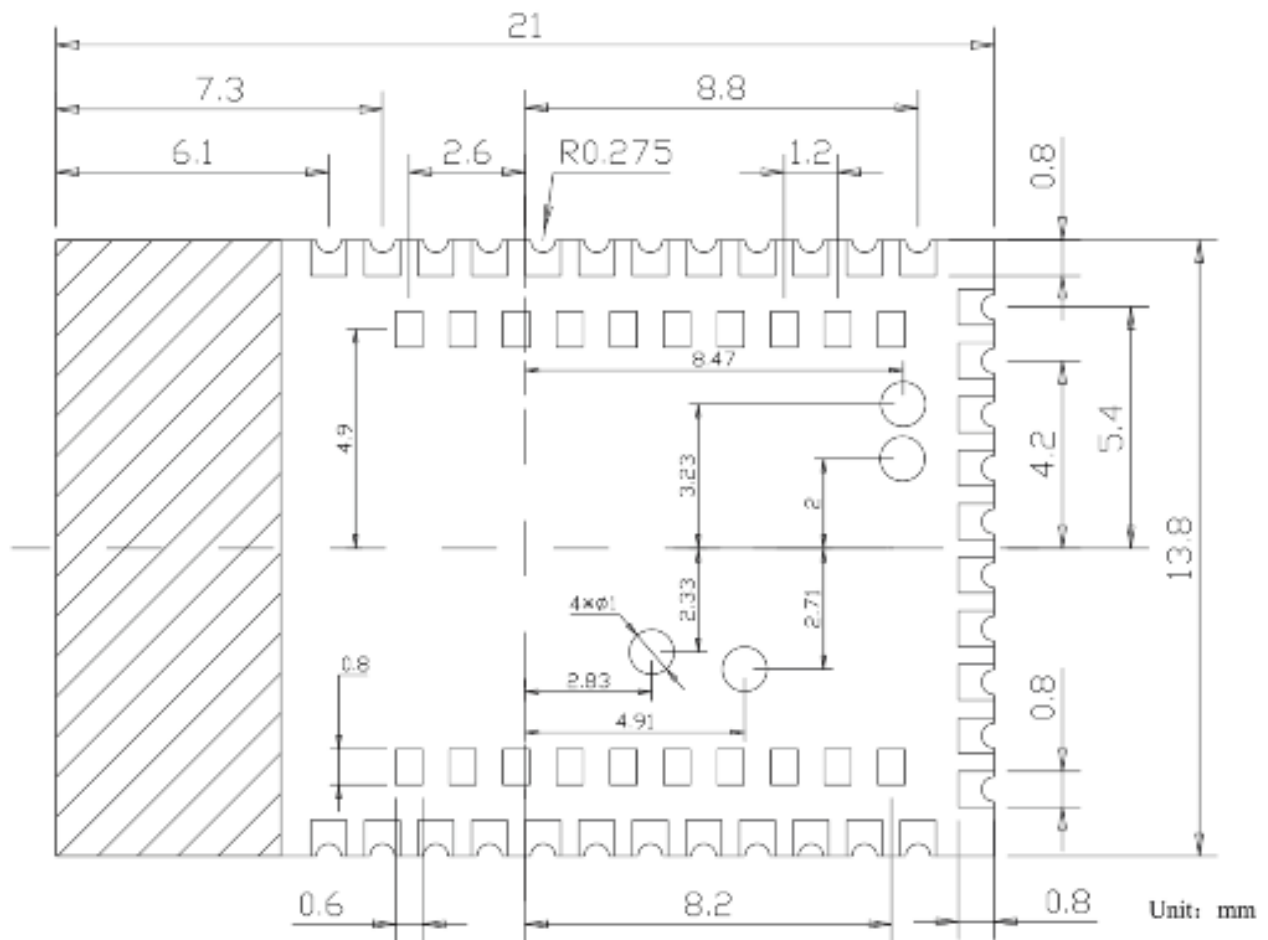
## 3. Mechanical specifications

### 3.1 Module Mechanical Dimensions

Symbol	Min.	Typ.	Max.
Length	-0.2mm	21mm	+0.2mm
Width	-0.2mm	13.8mm	+0.2mm
Height (PCB only)	-0.08mm	0.8mm	+0.08mm
Height (with shield)	-0.15mm	2.3mm	+0.1mm



## 3.2 Recommended PCB land pads



TR003nano PCB land pads (TOP View)

Symbol	Typ.
Half-hole Pad (Bottom)	0.8mm x 0.8mm
LGA Square Pad	0.8mm x 0.6mm
LGA Round pad	1mm (diameter)
Diameter of Half-hole	0.55mm

## 4. Pin Assignment

**TR003nano module pin diagram (Rear View)**

Pin No.	Name	Type	Description
1	P0.25	Digital I/O	General purpose I/O
2	P0.23	Digital I/O	General purpose I/O
3	P0.03	Digital I/O	General purpose I/O
	AIN1	Analog input 1	SAADC/COMP/LPCOMP input
4	P0.02	Digital I/O	General purpose I/O
	AIN0	Analog input 0	SAADC/COMP/LPCOMP input
5	P0.28	Digital I/O	General purpose I/O
	AIN4	Analog input 4	SAADC/COMP/LPCOMP input
6	P0.29	Digital I/O	General purpose I/O
	AIN5	Analog input 5	SAADC/COMP/LPCOMP input
7	P0.30	Digital I/O	General purpose I/O
	AIN6	Analog input 6	SAADC/COMP/LPCOMP input
8	P0.31	Digital I/O	General purpose I/O
	AIN7	Analog input 7	SAADC/COMP/LPCOMP input
9	VDD	Power	Power Supply
10	GND	Power	Ground
11	P0.27	Digital I/O	General purpose I/O
12	P0.26	Digital I/O	General purpose I/O

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Pin No.	Name	Type	Description
13	P0.04	Digital I/O	General purpose I/O
	AIN2	Analog input 2	SAADC/COMP/LPCOMP input
14	P0.06	Digital I/O	General purpose I/O
15	P0.05	Digital I/O	General purpose I/O
	AIN3	Analog input 3	SAADC/COMP/LPCOMP input
16	P0.08	Digital I/O	General purpose I/O
17	P0.09	Digital I/O	General purpose I/O
	NFC1	NFC input	NFC antenna connection
18	P0.10	Digital I/O	General purpose I/O
	NFC2	NFC input	NFC antenna connection
19	SWDCLK	Debug	Serial wire debug clock input for debug and programming
20	SWDIO	Debug	Serial wire debug I/O for debug and programming
21	P0.07	Digital I/O	General purpose I/O
	TRACECLK	Trace clock	Trace buffer clock
22	P0.11	Digital I/O	General purpose I/O
	TRACEDATA[2]	Trace data	Trace buffer TRACEDATA
23	P0.12	Digital I/O	General purpose I/O
	TRACEDATA[1]	Trace data	Trace buffer TRACEDATA
24	P0.13	Digital I/O	General purpose I/O
25	P0.14	Digital I/O	General purpose I/O
26	P0.15	Digital I/O	General purpose I/O
27	P0.16	Digital I/O	General purpose I/O
28	P0.17	Digital I/O	General purpose I/O
29	P0.18	Digital I/O	General purpose I/O
	nRESET		Configurable as pin RESET
30	P0.20	Digital I/O	General purpose I/O
31	P0.21	Digital I/O	General purpose I/O
32	P0.22	Digital I/O	General purpose I/O
33	P0.24	Digital I/O	General purpose I/O
34,35	GND	Power	Ground
36	P1.05	Digital I/O	General purpose I/O
37	P1.03	Digital I/O	General purpose I/O
38	GND	Power	Ground
39	GND	Power	Ground
40	P0.19	Digital I/O	General purpose I/O
41	VDDH	Power	High voltage power supply
42	GND	Power	Ground
43	P1.08	Digital I/O	General purpose I/O

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Pin No.	Name	Type	Description
44	P1.09	Digital I/O	General purpose I/O
	TRACEDATA[3]	Trace data	Trace buffer TRACEDATA
45	VBUS	Power	5 V input for USB 3.3 V regulator
46	D-	USB	USB D-
47	D+	USB	USB D+
48	GND	Power	Ground
49	P1.00	Digital I/O	General purpose I/O
	TRACEDATA[0]/ SWO	Trace data	Trace buffer TRACEDATA/ Serial wire output
50	P1.01	Digital I/O	General purpose I/O
51	P1.02	Digital I/O	General purpose I/O
52	P1.04	Digital I/O	General purpose I/O
53	P1.06	Digital I/O	General purpose I/O
54	P1.07	Digital I/O	General purpose I/O

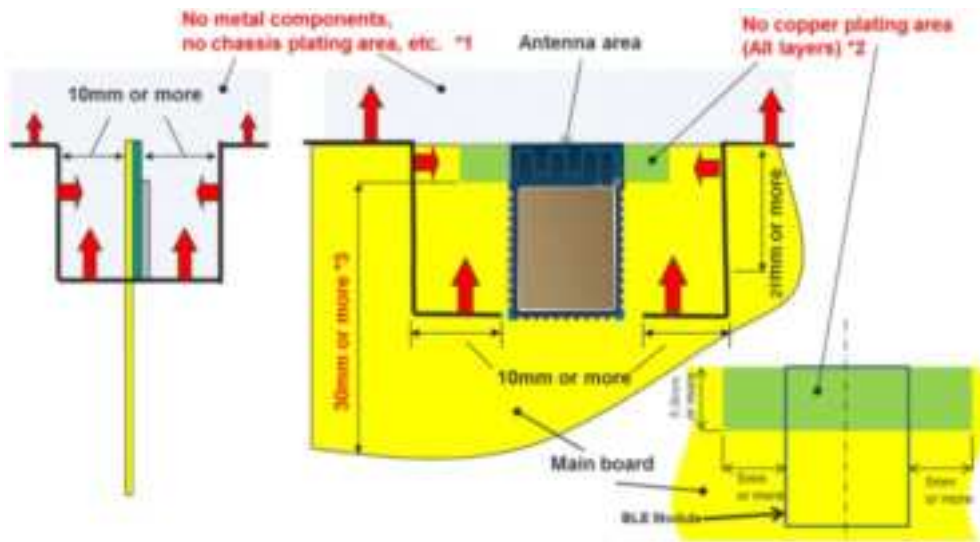
**Note:** Please refer to [Nordic nRF52833 Product Specifications](#) for detailed descriptions and features supported about the Pin assignments.

## 5. Mounting Suggestion

You can refer to the following references for the mounting design of the module with on-board antenna (TR003anano with antenna).

For external antenna modules (TR003bNANO needs to connect an external antenna to the u.FL connector), you need to refer to the external antenna design requirements.

### Recommended module mounting example:

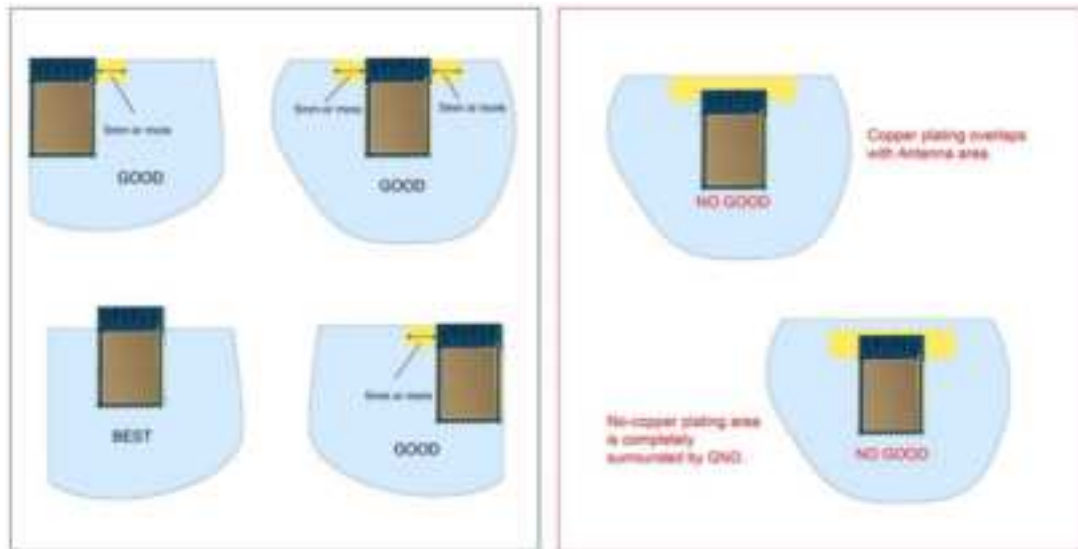


- Please do not place any metal components in blue shaded space (\*1), such as signal line and metal chassis as possible except for main board while mounting the components in \*1 space on the main board is allowed except for no copper plating area (\*2).
- (\*2) This area is routing prohibited area on the main board. Please do not place copper on any layer.
- (\*3) Characteristics may deteriorate when GND pattern length is less than 30mm. It should be 30 mm or more as possible.
- For the best Bluetooth range performance, the antenna area of module shall extend 3 mm outside the edge of main board, or 3 mm outside the edge of a ground plane. Ground plane shall be at least 5 mm from the edge of the antenna area of module.
- All module GND pins MUST be connected to main board GND. Place GND vias close to module GND pads as possible. Unused PCB area on surface layer can flooded with copper but place GND vias regularly to connect copper flood to inner GND plane. If GND flood copper underside the module then connect with GND vias to inner GND plane.
- Even when above mentioned condition is satisfied, communication performance may be significantly deteriorated depending on the structure of the product. Bluetooth range performance is degraded if a module is placed in the middle of the main board.
- For main board layout:
  - Avoid running any signal line below module whenever possible.
  - No ground plane below antenna.
  - If possible, cut-off the portion of main board below antenna.

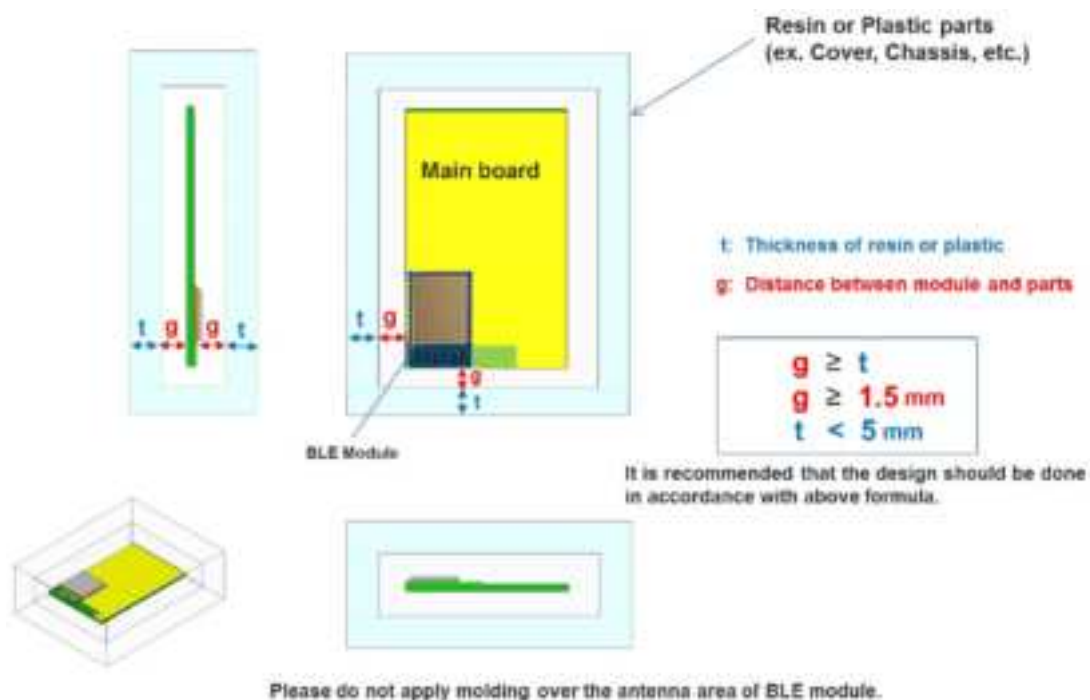
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Other module mounting examples:



Placement of resin or plastic parts:



Placement of metal parts

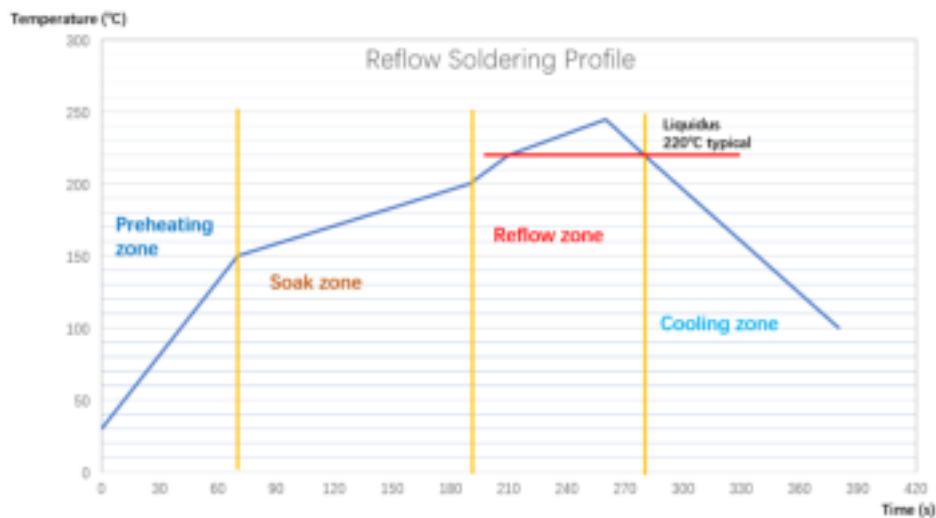
- Minimum safe distance for metal parts without seriously compromising the antenna (tuning) is 40 mm top/bottom and 30 mm left or right.
- Metal close to the module antenna (bottom, top, left, right, any direction) will have degradation on the antenna performance. The amount of that degradation is entirely system dependent, meaning you will need to perform some testing with your host application.
- Any metal closer than 20 mm will begin to significantly degrade performance (S11, gain, radiation efficiency).
- It is best that you test the range with a mock-up (or actual prototype) of the product to assess effects of enclosure height (and materials, whether metal or plastic).

## 7. Cautions

### 7.1 Reflow Soldering

Reflow soldering is a vitally important step in the SMT process. The temperature curve associated with the reflow is an essential parameter to control to ensure the correct connection of parts. The parameters of certain components will also directly impact the temperature curve selected for this step in the process.

#### Temperature-Time Profile for Reflow Soldering:



- The standard reflow profile has four zones: ①preheat, ②soak, ③reflow, ④cooling. The profile describes the ideal temperature curve of the top layer of the PCB.
- During reflow, modules should not be above 260°C and not for more than 30 seconds.

Specification	Value
Temperature Increase Rate	<2.5°C/s
Temperature Decrease Rate	Free air cooling
Preheat Temperature	0-150°C
Preheat Period (Typical)	40-90s
Soak Temp Increase Rate	0.4-1°C/s
Soak Temperature	150-200°C
Soak Period	60-120s
Liquidus Temperature (SAC305)	220°C
Time Above Liquidous	45-90s
Reflow Temperature	230-250°C
Absolute Peak Temperature	260°C

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Example of SMT reflow soldering:



**Note:** The module is LGA package. Please be careful of the amount of solder paste. The module may be lifted due to excess solder.

## 7.2 Usage Condition Notes

- Follow the conditions written in this specification, especially the recommended condition ratings about the power supply applied to this product.
- The supply voltage has to be free of AC ripple voltage (for example from a battery or a low noise regulator output). For noisy supply voltages, provide a decoupling circuit (for example a ferrite in series connection and a bypass capacitor to ground of at least 47uF directly at the module).
- Take measures to protect the unit against static electricity. If pulses or other transient loads (a large load applied in a short time) are applied to the products, check and evaluate their operation before assembly on the final products.
- The supply voltage should not be exceedingly high or reversed. It should not carry noise and/or spikes.
- This product away from other high frequency circuits.
- Keep this product away from heat. Heat is the major cause of decreasing the life of these products.
- Avoid assembly and use of the target equipment in conditions where the products' temperature may exceed the maximum tolerance.
- This device complies with Part 15C of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.
- Do not use dropped products.
- Do not touch, damage or soil the pins.
- Pressing on parts of the metal shield or fastening objects to the metal shield will cause damage.



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FCC Caution: The user is cautioned that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules and Industry Canada licence-exempt RSS standard(s). 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.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

(1) l'appareil ne doit pas produire de brouillage, et

(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

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.

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### FCC& IC Radiation Exposure Statement:

This equipment complies with FCC and Canada radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. Déclaration d'IC sur l'exposition aux radiations:

Cet équipement est conforme aux limites d'exposition aux radiations définies par le Canada pour des environnements non contrôlés. Cet équipement doit être installé et utilisé à une distance minimum de 20 cm entre l'antenne et votre corps.

Cet émetteur ne doit pas être installé au même endroit ni utilisé avec une autre antenne ou un autre émetteur.

## **FCC Statements**

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.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

### **FCC Radiation Exposure Statement**

The modular can be installed or integrated in mobile or fix devices only. This modular cannot be installed in any portable device, for example, USB dongle like transmitters is forbidden.

This modular complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This modular must be installed and operated with a minimum distance of 20 cm between the radiator and user body.

If the FCC identification number is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following:

“Contains Transmitter Module FCC ID: 2AMXZ-TR003ANANO Or Contains FCC ID: 2AMXZ-TR003ANANO”

“Contains Transmitter Module FCC ID: 2AMXZ-TR003BNANO Or Contains FCC ID: 2AMXZ-TR003BNANO”

When the module is installed inside another device, the user manual of this device must contain below warning statements:

1. 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.

2. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The devices must be installed and used in strict accordance with the manufacturer's instructions as described in the user documentation that comes with the product.

The host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. The final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

The end user manual shall include all required regulatory information/warning as shown in this manual, include:

This product must be installed and operated with a minimum distance of 20 cm between the radiator and user body.