

HCM512S Hardware Design

Short-Range Module Series

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Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any terminal or mobile incorporating the module. Manufacturers of the terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.



Full attention must be paid to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.



Switch off the terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If there is an Airplane Mode, it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on an aircraft.



Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.



Terminals or mobiles operating over radio signal and cellular network cannot be guaranteed to connect in certain conditions, such as when the mobile bill is unpaid or the (U)SIM card is invalid. When emergency help is needed in such conditions, use emergency call if the device supports it. In order to make or receive a call, the terminal or mobile must be switched on in a service area with adequate cellular signal strength. In an emergency, the device with emergency call function cannot be used as the only contact method considering network connection cannot be guaranteed under all circumstances.



The terminal or mobile contains a transceiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.



In locations with explosive or potentially explosive atmospheres, obey all posted signs and turn off wireless devices such as mobile phone or other terminals. Areas with explosive or potentially explosive atmospheres include fueling areas, below decks on boats, fuel or chemical transfer or storage facilities, and areas where the air contains chemicals or particles such as grain, dust or metal powders.

About the Document

Revision History

Version	Date	Author	Description
-	2025-02-13	Luke FU/ Allen KE/ Stephen LI	Creation of the document
1.0.0	2025-02-13	Luke FU/ Allen KE/ Stephen LI	Preliminary

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1 Introduction

This document defines HCM512S in GSDK solution and describes its hardware interfaces and air interfaces, which are connected with your applications. The document provides a quick insight into interface specifications, RF performance, electrical and mechanical specifications, as well as other related information of the module.

Hereby, Quectel Wireless Solutions Co., Ltd. declares that the radio equipment type HCM512S is in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address:
<http://www.quectel.com/support/technical.htm>

Disposal of old electrical appliances



The European directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), requires that old household electrical appliances must not be disposed of in the normal unsorted municipal waste stream. Old appliances must be collected separately in order to optimize the recovery and recycling of the materials they contain, and reduce the impact on human health and the environment.

The crossed out “wheeled bin” symbol on the product reminds you of your obligation, that when you dispose of the appliance, it must be separately collected.

Consumers should contact their local authority or retailer for information concerning the correct disposal of their old appliance.

	AT	BE	BG	HR	CY	CZ	DK
	EE	FI	FR	DE	EL	HU	IE
	IT	LV	LT	LU	MT	NL	PL
	PT	RO	SK	SI	ES	SE	UK(NI)

This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

2 Product Overview

HCM512S is a low-power and high performance MCU Bluetooth module supporting BLE 5.4 protocol. It integrates a highly configurable wireless transceiver. The module also provides multiple interfaces such as USART, EUART, SWD, I2C, ADC and PDM for various applications.

It is an SMD module with compact packaging. The general features of the module are as follows:

- Embedded 32-bit ARM Cortex-M33 processor with a frequency of up to 76.8 MHz
- 64 KB RAM and 768 KB flash
- Flexible and efficient power consumption management
- Bluetooth mesh network low-power nodes
- Support for Peripheral Reflex System (PRS) for autonomous inter-peripheral signaling
- Support for OTA (Over-The-Air Upgrade)
- Support for secondary development

Table 1: Basic Information

HCM512S	
Packaging Type	LCC
Pin Counts	24
Dimensions	(16.6 +0.3/-0.15) mm × (11.2 +0.3/-0.15) mm × (2.1 ±0.2) mm
Weight	Approx. 0.57 g

2.1. Key Features

Table 2: Key Features

Basic Information	
Protocol and Standard	<ul style="list-style-type: none"> Bluetooth protocol: BLE 5.4 All hardware components are fully compliant with EU RoHS directive
Power Supply	VBAT Power Supply: <ul style="list-style-type: none"> 1.71–3.8 V Typ.: 3.3 V
Temperature Ranges	<ul style="list-style-type: none"> Normal operating temperature ¹: -40 to +85 °C Storage temperature: -45 to +95 °C
TE-B Kit	HCM511S-TE-B ²
Antenna	
Antenna	<ul style="list-style-type: none"> PCB antenna 50 Ω characteristic impedance
Application Interface ³	
Application Interfaces	USART, EUART, SWD, I2C, ADC, PDM, GPIO

¹ Within the operating temperature range, the module's related performance meets Bluetooth specifications.

² Quectel supplies an evaluation board (HCM511S-TE-B) with accessories to develop and test the module. For more details, see **document [1]**.

³ For more details about the interfaces, see **Chapter 3.3** and **Chapter 3.4**.

3 Application Interfaces

3.1. Pin Assignment

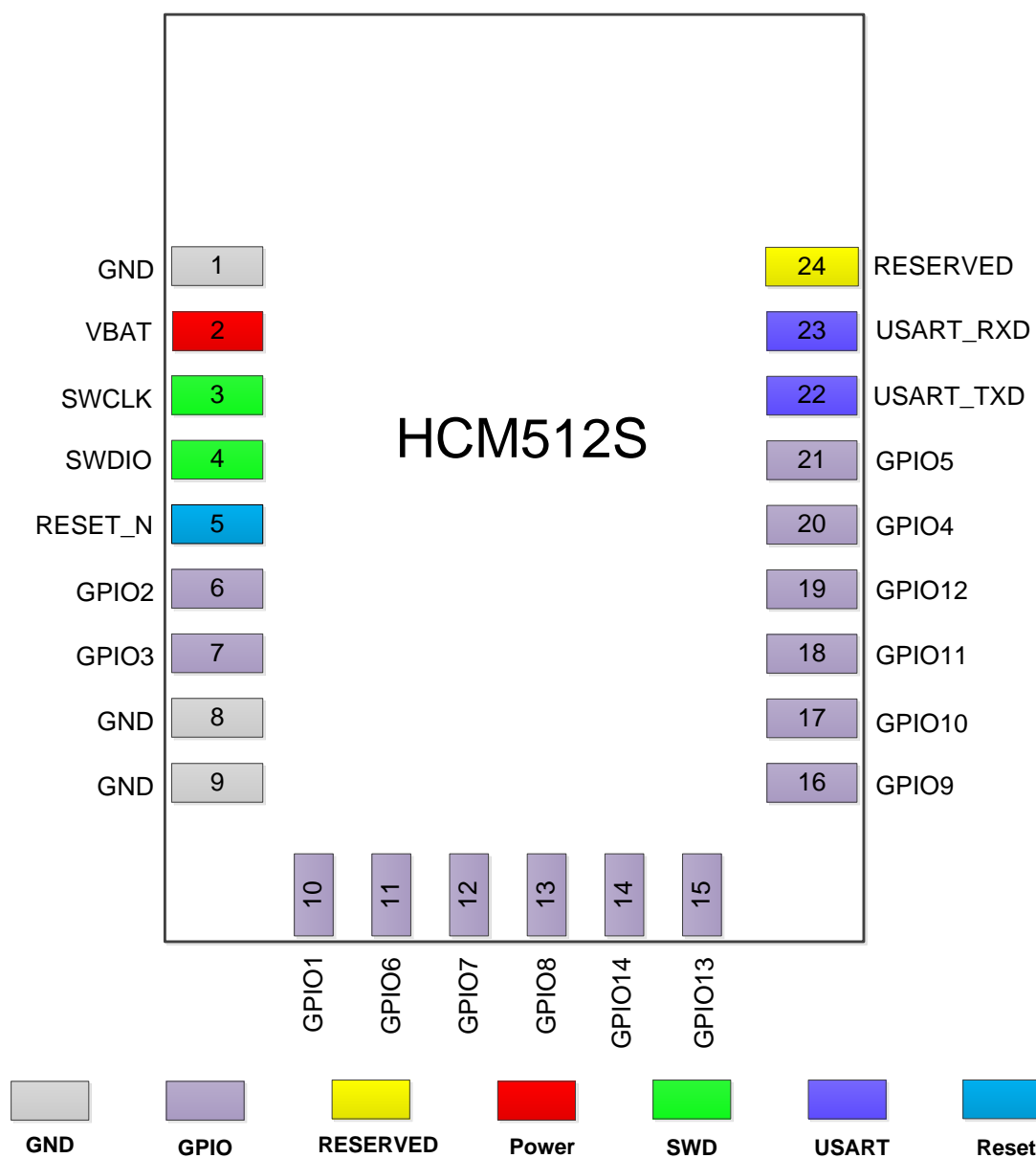


Figure 1: Pin Assignment (Top View)

NOTE

1. Keep the RESERVED and all unused pins unconnected.
2. All GND pins should be connected to ground.
3. The module supports 1 USART, 1 SWD and 14 GPIO interfaces by default. In the case of multiplexing, it supports interfaces including EUART, I2C, ADC and PDM. For more details, see **Chapter 3.3** and **Chapter 3.4**.
4. For the chip pin names corresponding to the module pin names, see **document [5]**.
5. Ensure that there is no current sink on the module's pins before the module turns on.

3.2. Pin Definitions

Table 3: Parameter Description

Parameter	Description
DI	Digital Input
DO	Digital Output
DIO	Digital Input/Output
PI	Power Input
PD	Pull-down
PU	Pull-up
Hi-Z	High Impedance

DC characteristics include power domain and rated current.

Table 4: Pin Description

Power Supply and GND Pins						
Pin Name	Pin No.	I/O	Status After Reset	Description	DC Characteristics	Comment
VBAT	2	PI	-	Power supply for the module	Vmax = 3.8 V Vmin = 1.71 V Vnom = 3.3 V	It is recommended to provide a

current of at least 20 mA.

GND 1, 8, 9

Connect these pins to ground.

Reset

Pin Name	Pin No.	I/O	Status After Reset	Description	DC Characteristics	Comment
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RESET_N	5	DI	PU	Reset the module	1.8 V	Hardware reset. Internally pulled up to 1.8 V. Active low.
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Hardware reset. Internally pulled up to 1.8 V. Active low.

USART

Pin Name	Pin No.	I/O	Status After Reset	Description	DC Characteristics	Comment
----------	---------	-----	--------------------	-------------	--------------------	---------

USART_TXD	22	DO	PU	USART transmit	VBAT	Used for debugging.
USART_RXD	23	DI	PU	USART receive		

Used for debugging.

SWD Interface

Pin Name	Pin No.	I/O	Status After Reset	Description	DC Characteristics	Comment
----------	---------	-----	--------------------	-------------	--------------------	---------

SWDIO	4	DIO	PU	Serial wire debugging input/output	VBAT	Used for program downloading. Enabled after power-up. Internally pulled up to 3.3 V.
SWCLK	3	DI	PD	Serial wire debugging clock		Used for program downloading. Enabled after power-up. Internally pulled down to

Used for program downloading. Enabled after power-up. Internally pulled up to 3.3 V. Used for program downloading. Enabled after power-up. Internally pulled down to

GND.

GPIO Interfaces

Pin Name	Pin No.	I/O	Status After Reset	Description	DC Characteristics	Comment
GPIO1	10	DIO	Hi-Z	General-purpose input/output	VBAT	All GPIO pins are selectable as interrupts in EM0 and EM1 mode.
GPIO2	6	DIO	Hi-Z	General-purpose input/output		
GPIO3	7	DIO	Hi-Z	General-purpose input/output		
GPIO4	20	DIO	Hi-Z	General-purpose input/output		
GPIO5	21	DIO	Hi-Z	General-purpose input/output		
GPIO6	11	DIO	Hi-Z	General-purpose input/output		
GPIO7	12	DIO	Hi-Z	General-purpose input/output		
GPIO8	13	DIO	Hi-Z	General-purpose input/output		
GPIO9	16	DIO	Hi-Z	General-purpose input/output		
GPIO10	17	DIO	Hi-Z	General-purpose input/output		
GPIO11	18	DIO	Hi-Z	General-purpose input/output		
GPIO12	19	DIO	Hi-Z	General-purpose input/output		
GPIO13	15	DIO	Hi-Z	General-purpose input/output		
GPIO14	14	DIO	Hi-Z	General-purpose input/output		

Reserved Pin

Pin Name	Pin No.	Comment
RESERVED	24	Keep it open.

NOTE

1. EM0 mode is the normal operating mode (Active mode); EM1 is the sleep mode.
2. To reduce the probability of module damage and extend module service life, do not power up and down frequently.

3.3. GPIO Multiplexing

The module provides 14 GPIO interfaces by default, and can support up to 18 GPIO interfaces in the case of multiplexing. Pins are defined as follows:

Table 5: GPIO Multiplexing (Digital Pins)

Multiplexing Function	GPIO Interface			
	SWCLK, SWDIO, GPIO1–5	GPIO6–8	USART_TXD, USART_RXD, GPIO9–12	GPIO13, GPIO14
EUART0_CTS	√	√	√	√
EUART0_RTS	√	√	√	√
EUART0_RXD	√	√	√	√
EUART0_TXD	√	√	√	√
I2C0_SCL	√	√	√	√
I2C0_SDA	√	√	√	√
I2C1_SCL	-	-	√	√
I2C1_SDA	-	-	√	√
PDM_CLK	√	√	√	√
PDM_DATA0	√	√	√	√
PDM_DATA1	√	√	√	√
USART0_CLK	√	√	√	√
USART0_CS	√	√	√	√

USART0_CTS	√	√	√	√
USART0_RTS	√	√	√	√
USART0_RXD	√	√	√	√
USART0_TXD	√	√	√	√
USART1_CLK	√	√	-	-
USART1_CS	√	√	-	-
USART1_CTS	√	√	-	-
USART1_RTS	√	√	-	-
USART1_RXD	√	√	-	-
USART1_TXD	√	√	-	-

Table 6: GPIO Multiplexing (Analog Pins)

Multiplexing Function	SWCLK, SWDIO, GPIO1–5	GPIO6–8	USART_TXD, USART_RXD, GPIO9–12	GPIO13, GPIO14
ADC0	√	√	√	√

NOTE

1. All GPIO pins are selectable as interrupts in EM0 and EM1 modes.
2. SWCLK, SWDIO, GPIO1–5, GPIO6–8 pins are selectable as interrupts in EM2 and EM3 modes.
3. GPIO4, GPIO12, GPIO7, USART_TXD are available for wake-up function in EM4 mode.
4. EM2 is deep sleep mode, EM3 is standby mode, and EM4 is shutoff mode.
5. After the module is powered off, all of its GPIOs must be driven low. Otherwise, the current leakage may make the module enter an abnormal state.
6. The maximum number of application interfaces multiplexed through GPIOs isn't available simultaneously. For the maximum number of different application interfaces that the module can support, see **Chapter 3.4**.

3.4. Application Interfaces

3.4.1. USART

The module supports 1 USART by default. In the case of multiplexing, it provides up to 2 USARTs. See **Table 5** for more details. The USART interface supports the following applications:

- UART (supporting full-duplex communication and hardware flow control)
- RS-485
- SPI
- MicroWire
- 3-wire
- ISO 7816 Smart-Cards
- IrDA
- I2S

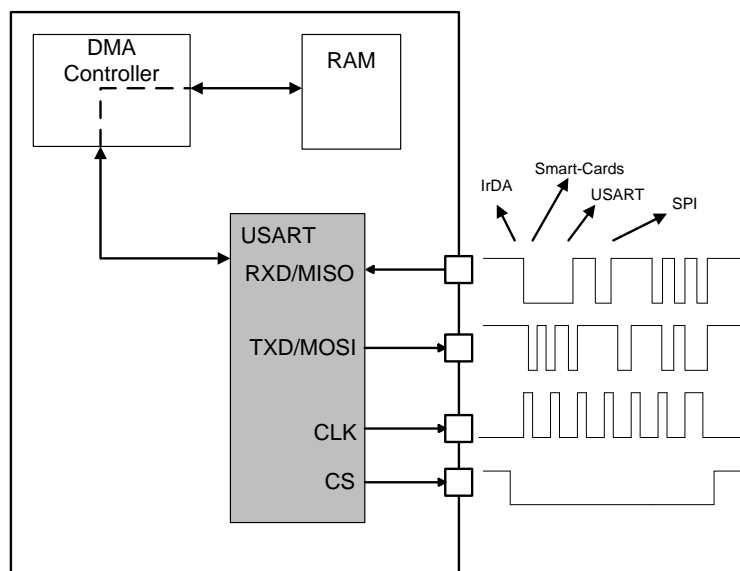


Figure 2: USART Functional Diagram

The USART operates in either asynchronous or synchronous mode:

- In synchronous mode, a separate clock signal generated by the bus master is transmitted with the data. Both the master and slave transmit data according to this clock. The synchronous communication mode is compatible with the SPI Bus standard.
- In asynchronous mode, no separate clock signal is transmitted with the data on the bus. The USART receiver thus has to determine where to sample the data on the bus from the actual data. To make it possible, additional synchronization bits are added to the data when operating in asynchronous mode.

Asynchronous or synchronous mode can be selected by configuring SYNC in register (USART_CTRL). For specific configuration methods, please consult Quectel Technical Support. The mode options with

supported protocols are listed below:

Table 7: USART Synchronous/Asynchronous Mode

SYNC	Communication Mode	Protocol
0	Asynchronous	UART, RS-232, RS-485 (with external driver), IrDA, ISO 7816 Smart-Cards
1	Synchronous	I2S, SPI, MicroWire, 3-wire

USART can be used as a UART application for AT command communication and data transmission. In this case, it supports a self-configurable baud rate with a default baud rate of 115200 bps. The USART connection between the module and the MCU is shown below. (The dotted lines are optional if required).

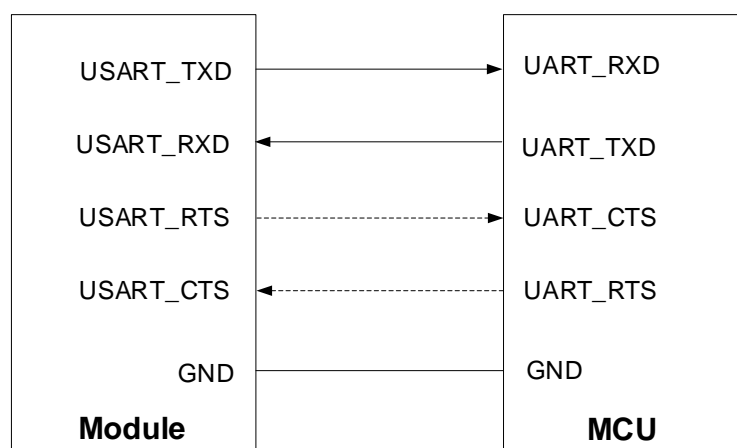


Figure 3: USART Connection

The following figure shows the USART connection between the module and the host when used as SPI application.

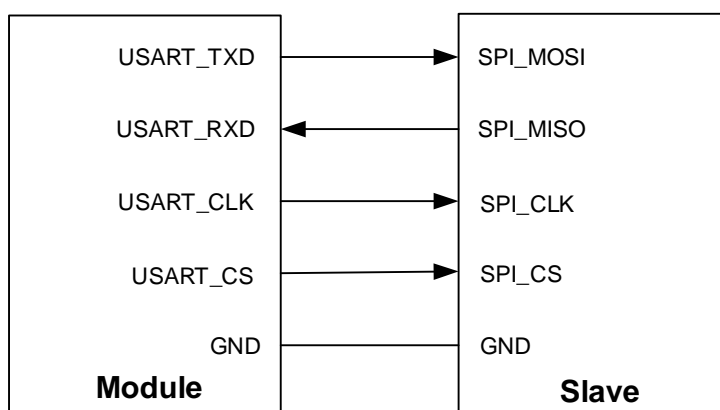


Figure 4: SPI Connection (Master Mode)

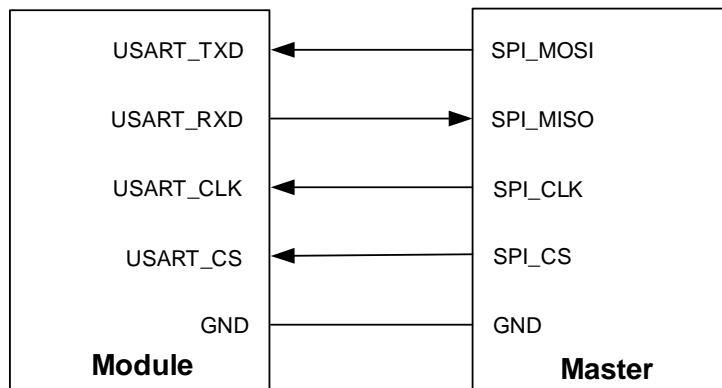


Figure 5: SPI Connection (Slave Mode)

NOTE

When USART is used as an SPI application, the input and output signals must be converted in slave mode: the receiver receives the signal through USART_TXD (SPI_MOSI), and the transmitter drives USART_RXD (SPI_MISO) to send the signal.

The following figure shows the USART connection between the module and the host when used as I2S application.

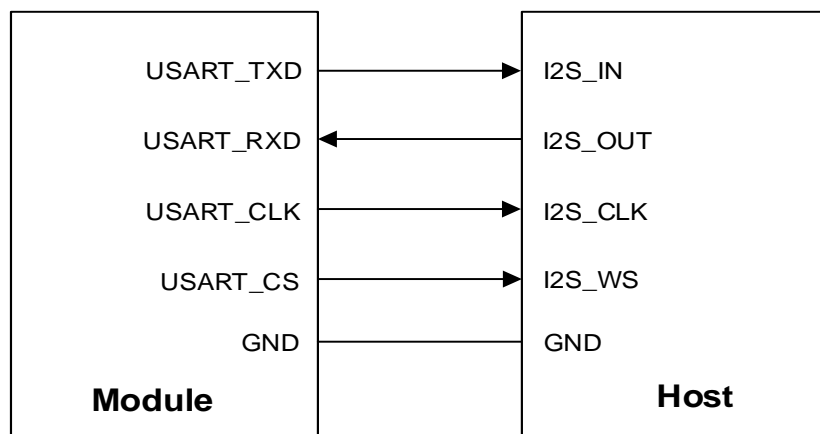


Figure 6: I2S Connection

The following figure shows the USART connection between the module and the host when used as RS-485 application.

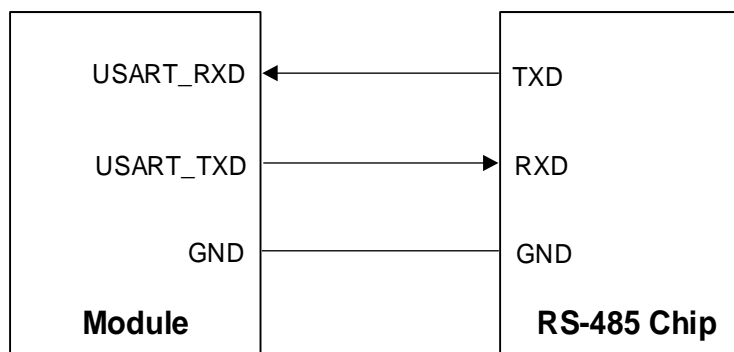


Figure 7: RS-485 Connection

3.4.2. EUART

In the case of multiplexing, the module supports 1 EUART for high-speed UART and IrDA communication, and see **Table 5** for more details.

- EUART has multiple modes of operation, with flexible configuration of frame format and baud rate. In multi-processor mode, EUART can remain idle when not addressed, helping to reduce power consumption and improve communication efficiency.
- EUART supports triple buffering and DMA (Direct Memory Access), and data transfer can be performed with minimal CPU usage, resulting in high-speed data transfer.
- EUART also supports the transmission and reception of large frame data in EM1 mode. In low-frequency EM2 mode, dedicated I/O ports can support data transmission and reception, allowing the module to maintain communication capabilities even in low-power states.

3.4.3. SWD Interface

The module supports a 2-pin SWD interface, the pin definitions are shown in the table below.

Table 8: Pin Definition of SWD Interface

Pin Name	Pin No.	I/O	Description	Comment
SWDIO	4	DIO	Serial wire debugging input/output	Used for program downloading. Enabled after power-up. Internally pulled up to 3.3 V.
SWCLK	3	DI	Serial wire debugging clock	Used for program downloading. Enabled after power-up. Internally pulled down to GND.

The SWD interface supports online program downloading and the common connection is shown below.

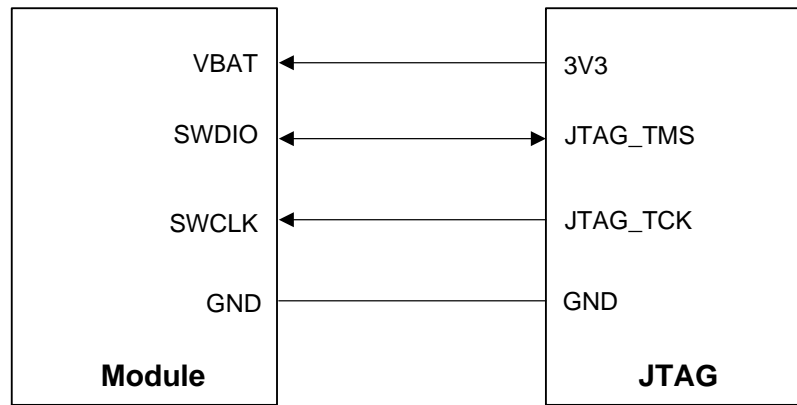


Figure 8: SWD Interface Connection

3.4.4. I2C Interfaces

In the case of multiplexing, the module can provide two I2C interfaces, both supporting master-slave mode and multi-master communication. Details of the interface multiplexing are shown in Table 5. The interface supports standard mode (100 kbps), fast mode (400 kbps) and fast mode + (1 Mbps), and also complies with slave device arbitration and timeout for compatibility with the SMBus system. Automatic identification of slave device addresses is supported in EM0~EM3 power modes.

Both the I2C interfaces are open-drain. The maximum value of the pull-up resistor (R_p) can be calculated by the maximal rise-time (T_r) for the given bus speed and the estimated bus capacitance (C_b) as shown below:

$$R_p = T_r / (0.8473 \times C_b)$$

The maximal rise times for 100 kHz, 400 kHz and 1 MHz rate is 1 μ s, 300 ns and 120 ns respectively.

3.4.5. ADC Interface

In the case of multiplexing, the module supports one ADC interface, see **Table 6** for more details. The interface supports up to 12-bit resolution at 1 million samples per second. The flexible incremental architecture uses oversampling, allowing applications to trade speed for higher resolution.

The key features of ADC interface are as below:

- Flexible and configurable oversampling rate architecture, allowing trade-offs between rate and resolution:
 - 1 Msps with oversampling ratio = 2
 - 555 ksps with oversampling ratio = 4
 - 76.9 ksps with oversampling ratio = 32
- Internal and external conversion trigger sources

- Immediate (software triggered)
- Local ADC timer
- External TIMER module (synchronous with output/PWM generation)
- General PRS hardware signal
- Selectable reference sources
 - 1.21 V internal reference
 - External precision reference
 - Analog supply

3.4.6. PDM Interface

In the case of multiplexing, the module supports one PDM interface, see **Table 5** for more details. The PDM interface provides decimation filters for pulse-density modulated (PDM) microphones, isolated sigma-delta analogue-to-digital converters, digital sensors, and other PDM or sigma-delta bitstream peripherals. The decimation filter uses a programmable comb filter to decimate the incoming bitstream. PDM supports stereo or mono input and DMA transfers.

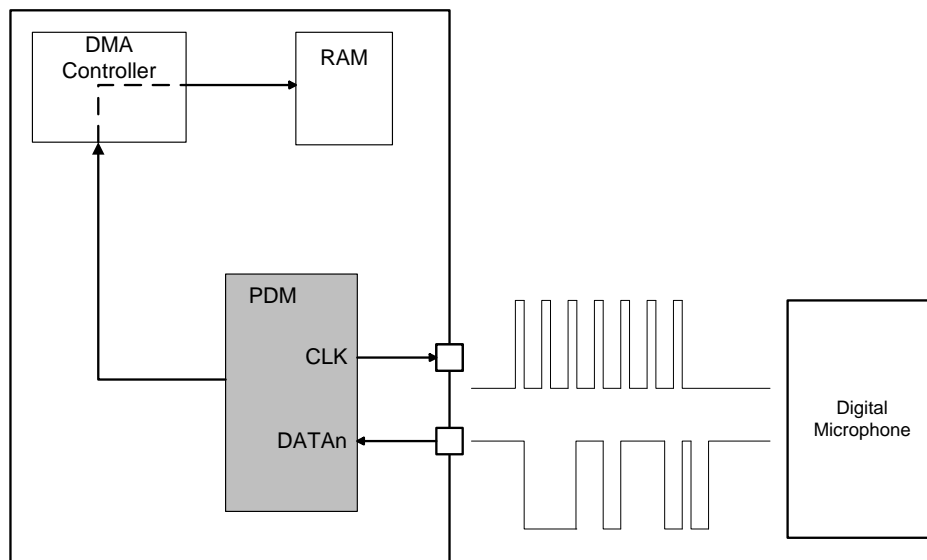


Figure9: PDM Interface Functional Diagram

3.4.7. GPIO Interfaces

In the case of multiplexing, the module supports up to 18 GPIO interfaces, see **Table 5** and **Table 6** for more details. Each GPIO pin can be independently configured as input or output, as well as open-drain, open-source, glitch filtering, and other functions. Except for the SWD interface pins (SWDIO, SWCLK), the input and output functions of the other 16 GPIO pins are disabled after system reset. External resources such as timers, PWM, or USART_RXD/_TXD can be customized via the GPIO pins as required. The input value of a single pin can be configured to other peripherals via PRS or used to trigger external interrupts.

4 Operating Characteristics

4.1. Power Supply Interface

Power supply pin and ground pins of the module are defined in the following table.

Table 9: Pin Definition of Power Supply and GND Pins

Pin Name	Pin No.	I/O	Description	Min.	Typ.	Max.	Unit
VBAT	2	PI	Power supply for the module	1.71	3.3	3.8	V
GND	1, 8, 9						

4.1.1. Reference Design for Power Supply

The module is powered by VBAT, and it is recommended to use a power supply chip that can provide sufficient current of at least 20 mA. For better power supply performance, it is recommended to parallel a 22 μ F decoupling capacitor, and two filter capacitors (1 μ F and 100 nF) near the module's VBAT pin. C4 is reserved for debugging and not mounted by default. In addition, it is recommended to add a TVS near the VBAT to improve the surge voltage bearing capacity of the module. In principle, the longer the VBAT trace is, the wider it should be.

VBAT reference circuit is shown below:

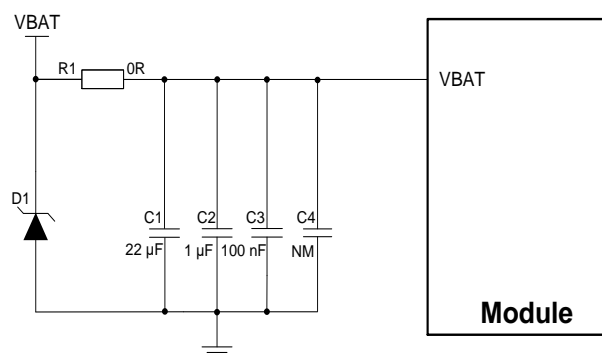


Figure 10: VBAT Reference Circuit

4.2. Reset

Pull the RESET_N low for at least 100 ns and then release it to reset the module.

Table 10: Pin Definition of RESET_N

Pin Name	Pin No.	I/O	Description	Comment
RESET_N	5	DI	Reset the module	Hardware reset. Internally pulled up to 1.8 V. Active low.

The reference design for resetting the module is shown below. Press the button directly to realize the resetting of the module. At the same time, it is recommended to place a TVS near the button for ESD protection and a 100 nF capacitor to avoid jittering.

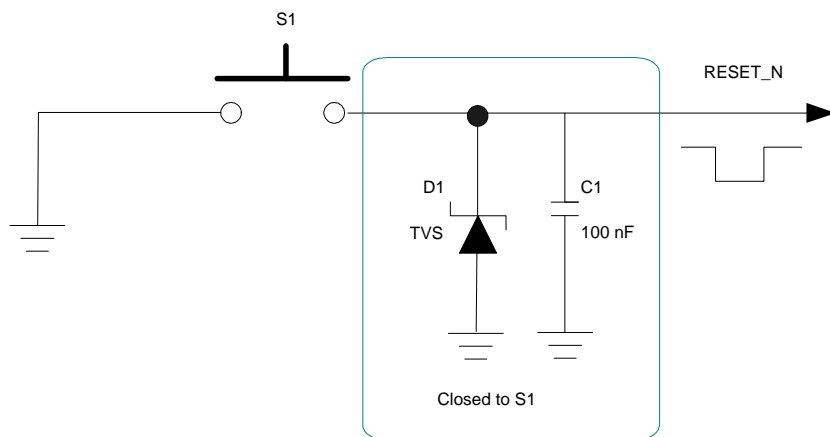


Figure 11: Reference Circuit for RESET_N with a Button

The module reset timing is illustrated in the following figure.

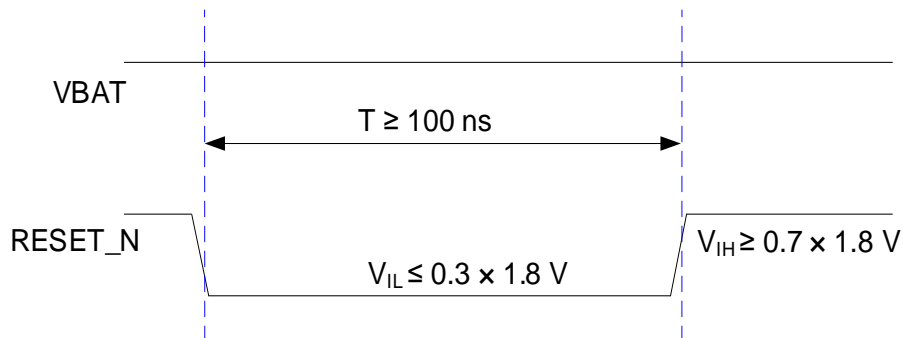


Figure 12: Reset Timing

NOTE

RESET_N is internally pulled up/down with a 44 k Ω (Typ.) resistor.

5 RF Performances

5.1. Bluetooth Performances

Table 11: Bluetooth Performances

Operating Frequency		
2.400–2.4835 GHz		
Modulation		
GFSK		
Operating Mode		
BLE		
Condition (VBAT = 3.3 V; Temp. 25 °C)	Transmitting Power	Receiver Sensitivity
BLE (1 Mbps)	≤ 9 dBm	-98 dBm ±2 dB
BLE (2 Mbps)	≤ 9 dBm	-95 dBm ±2 dB
BLE (S = 2)	≤ 9 dBm	-101.5 dBm ±2 dB
BLE (S = 8)	≤ 9 dBm	-106 dBm ±2 dB

5.2. PCB Antenna

The module supports PCB antenna and the antenna specifications are shown below:

Table 12: PCB Antenna Specifications

Parameter	Specification
Frequency Range (GHz)	2.400–2.500
Input Impedance (Ω)	50 (Typ.)
VSWR	≤ 2
Gain (dBi)	-0.5 (Max.)
Efficiency	30 % (Avg.)

The performance of the PCB antenna depends on the entire product, including the motherboard, case, and other RF signals, and it is recommended to verify it at the early stage of design. To ensure the performance and reliability when designed with PCB antenna, follow the basic principles below for module's placement and layout:

1. The module should be placed on the edge of the motherboard.
2. On the motherboard, all PCB layers under the PCB antenna and within at least 10 mm to the left and right should be designed as keepout areas.
3. On the motherboard, ensure a minimum clearance of 16 mm between the PCB antenna and power connectors, Ethernet ports, USB ports, and other large form-factor components (if any).
4. If using a plastic case, ensure a minimum clearance of 10 mm between the PCB antenna and the plastic case. If using a metal case, it is recommended to use an external antenna.

NOTE

If any of the above principles cannot be guaranteed, it is advisable to explore alternative antenna solutions for the module or seek assistance from the Quectel Antenna Team, who can offer design assistance and recommend suitable external antennas. Please feel free to contact Quectel Technical Support if necessary.

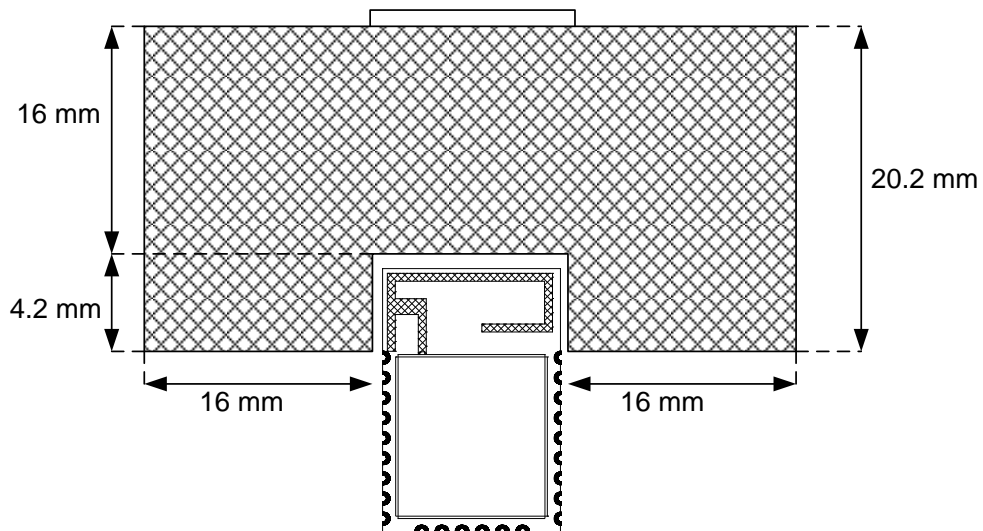


Figure 13: Keepout Area on Motherboard

To ensure module performance, do not route at the RF test point at the bottom of the module during PCB design. The prohibited area during routing is shown in the red box below:

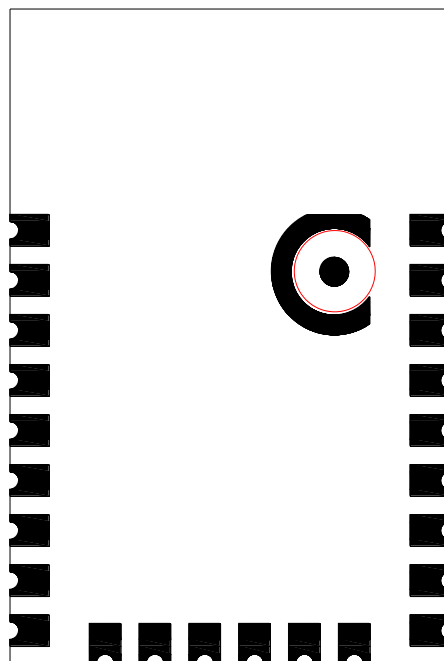


Figure 14: Prohibited Area During Routing (Bottom View)

6 Electrical Characteristics & Reliability

6.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of the module are listed in the following table.

Table 13: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VBAT	-0.3	3.8
Voltage at Digital Pins	-0.3	4.1

NOTE

Exceeding the conditions of use as shown above may cause permanent damage to the module.

6.2. Power Supply Ratings

Table 14: Module Power Supply Ratings (Unit: V)

Parameter	Description	Condition	Min.	Typ.	Max.
VBAT	Power supply for the module	The actual input voltages must be kept between the minimum and maximum values.	1.71	3.3	3.8

6.3. Bluetooth Power Consumption

Table 15: Bluetooth Consumption (Unit: mA)

Mode	Typ.	Max.	Unit
Sleep Mode	-	TBD	μA
BLE 1 Mbps @ Tx 8.82 dBm	9.313	10.603	mA
BLE 2 Mbps @ Tx 8.83 dBm	5.927	7.242	mA
BLE S = 2 @ Tx 8.82 dBm	8.199	12.324	mA
BLE S = 8 @ Tx 8.8 dBm	11.080	12.984	mA

NOTE

1. Test conditions: ambient temperature 25 °C, and typical power domain.
2. The above power consumption data is the typical value for your reference only. Actual values may vary among different modules due to differences in internal components, software versions and test ambient temperatures. For more details, please contact Quectel Technical Support.

6.4. Digital I/O Characteristics

Table 16: VBAT I/O Characteristics (Unit: V)

Parameter	Description	Min.	Max.
V _{IH}	High-level input voltage	0.7 × VBAT	-
V _{IL}	Low-level input voltage	-	0.3 × VBAT
V _{OH}	High-level output voltage	0.8 × VBAT	-
V _{OL}	Low-level output voltage	-	0.2 × VBAT

NOTE

VBAT = 3.3 V.

6.5. ESD Protection

Static electricity occurs naturally and may damage the module. Therefore, applying proper ESD countermeasures and handling methods is imperative. For example, wear anti-static gloves during the development, production, assembly and testing of the module; add ESD protection components to the ESD sensitive interfaces and points in the product design.

7 Mechanical Information

This chapter describes the mechanical dimensions of the module. All dimensions are measured in millimeters (mm), and the dimensional tolerances are ± 0.2 mm unless otherwise specified.

7.1. Mechanical Dimensions

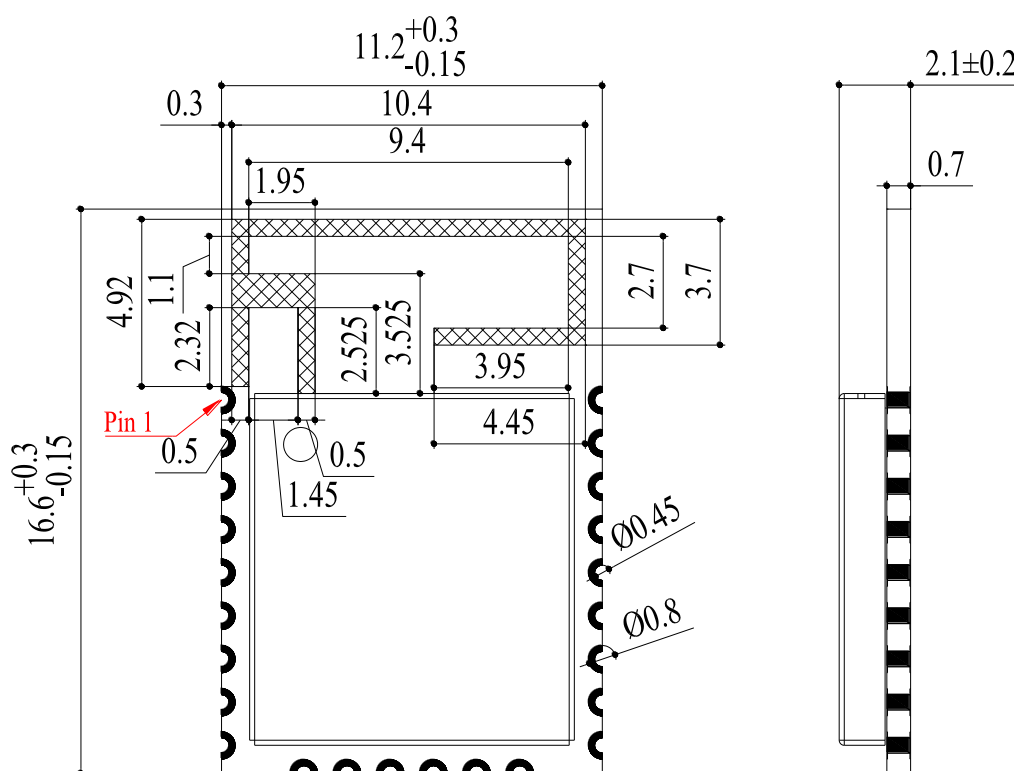


Figure 15: Top and Side Dimensions

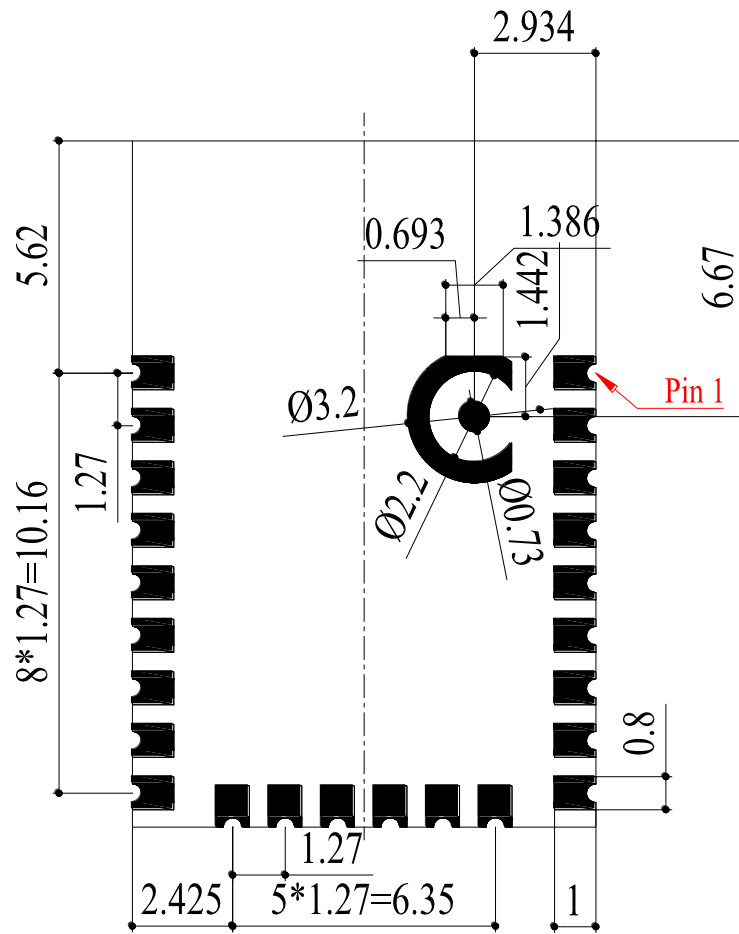


Figure 16: Bottom Dimensions (Bottom View)

NOTE

The module's coplanarity standard: $\leq 0.13 \text{ mm}$.

7.2. Recommended Footprint

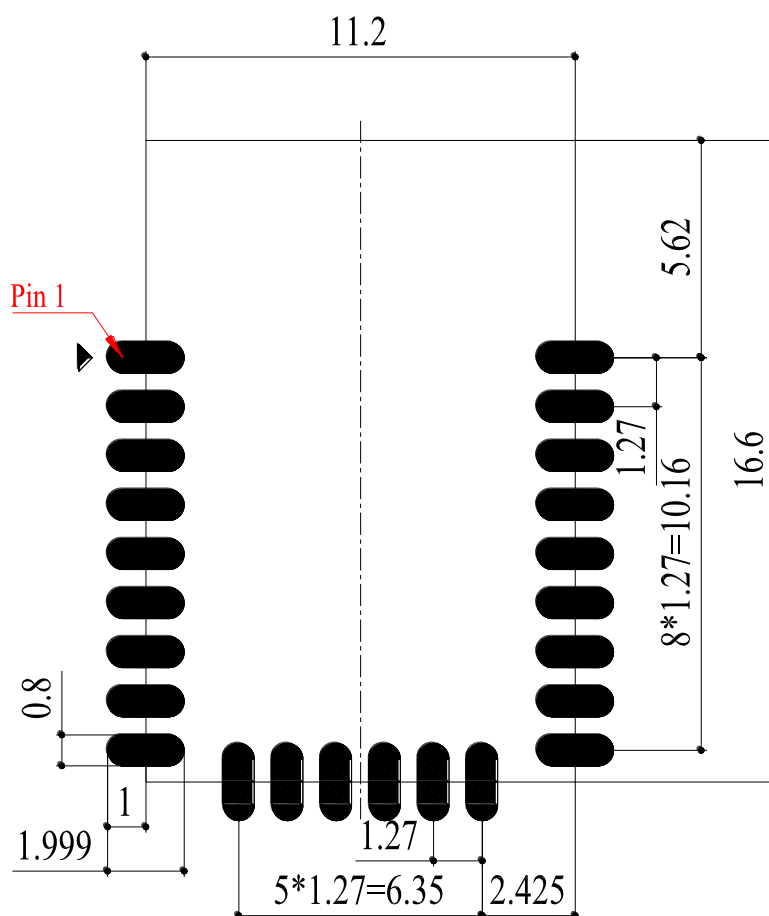


Figure 17: Recommended Footprint

NOTE

Keep at least 3 mm between the module and other components on the motherboard to improve soldering quality and maintenance convenience.

7.3. Top and Bottom Views

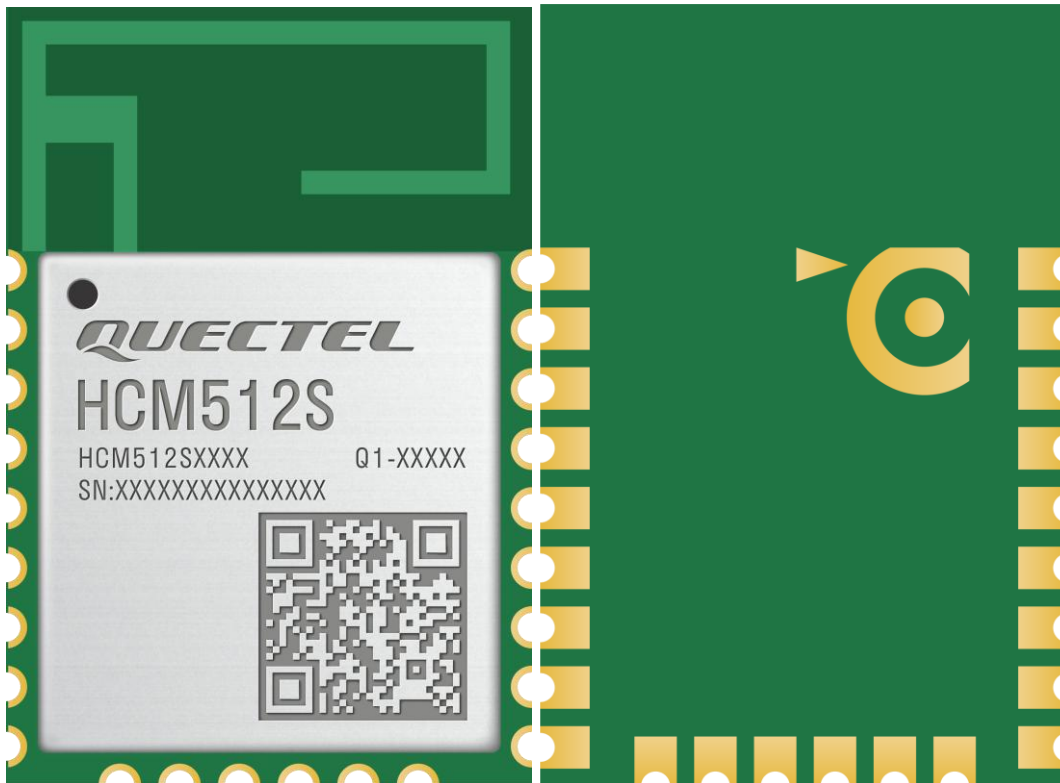


Figure 18: Top and Bottom Views

NOTE

Images above are for illustrative purposes only and may differ from the actual module. For authentic appearance and label, please refer to the module received from Quectel.

8 Storage and Packaging

8.1. Storage Conditions

The module is provided with vacuum-sealed packaging. MSL of the module is rated as 3. The storage requirements are shown below.

1. Recommended Storage Condition: the temperature should be 23 ± 5 °C and the relative humidity should be 35–60 %.
2. Shelf life (in a vacuum-sealed packaging): 12 months in Recommended Storage Condition.
3. Floor life: 168 hours ⁴ in a factory where the temperature is 23 ± 5 °C and relative humidity is below 60 %. After the vacuum-sealed packaging is removed, the module must be processed in reflow soldering or other high-temperature operations within 168 hours. Otherwise, the module should be stored in an environment where the relative humidity is less than 10 % (e.g., a dry cabinet).
4. The module should be pre-baked to avoid blistering, cracks and inner-layer separation in PCB under the following circumstances:
 - The module is not stored in Recommended Storage Condition;
 - Violation of the third requirement mentioned above;
 - Vacuum-sealed packaging is broken, or the packaging has been removed for over 24 hours;
 - Before module repairing.
5. If needed, the pre-baking should follow the requirements below:
 - The module should be baked for 24 hours at 120 ± 5 °C;
 - The module must be soldered to PCB within 24 hours after the baking, otherwise it should be put in a dry environment such as in a dry cabinet.

⁴ This floor life is only applicable when the environment conforms to *IPC/JEDEC J-STD-033*. It is recommended to start the solder reflow process within 24 hours after the package is removed if the temperature and moisture do not conform to, or are not sure to conform to *IPC/JEDEC J-STD-033*. Do not unpack the modules in large quantities until they are ready for soldering.

NOTE

1. To avoid blistering, layer separation and other soldering issues, extended exposure of the module to the air is forbidden.
2. Take out the module from the package and put it on high-temperature-resistant fixtures before baking. If shorter baking time is desired, see *IPC/JEDEC J-STD-033* for the baking procedure.
3. Pay attention to ESD protection, such as wearing anti-static gloves, when touching the modules.

8.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. Apply proper force on the squeegee to produce a clean stencil surface on a single pass. To guarantee module soldering quality, the thickness of stencil for the module is recommended to be 0.15–0.18 mm. For more details, see **document [3]**.

The recommended peak reflow temperature should be 235–246 °C, with 246 °C as the absolute maximum reflow temperature. To avoid damage to the module caused by repeated heating, it is recommended that the module should be mounted only after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

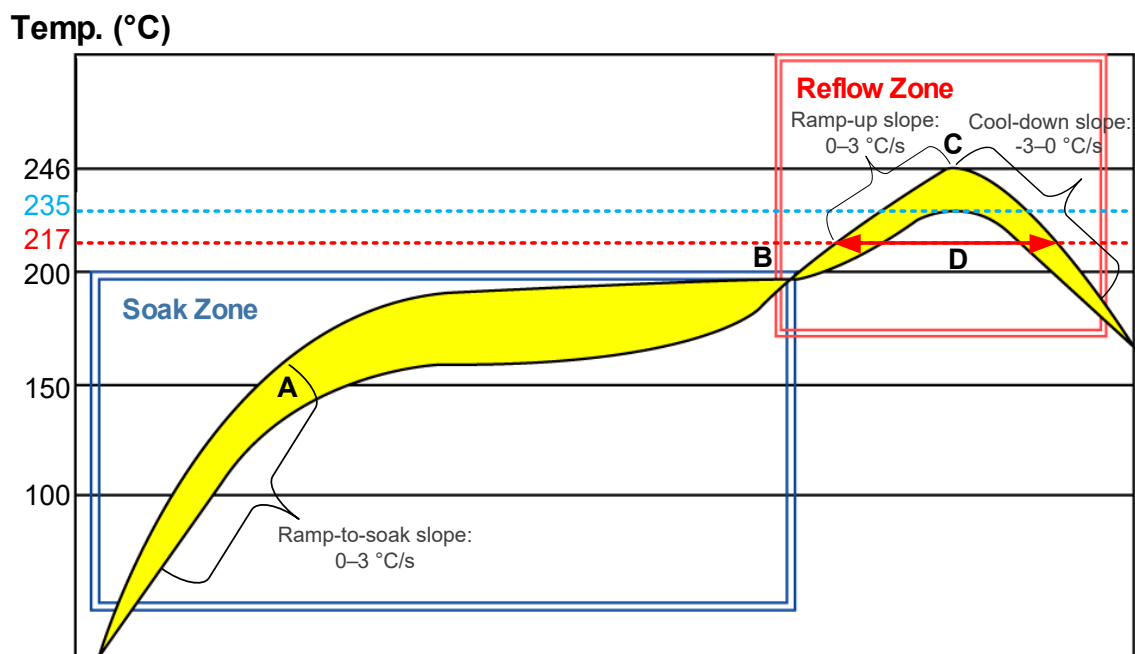


Figure 19: Recommended Reflow Soldering Thermal Profile

Table 17: Recommended Thermal Profile Parameters

Factor	Recommended Value
Soak Zone	
Ramp-to-soak Slope	0–3 °C/s
Soak Time (between A and B: 150 °C and 200 °C)	70–120 s
Reflow Zone	
Ramp-up Slope	0–3 °C/s
Reflow Time (D: over 217 °C)	40–70 s
Max. Temperature	235–246 °C
Cool-down Slope	-3–0 °C/s
Reflow Cycle	
Max. Reflow Cycle	1

NOTE

1. The above profile parameter requirements are for the measured temperature of solder joints. Both the hottest and coldest spots of solder joints on the PCB should meet the above requirements.
2. During manufacturing and soldering, or any other processes that may contact the module directly, NEVER wipe the module's shielding can with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, trichloroethylene. Otherwise, the shielding can may become rusted.
3. The shielding can for the module is made of Cupro-Nickel base material. It is tested that after 12 hours' Neutral Salt Spray test, the laser engraved label information on the shielding can is still clearly identifiable and the QR code is still readable, although white rust may be found.
4. If a conformal coating is necessary for the module, do NOT use any coating material that may chemically react with the PCB or shielding cover, and prevent the coating material from flowing into the module.
5. Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.
6. Avoid using materials that contain mercury (Hg), such as adhesives, for module processing, even if the materials are RoHS compliant and their mercury content is below 1000 ppm (0.1 %).
7. Corrosive gases may corrode the electronic components inside the module, affecting their reliability and performance, and potentially leading to a shortened service life that fails to meet the designed lifespan. Therefore, do not store or use unprotected modules in environments containing corrosive gases such as hydrogen sulfide, sulfur dioxide, chlorine, and ammonia.
8. Due to the complexity of the SMT process, please contact Quectel Technical Support in advance for any situation that you are not sure about, or any process (e.g. selective soldering, ultrasonic

soldering) that is not mentioned in **document [4]**.

8.3. Packaging Specification

This chapter outlines the key packaging parameters and processes. All figures below are for reference purposes only, as the actual appearance and structure of packaging materials may vary in delivery.

The modules are packed in a tape and reel packaging as specified in the sub-chapters below.

8.3.1. Carrier Tape

Carrier tape dimensions are illustrated in the following figure and table:

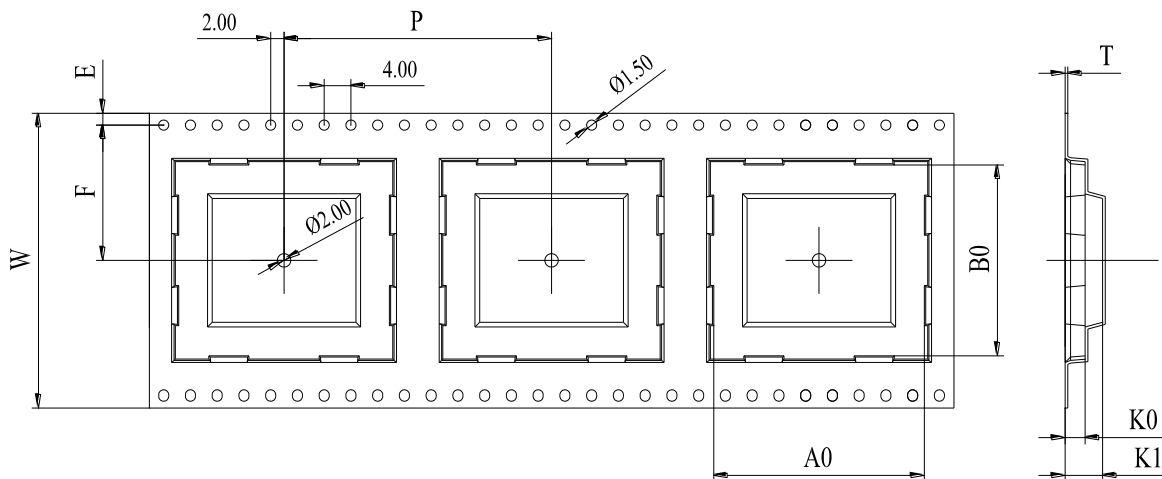


Figure 20: Carrier Tape Dimension Drawing (Unit: mm)

Table 18: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
32	24	0.4	11.6	17	2.6	4.6	14.2	1.75

8.3.2. Plastic Reel

Plastic reel dimensions are illustrated in the following figure and table:

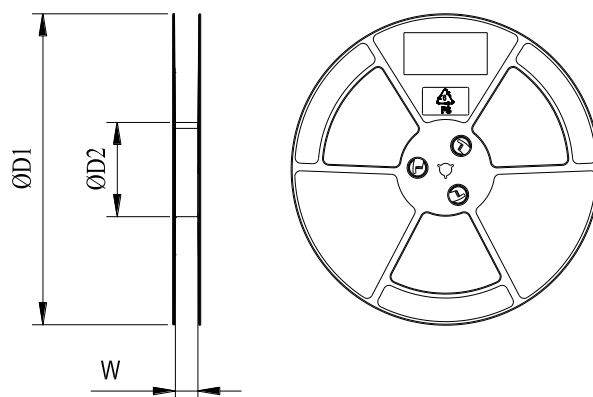


Figure 21: Plastic Reel Dimension Drawing

Table 19: Plastic Reel Dimension Table (Unit: mm)

$\varnothing D1$	$\varnothing D2$	W
330	100	32.5

8.3.3. Mounting Direction

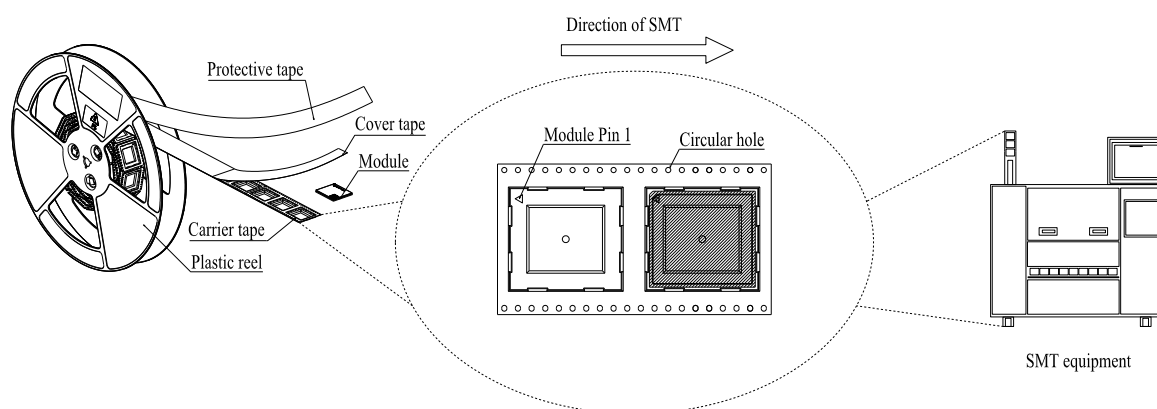
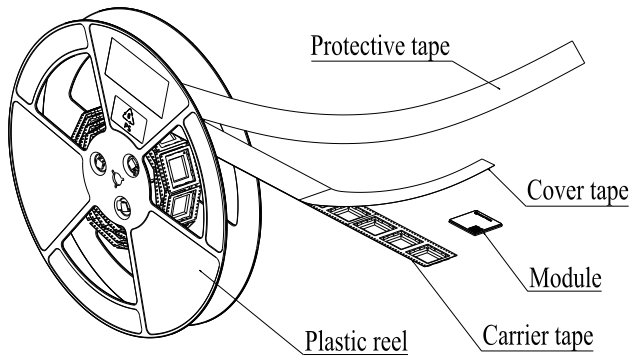


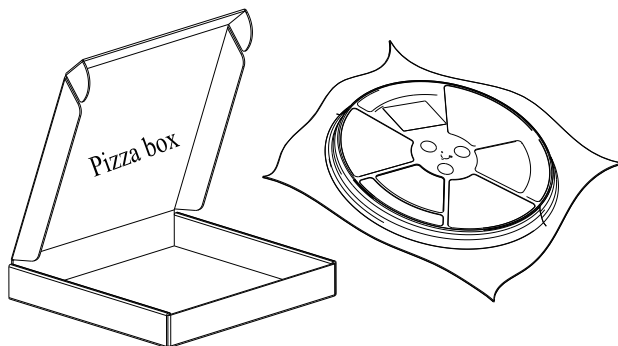
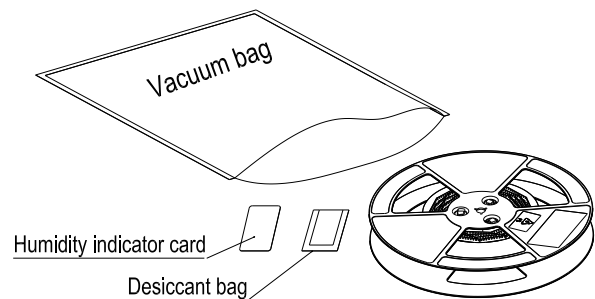
Figure 22: Mounting Direction

8.3.4. Packaging Process



Place the modules onto the carrier tape cavity and cover them securely with cover tape. Wind the heat-sealed carrier tape onto a plastic reel and apply a protective tape for additional protection. 1 plastic reel can pack 500 modules.

Place the packaged plastic reel, humidity indicator card and desiccant bag into a vacuum bag, and vacuumize it.



Place the vacuum-packed plastic reel into a pizza box.

Place the 4 packaged pizza boxes into 1 carton and seal it. 1 carton can pack 2000 modules.

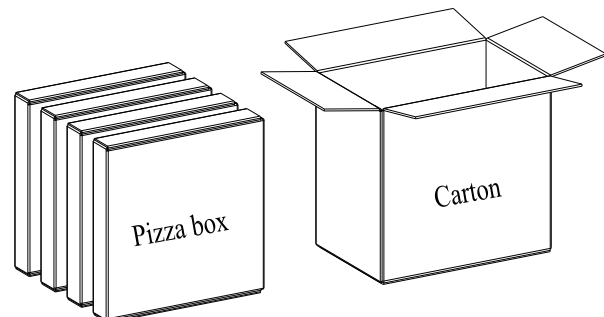


Figure 23: Packaging Process

9 Appendix References

Table 20: Reference Documents

Document Name
[1] Quectel_HCM511S_TE-B_User_Guide
[2] Quectel_HCM512S_AT_Commands_Manual
[3] Quectel_Module_Stencil_Design_Requirements
[4] Quectel_Module_SMT_Application_Note
[5] Quectel_HCM010S&HCM51xS_Series_GSDK(SDK)_Quick_Start_Guide

Table 21: Terms and Abbreviations

Abbreviation	Description
ADC	Incremental Analog to Digital Converter
ARM	Advanced RISC Machine
BLE	Bluetooth Low Energy
CDM	Charged Device Model
CMU	Clock Management Unit
CPU	Central Processing Unit
DC	Direct Current
DMA	Direct Memory Access
EM	Energy Mode
ESD	Electrostatic Discharge

ETM	Embedded Trace Macrocell
EUART	Enhanced Universal Asynchronous Receiver/Transmitter
FRC	Frame Controller
GFSK	Gauss frequency Shift Keying
GND	Ground
GPIO	General-Purpose Input/Output
HBM	Human Body Mode
I2C	Inter-Integrated Circuit
I2S	Inter-IC Sound
I/O	Input/Output
IrDA	Infra-red Data Association
JTAG	Joint Test Action Group
LCC	Leadless Chip Carrier (package)
Mbps	Million Bits Per Second
MCU	Microcontroller Unit
MISO	Master In Slave Out
MOSI	Master Out Slave In
OTA	Over-The-Air
PCB	Printed Circuit Board
PDM	Pulse Density Modulation
PRS	Peripheral Reflex System
PWM	Pulse Width Modulation
RAM	Random Access Memory
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances

SPI	Serial Peripheral Interface
SWD	Serial Wire Debug
TVS	Transient Voltage Suppressor
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
USART	Universal Synchronous/Asynchronous Receiver/ Transmitter
(U)SIM	(Universal) Subscriber Identity Module
V_{IH}	High-level Input Voltage
V_{IL}	Low-level Input Voltage
V_{max}	Maximum Voltage
V_{min}	Minimum Voltage
V_{nom}	Nominal Voltage
V_{OH}	High-level Output Voltage
V_{OL}	Low-level Output Voltage
VSWR	Voltage Standing Wave Ratio

FCC Statement

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

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

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

FCC Radiation Exposure Statement

This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

Does not comply with the use restrictions of the product:

Portable devices used close with human's body (within 20cm), Like Cell phone, Notebook etc.

Integration instructions for host product manufacturers according to KDB 996369 D03 OEM Manual v01

2.2 List of applicable FCC rules

FCC Part 15 Subpart C 15.247 & 15.209.

2.3 Specific operational use conditions

The module can be used for mobile applications with a maximum -1.85dBi antenna. The host manufacturer installing this module into their product must ensure that the final product complies with the FCC requirements by a technical assessment or evaluation to the FCC rules, including the transmitter operation. The host manufacturer has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as shown in this manual.

2.4 Limited module procedures

Not applicable. The module is a Single module and complies with the requirement of FCC Part 15.212.

2.5 Trace antenna designs

Not applicable. The module has its own antenna, and doesn't need a host's printed board micro strip trace antenna etc.

2.6 RF exposure considerations

The module must be installed in the host equipment such that at least 20cm is maintained between the antenna and user's body; and if RF exposure statement or module layout is changed, then the host product manufacturer is required to take responsibility of the module through a change in FCC ID or new application. The FCC ID of the module cannot be used on the final product. In these circumstances, the host manufacturer will be responsible for reevaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

2.7 Antennas

Antenna Specification are as follows:

Type: PCB Antenna

Gain: -0.5dBi;

This device is intended only for host manufacturers under the following conditions: The transmitter module may not be co-located with any other transmitter or antenna; The module shall be only used with the internal antenna(s) that has been originally tested and certified with this module. The antenna must be either permanently attached or employ a "unique" antenna coupler.

As long as the conditions above are met, further transmitter test will not be required. However, the host manufacturer is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc).

2.8 Label and compliance information

Host product manufacturers need to provide a physical or e-label stating "Contains FCC ID: XMR2025HCM512S" with their finished product.

2.9 Information on test modes and additional testing requirements

Host manufacturer must perform test of radiated & conducted emission and spurious emission, etc. according to the actual test modes for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product. Only when all

the test results of test modes comply with FCC requirements, then the end product can be sold legally.

2.10 Additional testing, Part 15 Subpart B disclaimer

The modular transmitter is only FCC authorized for FCC Part 15 Subpart C 15.247 & 15.209 and that 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. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuitry), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

Federal Communication Commission Statement (FCC, U S)

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 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

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.

FCC Caution:

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

IMPORTANT NOTES

Co-location warning:

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

OEM integration instructions:

This device is intended only for OEM integrators under the following conditions:

The transmitter module may not be co-located with any other transmitter or antenna. The module shall be only used with the external antenna(s) that has been originally tested and certified with this module.

As long as the conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

Validity of using the module certification:

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End product labeling:

The final end product must be labeled in a visible area with the following: "Contains Transmitter Module **FCC ID: XMR2025HCM512S**"

Information that must be placed in the end user manual:

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as shown in this manual.

IC Statement

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

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.

The device is compliance with RF field strength limits, users can obtain Canadian information on RF exposure and compliance.

IC Radiation Exposure Statement

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

Déclaration d' exposition aux radiations:

Cet équipement est conforme aux limites d' exposition aux rayonnements IC établies pour un environnement non contrôlé. Cet équipement doit être installé et utilisé avec un minimum de 20 cm de distance entre la source de rayonnement et votre corps.

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: "Contains IC:10224A-2025HCM512S".

Étiquetage du produit final

Ce module émetteur n'est autorisé que pour une utilisation dans un dispositif où l'antenne peut être installée de telle sorte que 20 cm puissent être maintenus entre l'antenne et les utilisateurs. Le produit final doit être étiqueté dans une zone visible avec la mention suivante: "contient IC:10224A-2025HCM512S".