# HCM111Z Hardware Design

**Bluetooth 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 cellular or mobile terminal incorporating the module. Manufacturers of the cellular terminal should notify users and operating personnel of the following safety precautions by incorporating them into all product manuals. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

Full attention must be paid to driving at all times to reduce the risk of an accident. Using a mobile phone 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 cellular or mobile terminal 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.


Cellular 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. If emergency assistance is needed, use emergency call if the device supports it. To make or receive a call, the cellular or mobile terminal 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 since network connection cannot be guaranteed under all circumstances.

The cellular or mobile terminal contains a transceiver. When it is ON, it receives and transmits radio 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 phones or other cellular 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

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|---|---|---|---|
| - | 2023-06-15 | Janson CHEN/ Vic CHENG | Creation of the document |
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# 1 Introduction

QuecOpen® is a solution where the module acts as the main processor. Constant transition and evolution of both the communication technology and the market highlight its merits. It can help you to:

- Realize embedded applications' quick development and shorten product R&D cycle
- Simplify circuit and hardware structure design to reduce engineering costs
- Miniaturize products
- Reduce product power consumption
- Apply OTA technology
- Enhance product competitiveness and price-performance ratio

This document defines HCM111Z in QuecOpen® 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.

## 1.1. Special Marks

**Table 1: Special Marks**

| Mark | Definition |
|---|---|
| * | Unless otherwise specified, when an asterisk (*) is used after a function, feature, interface, pin name, AT command, or argument, it indicates that the function, feature, interface, pin, AT command, or argument is under development and currently not supported; and the asterisk (*) after a model indicates that the sample of the model is currently unavailable. |
| […] | Brackets ([…]) used after a pin enclosing a range of numbers indicate all pins of the same type. For example, SDIO_DATA[0:3] refers to all four SDIO pins: SDIO_DATA0, SDIO_DATA1, SDIO_DATA2, and SDIO_DATA3. |

# 2 Product Overview

HCM111Z is a low-power and high performance MCU Bluetooth module compliant with BLE 5.0 protocol. The module, featuring built-in PMU, channel filter, digital demodulator for improving sensitivity and same-frequency interference suppression, supports multiple interfaces such as UART, SWD, I2C, ADC and GPIO for various applications.

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

- Embedded 32-bit ARM Corte-M3 processor with a frequency of up to 48 MHz
- 48 KB SRAM memory and 512 KB Flash
- Supporting OTA (Over-The-Air Upgrade)
- Supporting secondary development

**Table 2: Basic Information**

| HCM111Z | |
|---|---|
| Packaging type | LCC |
| Pin counts | 23 |
| Dimensions | (15 ±0.2) mm × (12 ±0.2) mm × (2.25 ±0.2) mm |
| Weight | Approx. 0.62 g |

## 2.1. Key Features

**Table 3: Key Features**

| | |
|---|---|
| **Basic Information** | |
| Protocols and Standards | ● Bluetooth protocol: BLE 5.3<br>● All hardware components are fully compliant with EU RoHS directive |
| Power Supply | **VBAT Power Supply:**<br>● 1.8–4.3 V<br>● Typ.: 3.3 V |
| Temperature Ranges | ● Operating temperature [1]: -40 to +85 °C<br>● Storage temperature: -45 to +95 °C |
| EVB Kit | HCM111Z-TE-B [2] |
| **Antenna/Antenna Interface** | |
| Antenna/Antenna Interfaces [3] | ● Pin antenna interface (ANT_BT)<br>● PCB antenna<br>● Coaxial RF connector<br>● 50 Ω characteristic impedance |
| **Application Interface [4]** | |
| Application Interfaces | UART, SWD, I2C, ADC, PWM, SPI, I2S*, Audio* |

[1] Within the operating temperature range, the module's related performance meets Bluetooth specifications.
[2] For more details about the EVB, see ***document [1]***.
[3] The module is provided in one of the three antenna/antenna interface designs. For more details, contact Quectel Technical Support.
[4] For more details about the interfaces, see ***Chapter 3.3*** and ***Chapter 3.4***.

# 3 Application Interfaces

## 3.1. Pin Assignment

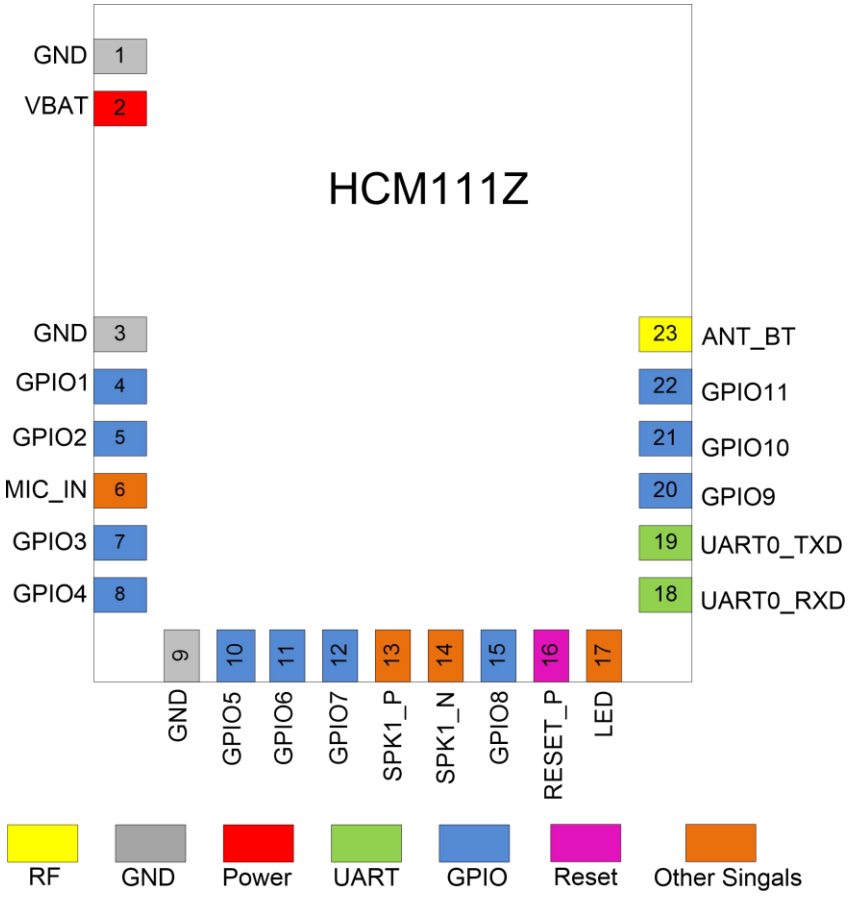



**Figure 2: Pin Assignment (Top View)**

**NOTE**

1. Keep all RESERVED and unused pins unconnected.
2. All GND pins should be connected to ground.
3. The module provides 11 GPIO interfaces by default. In the case of multiplexing it supports up to 13 GPIO interfaces, 2 UARTs, 1 SWD interface, 2 I2C interfaces, 4 ADC interfaces, 6 PWM interfaces, 1 I2S* interface and 1 SPI. For more details, see ***Chapter 3.3*** and ***Chapter 3.4***.

## 3.2. Pin Description

**Table 4: I/O Parameter Description**

| Type | Description |
|---|---|
| AI | Analog Input |
| AO | Analog Output |
| AIO | Analog Input/Output |
| DI | Digital Input |
| DO | Digital Output |
| DIO | Digital Input/Output |
| PI | Power Input |

DC characteristics include power domain and rated current, etc.

**Table 5: Pin Description**

| **Power Supply** | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| VBAT | 2 | PI | Power supply for the module | Vmin = 1.8 V<br>Vnom = 3.3 V<br>Vmax = 4.3 V | The power supply must be provided with sufficient current of more than 100mA. |
| GND | 1, 3, 9 | | | | |
| **Reset** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| RESET_P | 16 | DI | Reset the module | VBAT | Hardware reset.<br>Active high. |
| **UART** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| UART0_TXD | 19 | DO | UART0 transmit | VBAT | |
| UART0_RXD | 18 | DI | UART0 receive | | |
| **GPIO Interfaces** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| GPIO1 | 4 | DIO | General-purpose input/output | VBAT | Interrupt wakeup. |
| GPIO2 | 5 | DIO | | | |
| GPIO3 | 7 | DIO | | | |
| GPIO4 | 8 | DIO | | | |
| GPIO5 | 10 | DIO | | | |
| GPIO6 | 11 | DIO | | | |
| GPIO7 | 12 | DIO | | | |
| GPIO8 | 15 | DIO | | | |
| GPIO9 | 20 | DIO | | | |
| GPIO10 | 21 | DIO | | | |
| GPIO11 | 22 | DIO | | | |
| **Analog Audio Interface** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| MIC_IN | 6 | AI | Microphone input | | |
| SPK1_P | 13 | AO | Analog audio differential output 1 (+) | | |
| SPK1_N | 14 | AO | Analog audio differential output 1 (-) | | |
| **LED Interface** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| LED | 17 | DO | LED output | VBAT | |

| RF antenna interface | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| ANT_BT | 23 | AIO | Bluetooth antenna interface | | 50 Ω characteristic impedance. |

## 3.3. GPIO Multiplexing

The module provides 11 GPIO interfaces by default, and can support up to 13 GPIO interfaces in the case of multiplexing. Pins are defined as follows:

**Table 6: GPIO Multiplexing**

| | Pin No. | Multiplexing (GPIO No.) | Multiplexing Function 1 | Multiplexing Function 2 | Multiplexing Function 3 | Multiplexing Function 4 | Multiplexing Function 5 | Multiplexing Function 6 | Multiplexing Function 7 | Multiplexing Function 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| GPIO1 | 4 | GPIO1 | I2C1_SDA | PWM5 | UART0_TXD | UART1_TXD | - | SW_DIO | I2S_DIN | SPI_MOSI |
| GPIO2 | 5 | GPIO2 | I2C1_SCL | PWM4 | UART0_RXD | UART1_RXD | - | SW_CLK | I2S_DOUT | SPI_MISO |
| GPIO3 | 7 | GPIO3 | I2C1_SCL | PWM0 | UART0_RXD | UART1_RXD | - | CLK_OUT | I2S_DOUT | SPI_MISO |
| GPIO4 | 8 | GPIO4 | I2C1_SDA | PWM1 | UART0_TXD | UART1_TXD | - | ANT_CTL0 | I2S_DIN | SPI_MOSI |
| GPIO5 | 10 | GPIO5 | I2C0_SDA | PWM1 | UART0_TXD | UART1_TXD | - | ANT_CTL0 | I2S_WS | SPI_CS |
| GPIO6 | 11 | GPIO6 | I2C0_SDA | PWM5 | UART0_TXD | UART1_TXD | - | - | I2S_WS | SPI_CS |
| GPIO7 | 12 | GPIO7 | I2C0_SCL | PWM0 | UART0_RXD | UART1_RXD | - | CLK_OUT | I2S_CLK | SPI_CLK |
| GPIO8 | 15 | GPIO8 | I2C0_SCL | PWM4 | UART0_RXD | UART1_RXD | ADC0 | ANT_CTL0 | I2S_CLK | SPI_CLK |
| GPIO9 | 20 | GPIO9 | I2C1_SCL | PWM0 | UART0_RXD | UART1_RXD | ADC2 | CLK_OUT | I2S_DOUT | SPI_MISO |
| GPIO10 | 21 | GPIO10 | I2C0_SDA | PWM5 | UART0_TXD | UART1_TXD | ADC1 | ANT_CTL0 | I2S_WS | SPI_CS |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| GPIO11 | 22 | GPIO11 | I2C1_SDA | PWM1 | UART0_TXD | UART1_TXD | ADC3 | ANT_CTL1 | I2S_DIN | SPI_MOSI |
| UART0_TXD | 19 | GPIO12 | I2C1_SDA | PWM3 | - | UART1_TXD | - | ANT_CTL1 | I2S_DIN | - |
| UART0_RXD | 18 | GPIO13 | I2C1_SCL | PWM2 | - | UART1_RXD | - | ANT_CTL0 | I2S_DOUT | - |

## 3.4. Application Interfaces

### 3.4.1. UART

The module supports up to 2 UARTs. One is default configuration, see ***Table 7***, and another is multiplexed from GPIO interfaces, see ***Table 6***.

**Table 7: Pin Definition of UARTs**

| Pin Name | Multiplexing Function | Pin No. | I/O | Description | Comment |
|---|---|---|---|---|---|
| UART0_TXD | - | 19 | DO | UART0 transmit | |
| UART0_RXD | - | 18 | DI | UART0 receive | |
| GPIO1 | UART1_TXD | 4 | DO | UART1 transmit | Only used under AT solution for debugging. |

UART0 can be used for AT command communication, data transmission and firmware upgrade. It supports self-configurable baud rate with default baud rate of 115200 bps. When used for firmware upgrade, the UART0 (UART0_ RXD/UART0_TXD) can only choose the pin 18 and pin 19.

The UART0 connection between the module and MCU is illustrated below.

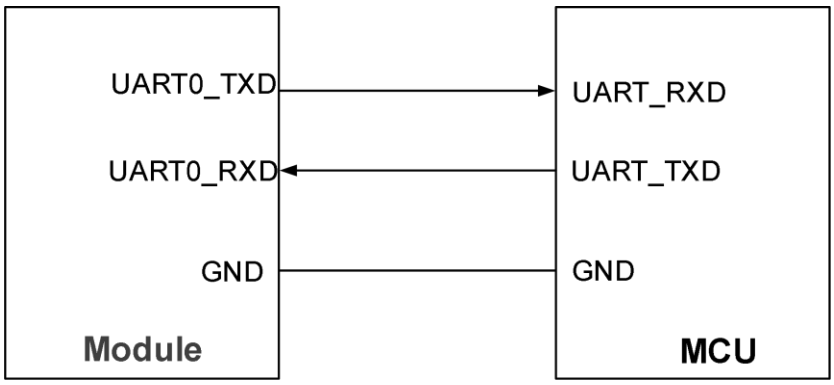



**Figure 3: UART0 Connection**

The UART1 can be used as debug UART for outputting partial logs with debugging tools and supports 921600 bps baud rate by default. The following is a reference design for debug UART.

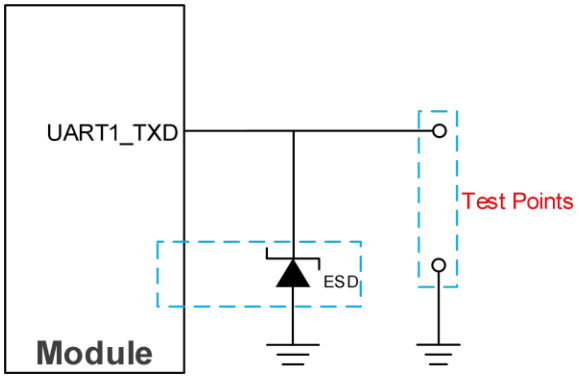



**Figure 4: Debug UART Reference Circuit**

### 3.4.2. SWD Interface

**Table 8: Pin Definition of SWD Interface**

| Pin Name | Pin No. | Multiplexing Function | I/O | Description |
|---|---|---|---|---|
| GPIO1 | 4 | SW_DIO | DIO | Serial data input and output |
| GPIO2 | 5 | SW_CLK | DI | Serial clock input |

The module supports 1 SWD interface multiplexed with GPIOs. The SWD interface supports online program writing.

The common connection of SWD interface is shown below.

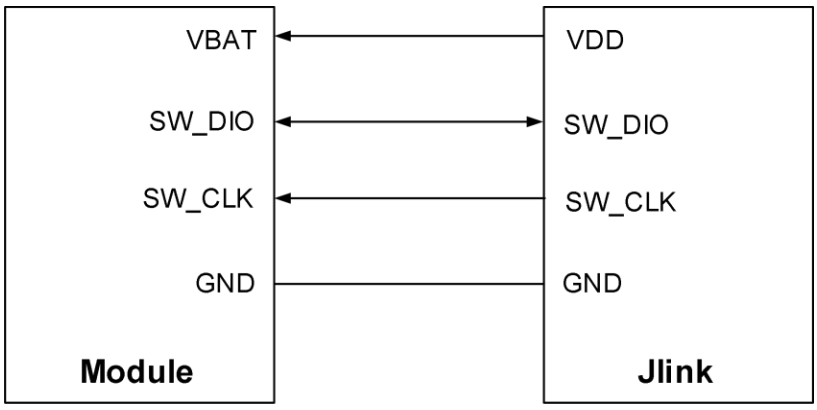



**Figure 5: SWD Interface Connection**

### 3.4.3. I2C Interfaces

In the case of multiplexing, the module supports up to 2 I2C interfaces supporting master and slave modes, and the main features are as follows:

- Support AMBA 2.0 APB bus
- Support standard mode (100 Kbps) and fast mode (400 Kbps) protocols
- Support programmable master-slave mode
- Support 7-bit and 10-bit addressing mode
- Support automatic clock extension
- Support programmable clock and data timing
- Support DMA
- Support universal call addresses

**Table 9: Pin Definition of I2C Interfaces**

| Pin Name | Pin No. | Multiplexing Function | I/O | Description | Comment |
|---|---|---|---|---|---|
| GPIO3 | 7 | I2C1_SCL | OD | I2C serial clock | See ***Table 6*** for other GPIO pins multiplexed as I2C interfaces. |
| GPIO4 | 8 | I2C1_SDA | OD | I2C serial data | |
| GPIO5 | 10 | I2C0_SDA | OD | I2C serial data | |
| GPIO7 | 12 | I2C0_SCL | OD | I2C serial clock | |

### 3.4.4. ADC Interfaces

In the case of multiplexing, the module supports up to 4 ADC interfaces with an internal LDO voltage of 2.9 V. To improve ADC accuracy, surround ADC trace with ground.

**Table 10: Pin Definition of ADC Interfaces**

| Pin Name | Pin No. | Multiplexing Function | I/O | Description |
|---|---|---|---|---|
| GPIO8 | 15 | ADC0 | AI | General-purpose ADC interface |
| GPIO9 | 20 | ADC2 | AI | General-purpose ADC interface |
| GPIO10 | 21 | ADC1 | AI | General-purpose ADC interface |
| GPIO11 | 22 | ADC3 | AI | General-purpose ADC interface |

**Table 11：ADC Features**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| ADC Voltage Range | 0 | 2.9 | 3.3 | V |
| ADC Resolution Rate | - | 10 | - | bit |

### 3.4.5. PWM Interfaces

The module supports up to 6 PWM interfaces multiplexed with GPIOs, and the pin definitions are shown in the table below.

**Table 12：Pin Definition of PWM Interfaces**

| Pin Name | Pin No. | Multiplexing Function | I/O | Description | Comment |
|---|---|---|---|---|---|
| GPIO9 | 20 | PWM0 | DO | PWM0 output | See ***Table 6*** for other GPIO pins multiplexed as PWM interfaces. |
| GPIO11 | 22 | PWM1 | DO | PWM1 output | |
| UART0_RXD | 18 | PWM2 | DO | PWM2 output | |
| UART0_TXD | 19 | PWM3 | DO | PWM3 output | |
| GPIO8 | 15 | PWM4 | DO | PWM4 output | |
| GPIO10 | 21 | PWM5 | DO | PWM5 output | |

### 3.4.6. I2S Interface*

The module supports 1 I2S interface multiplexed with GPIOs for digital audio data transmission between internal devices of the system, such as codecs, DSP, digital input/output interfaces, ADC, DAC, and digital filters.

**Table 13：Pin Definition of I2S Interface**

| Pin Name | Pin No. | Multiplexing Function | I/O | Description | Comment |
|---|---|---|---|---|---|
| GPIO11 | 22 | I2S_DIN | DI | I2S data input | See ***Table 6*** for other GPIO pins multiplexed as I2S interface. |
| GPIO9 | 20 | I2S_DOUT | DO | I2S data output | |

| | | | | |
|---|---|---|---|---|
| GPIO8 | 15 | I2S_CLK | OD | I2S clock |
| GPIO10 | 21 | I2S_WS | DIO | I2S word select |

### 3.4.7. SPI

The module supports 1 SPI multiplexed with GPIOs supporting master mode and slave mode. The maximum clock frequency can reach 20 MHz in the slave mode and 40 MHz in the holotype.

**Table 14：Pin Definition of SPI**

| Pin Name | Pin No. | Multiplexing Function | I/O | Description | Comment |
|---|---|---|---|---|---|
| GPIO3 | 7 | SPI_MISO | DIO | SPI master-in slave-out | See ***Table 6*** for other GPIO pins multiplexed as SPI. |
| GPIO4 | 8 | SPI_MOSI | DIO | SPI master-out slave-in | |
| GPIO6 | 11 | SPI_CS | DIO | SPI chip select | |
| GPIO7 | 12 | SPI_CLK | DIO | SPI clock | |

The common connection of SPI is shown below.

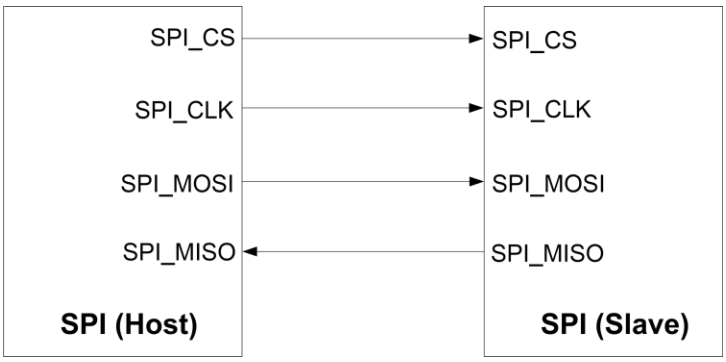



**Figure 6: SPI Connection**

# 4 Operating Characteristics

## 4.1. Power Supply

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

**Table 15: 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 | 1.8 | 3.3 | 4.3 | V |
| GND | 1, 3, 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 more than 100mA output current. For better power supply performance, it is recommended to parallel a 22 µF decoupling capacitor, and two filter capacitors (1 µF and 100 nF) near the module's VBAT pin. 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:

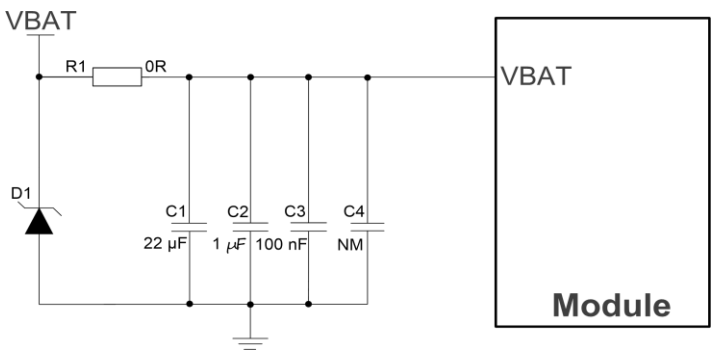



**Figure 7: VBAT Reference Circuit**

## 4.2. Turn On

The module can automatically start up after the VBAT is powered on.

The turn-on timing is shown below:

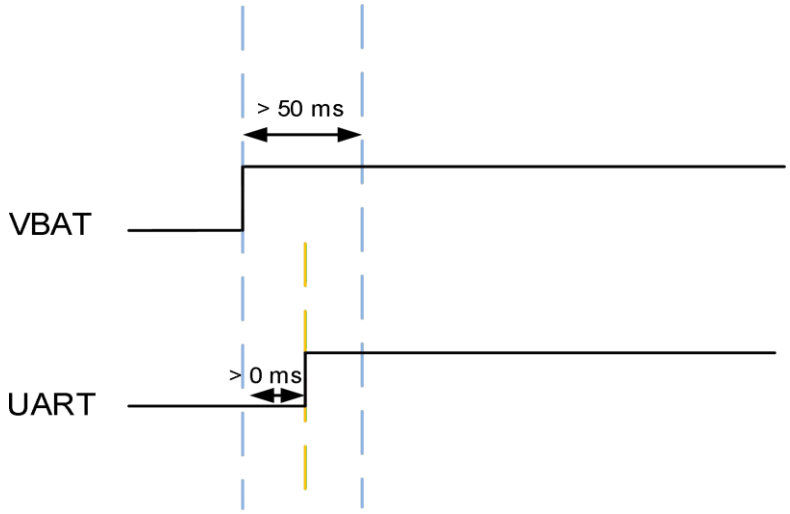



**Figure 8: Turn-on Timing**

## 4.3. Reset

Pull the RESET_P up for at least 50 ms and then release it to reset the module.

**Table 16: Pin Definition of RESET_P**

| Pin Name | Pin No. | I/O | Description | Comment |
|---|---|---|---|---|
| RESET_P | 19 | DI | Reset the module | Hardware reset.<br>Active high. |

The reference design for resetting the module is shown below. Pull up the button directly to realize the resetting of the module. And the button needs to be connected to a large capacitor (about 10 μF) in parallel. At the same time, a TVS should be placed near the button for ESD protection.

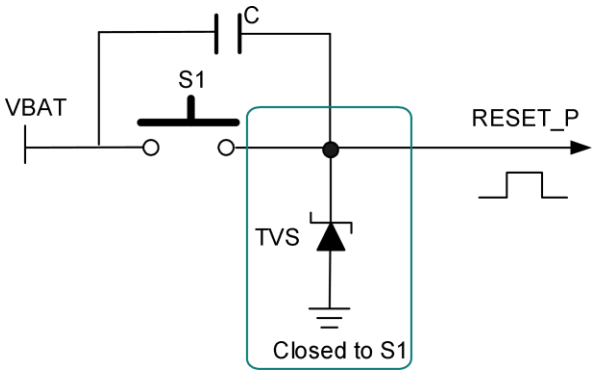



**Figure 9: Reference Circuit of RESET with A Button**

The module reset timing is illustrated in the following figure.

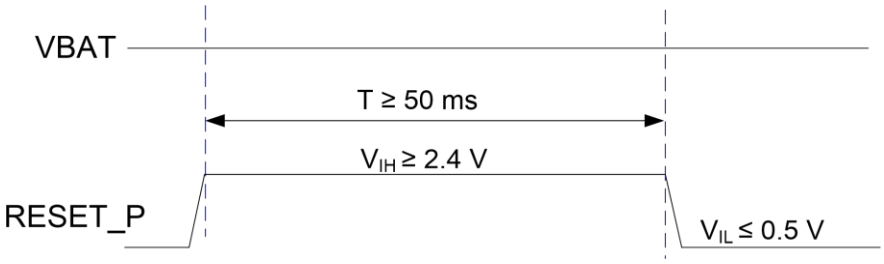



**Figure 10: Reset Timing**

## 4.4. Download Mode

Keep the RESET_P at high level during resetting or power-up will enter download mode. In the download mode, the firmware can be download through the UART0 (pin 18 and 19).

# 5 RF Performances

## 5.1. Bluetooth Performances

**Table 17: Bluetooth Performances**

| **Operating Frequency** | | |
|---|---|---|
| 2.400–2.4835 GHz | | |
| **Modulation** | | |
| GFSK | | |
| **Operating Mode** | | |
| BLE | | |
| **Condition** | **Typ.; Unit: dBm; Tolerance: TBD** | |
| | **Transmitting Power** | **Receiving Sensitivity** |
| BLE (1 Mbps) | ≤ 8 dBm | -95 dBm ±2 dB |
| BLE (2 Mbps) | ≤ 8 dBm | -90 dBm ±2 dB |

## 5.2. Antenna/Antenna Interfaces

Appropriate antenna type and design should be used with matched antenna parameters according to specific application. It is required to perform a comprehensive functional test for the RF design before mass production of terminal products. The entire content of this chapter is provided for illustration only. Analysis, evaluation and determination are still necessary when designing target products.

The module is provided in one of the three antenna/antenna interface designs: pin antenna interface (ANT_BT), PCB antenna and coaxial RF connector. The coaxial RF connector is not available when the module is designed with ANT_BT antenna interface or PCB antenna. The impedance of antenna port is 50 Ω.

### 5.2.1. Pin Antenna Interface (ANT_BT) [5]

**Table 18: ANT_BT Pin Description**

| Pin Name | Pin No. | I/O | Description | Comment |
|---|---|---|---|---|
| ANT_BT | 23 | AIO | Bluetooth antenna interface | 50 Ω characteristic impedance. |

#### 5.2.1.1. Reference Design

A reference circuit for the RF antenna interface is provided below. For better RF performance, it is necessary to reserve a π-type matching circuit and add an ESD protection component. Matching components such as R1, C1, C2, and D1 should be placed as close to the antenna as possible. C1, C2, and D1 are not mounted by default. The parasitic capacitance of TVS should be less than 0.05 pF and it is recommended to use a 0 Ω for R1.

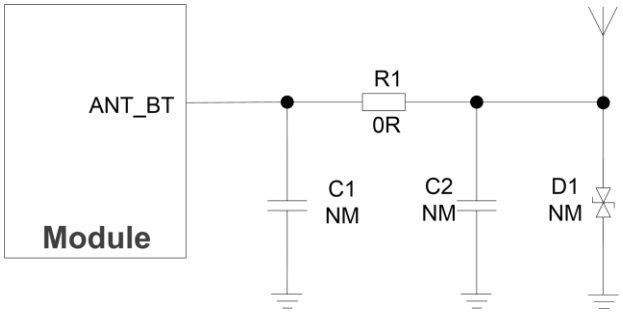



**Figure 11: Reference Design of RF Antenna Interface**

[5] The module is provided in one of the three antenna/antenna interface designs. For more details, contact Quectel Technical Support.

#### 5.2.1.2. Antenna Design Requirements

**Table 19: Antenna Design Requirements**

| Parameter | Requirement |
|---|---|
| Frequency Range (GHz) | 2.400–2.4835 |
| Cable Insertion Loss (dB) | < 1 |
| VSWR | ≤ 2 (Typ.) |
| Gain (dBi) | -3.7 (Typ.) |
| Max. input power (W) | 50 |
| Input impedance (Ω) | 50 |
| Polarization type | Vertical |

#### 5.2.1.3. RF Routing Guidelines

For user's PCB, the characteristic impedance of all RF traces should be controlled to 50 Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, the height from the reference ground to the signal layer (H), and the spacing between RF traces and grounds (S). Microstrip or coplanar waveguide is typically used in RF layout to control characteristic impedance. The following are reference designs of microstrip or coplanar waveguide with different PCB structures.

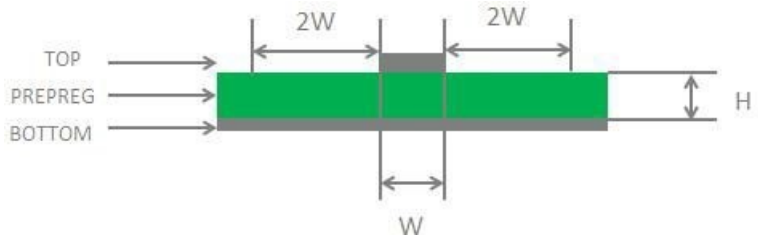



**Figure 12: Microstrip Design on a 2-layer PCB**

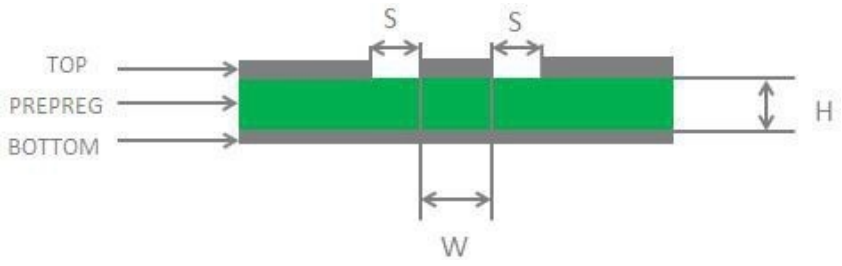



**Figure 13: Coplanar Waveguide Design on a 2-layer PCB**

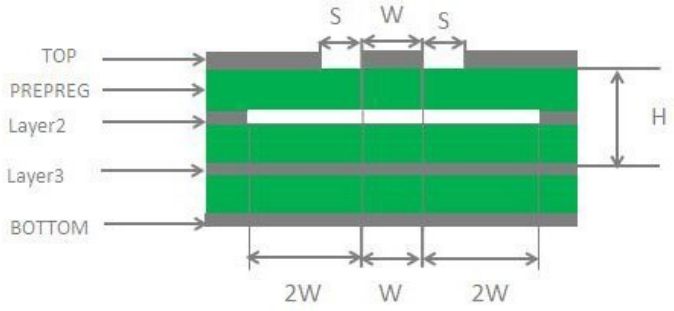



**Figure 14: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)**

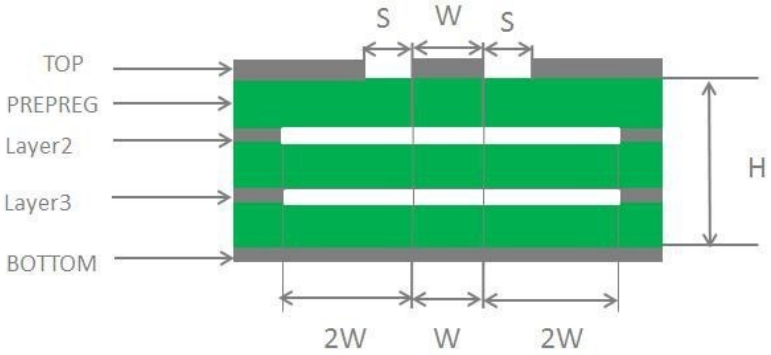



**Figure 15: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)**

To ensure RF performance and reliability, follow the principles below in RF layout design:

- Use an impedance simulation tool to control the characteristic impedance of RF traces to 50 Ω.
- GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to the ground.
- The distance between the RF pins and the RF connector should be as short as possible and all right-angle traces should be changed to curved ones. The recommended trace angle is 135°.
- There should be clearance under the signal pin of the antenna connector or solder joint.

- The reference ground of RF traces should be complete. In addition, adding some ground vias around RF traces and the reference ground could help to improve RF performance. The distance between the ground vias and RF traces should be at least twice the width of RF signal traces (2 × W).
- Keep RF traces away from interference sources, and avoid intersection and paralleling between traces on adjacent layers.

For more details about RF layout, see ***document [2]***.

### 5.2.2. PCB Antenna [6]

**Table 19：PCB antenna parameters**

| Parameter | Requirement |
|---|---|
| Frequency range（GHz） | 2.400–2.500 |
| Impedance （Ω） | 50 |
| VSWR | ≤4.2 |
| Gain（dBi） | - 3.7 (Max) |
| Efficiency | 18.8 % |

When designed with PCB antenna, the module should be placed on the edge of the motherboard. The PCB antenna should be at least 16 mm away from the metal components, connectors, vias, traces, and copper pour area on the motherboard. On the motherboard, all PCB layers under the PCB antenna should be designed as a keepout area.

[6] The module is provided in one of the three antenna/antenna interface designs. For more details, contact Quectel Technical Support.

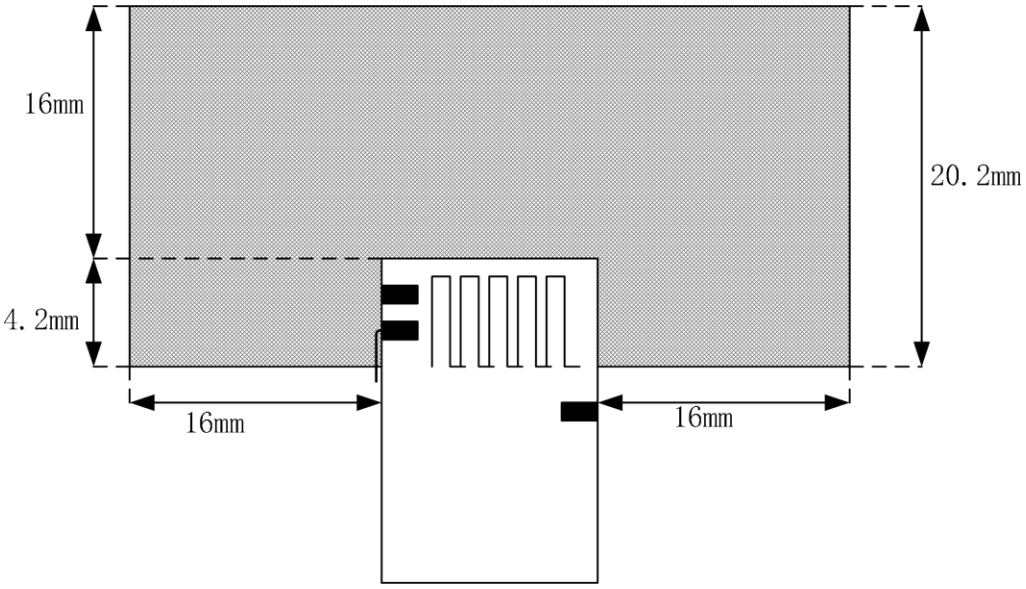



**Figure 16: Keepout Area on Motherboard**

During PCB design, do not route traces across the RF test point at the bottom of the module to ensure the module performance.

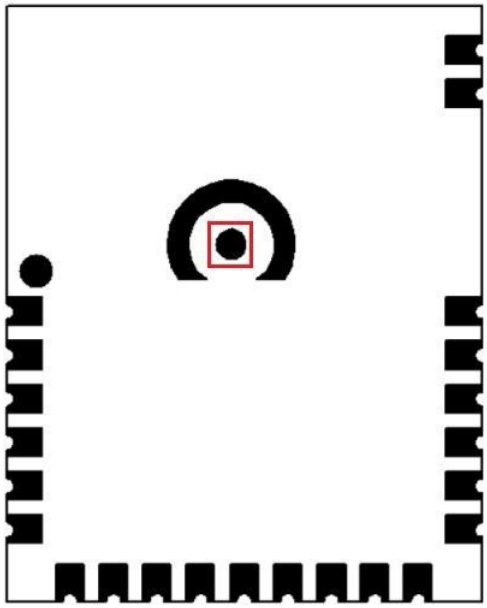


**Figure 17: Prohibited Area for Routing**

### 5.2.3. Coaxial RF Connector [7]

#### 5.2.3.1. Receptacle Specifications

The module provides 4th generation coaxial RF connector and the mechanical dimensions of the receptacle mounted on the module are as follows.

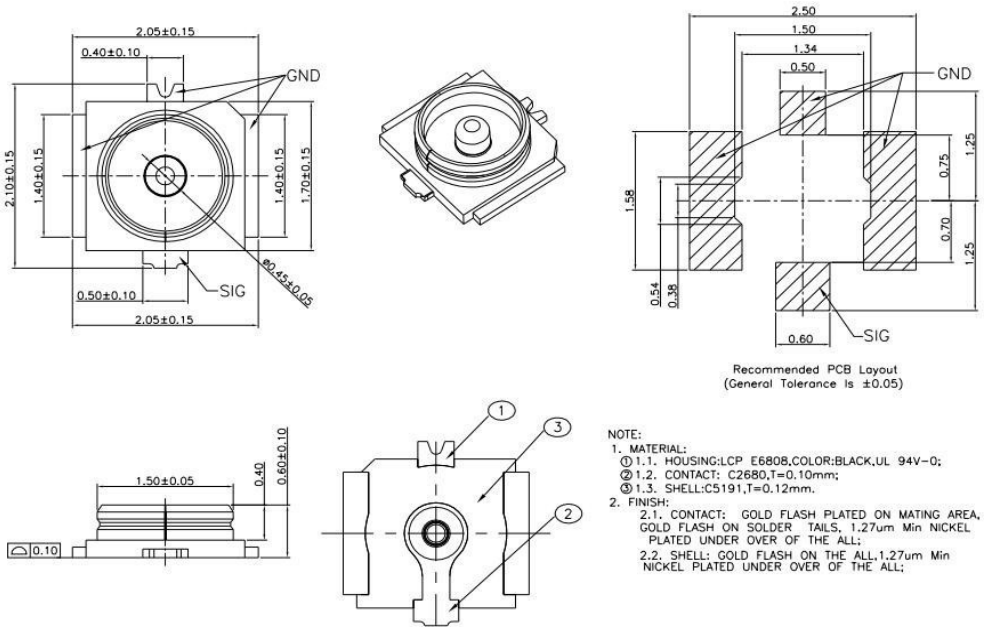



**Figure 18: Dimensions of the Receptacle (Unit: mm)**

**Table 20: Major Specifications of the RF Connector (Receptacle)**

| Item | Specification |
|---|---|
| Nominal Frequency Range | DC to 6 GHz |
| Nominal Impedance | 50 Ω |
| Temperature Rating | -40 °C to +85 °C |
| Voltage Standing Wave Ratio (VSWR) | Meet the requirements of:<br>Max. 1.3 (DC–3 GHz)<br>Max. 1.45 (3–6 GHz) |

[7] The module is provided in one of the three antenna/antenna interface designs. For more details, contact Quectel Technical Support.

#### 5.2.3.2. Antenna Connector Installation

The receptacle mounted on the module accepts two types of mated plugs that will meet a maximum height of 1.2 mm using a Ø 0.81 mm coaxial cable or a maximum height of 1.45 mm utilizing a Ø 1.13 mm coaxial cable.

The following figure shows the dimensions of mated plugs using Ø 0.81 mm coaxial cables.

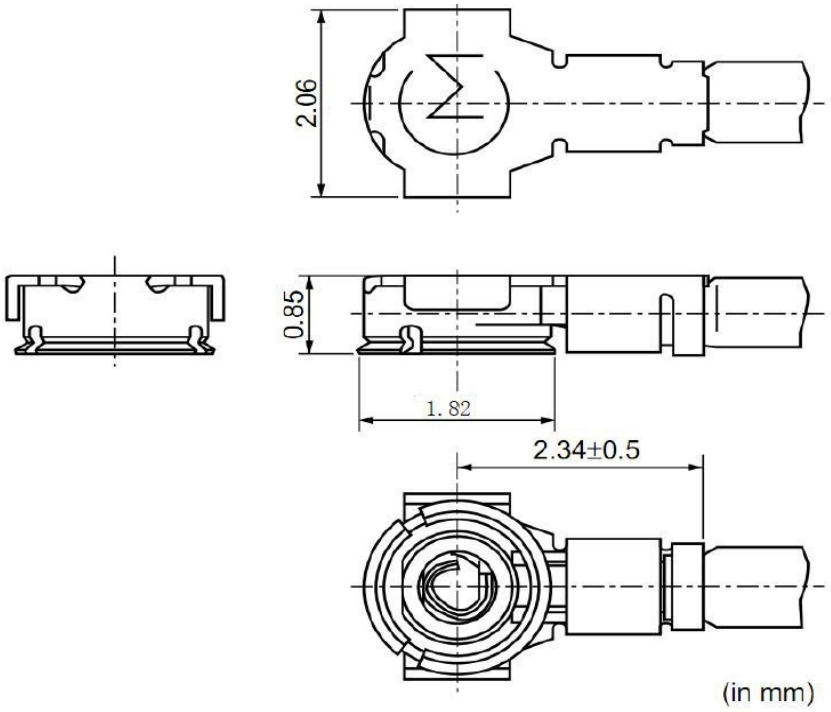



**Figure 19: Dimensions of Mated Plugs (Ø 0.81 Coaxial Cables) (Unit: mm)**

The following figure illustrates the connection between the receptacle on the module and the mated plug using a Ø 0.81 mm coaxial cable.

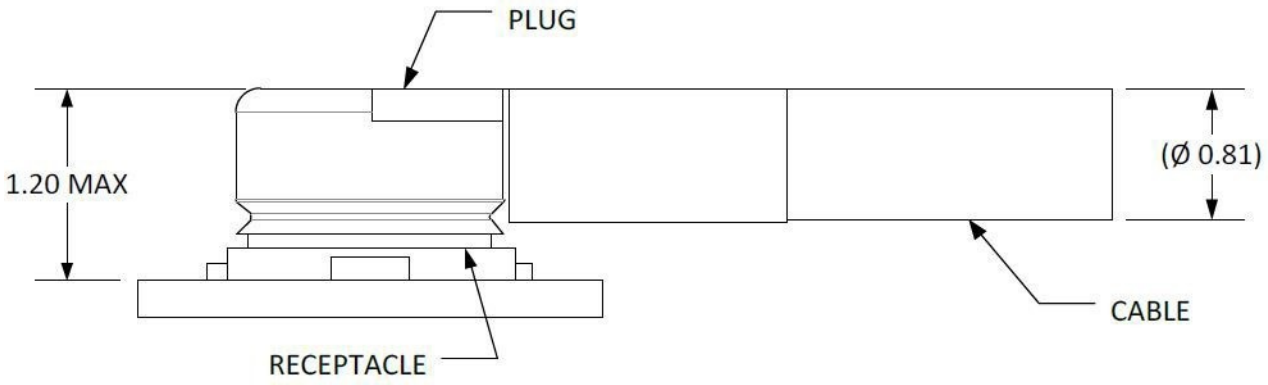



**Figure 20: Space Factor of Mated Connectors (Ø 0.81 mm Coaxial Cables) (Unit: mm)**

The following figure illustrates the connection between the receptacle mounted on the module and the mated plug using a Ø 1.13 mm coaxial cable.

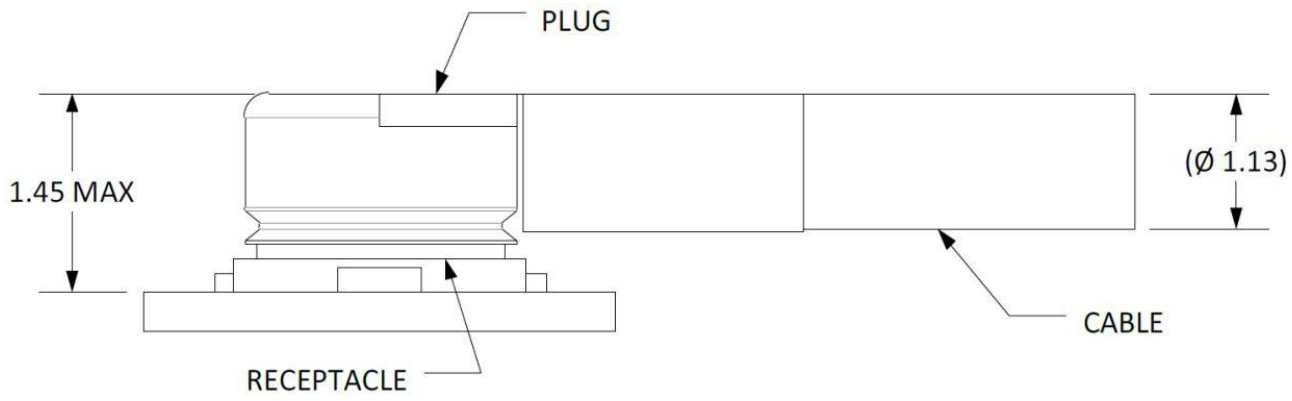



**Figure 21: Space Factor of Mated Connectors (Ø 1.13 mm Coaxial Cables) (Unit: mm)**

#### 5.2.3.3. Assemble Coaxial Cable Plug Manually

The pictures for plugging in a coaxial cable plug is shown below, θ = 90° is acceptable, while θ ≠ 90° is not.

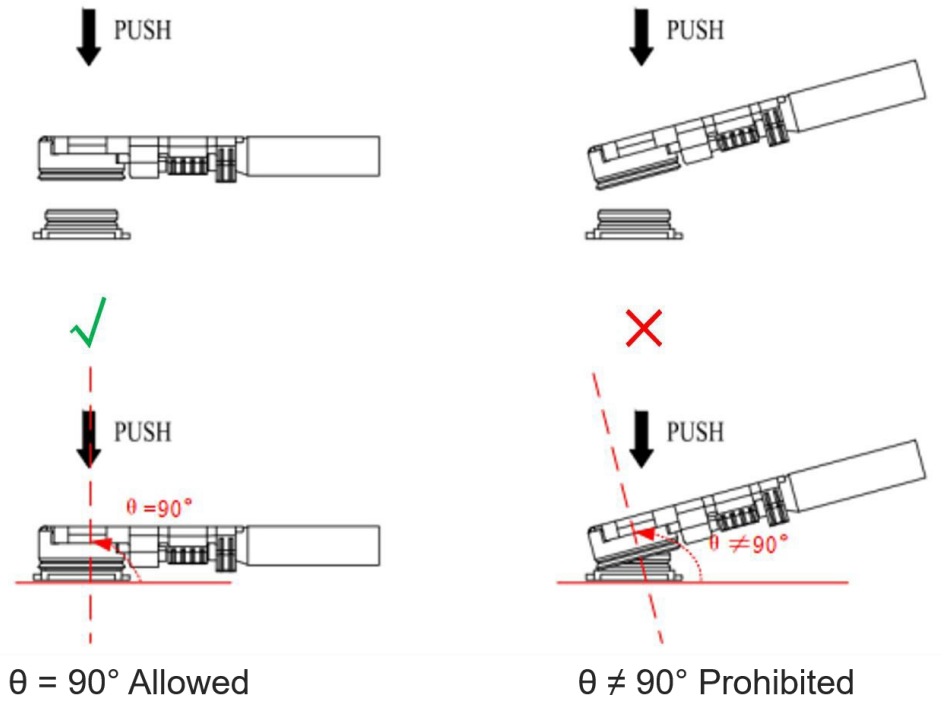



**Figure 22: Plug in a Coaxial Cable Plug**

The pictures of pulling out the coaxial cable plug is shown below, θ = 90° is acceptable, while θ ≠ 90° is not.

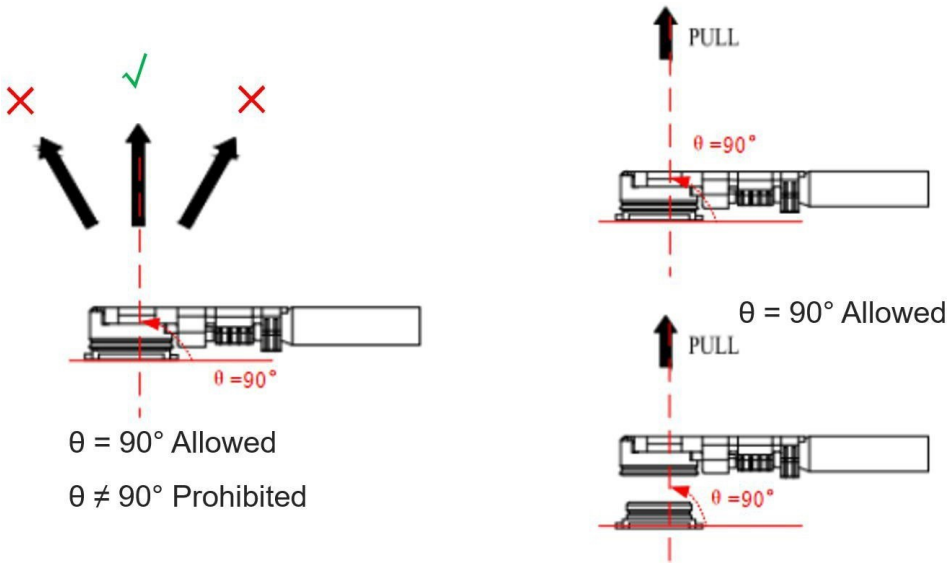



**Figure 23: Pull out a Coaxial Cable Plug**

#### 5.2.3.4. Assemble Coaxial Cable Plug with Jig

The pictures of installing the coaxial cable plug with a jig is shown below, θ = 90° is acceptable, while θ ≠ 90° is not.

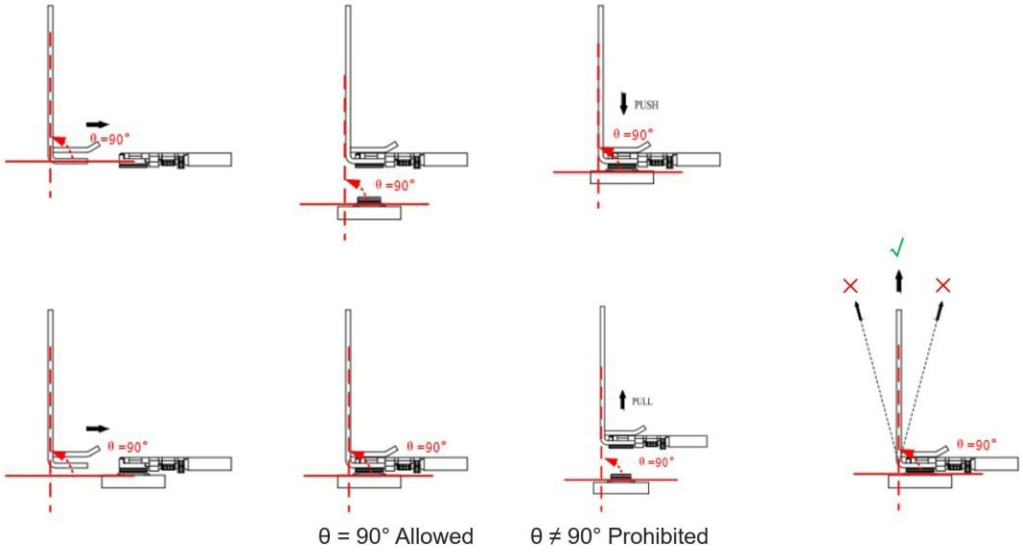



**Figure 24: Install the Coaxial Cable Plug with Jig**

#### 5.2.3.5. Recommended Mated Plug and Cable Manufacturer

Mated plugs and cables by IPEX are recommended. For more details, visit https://www.i-pex.com.

# 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 21: Absolute Maximum Ratings (Unit: V)**

| Parameter | Min. | Max. |
|---|---|---|
| VBAT | -0.3 | 4.3 |
| Voltage at Digital Pins | -0.3 | 3.3 |
| Voltage at ADC[0:3] | 0 | 3.3 |

## 6.2. Power Supply Ratings

**Table 22: 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. | 1.8 | 3.3 | 4.3 |

## 6.3. Bluetooth Power Consumption

**Table 23: Power Consumption in Low Power Modes**

| Mode | Typ. | Max. | Unit |
|---|---|---|---|
| Sleep | 6.2 | - | μA |
| Shutdown | 3.1 | - | μA |
| BLE 1 Mbps @ Tx 10 dBm | - | 21.9 | mA |
| BLE 2 Mbps @ Tx 10 dBm | - | 14.4 | mA |

## 6.4. Digital I/O Characteristics

**Table 24: VBAT I/O Characteristics (Unit: V)**

| Parameter | Description | Min. | Max. |
|---|---|---|---|
| $V_{IH}$ | High-level input voltage | 0.7 × VBAT | VBAT |
| $V_{IL}$ | Low-level input voltage | -0.3 | 0.3 × VBAT |
| $V_{OH}$ | High-level output voltage | 0.9 × VBAT | VBAT |
| $V_{OL}$ | Low-level output voltage | 0 | 0.1 × VBAT |

## 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.

**Table 25: ESD Characteristics (Unit: kV)**

| Model | Test Result | Standard |
|---|---|---|
| Human Body Model (HBM) | ±4 | *ANSI/ESDA/JEDEC JS-001-2017* |
| Charged Device Model (CDM) | ±0.5 | *ANSI/ESDA/JEDEC JS-002-2018* |

# 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

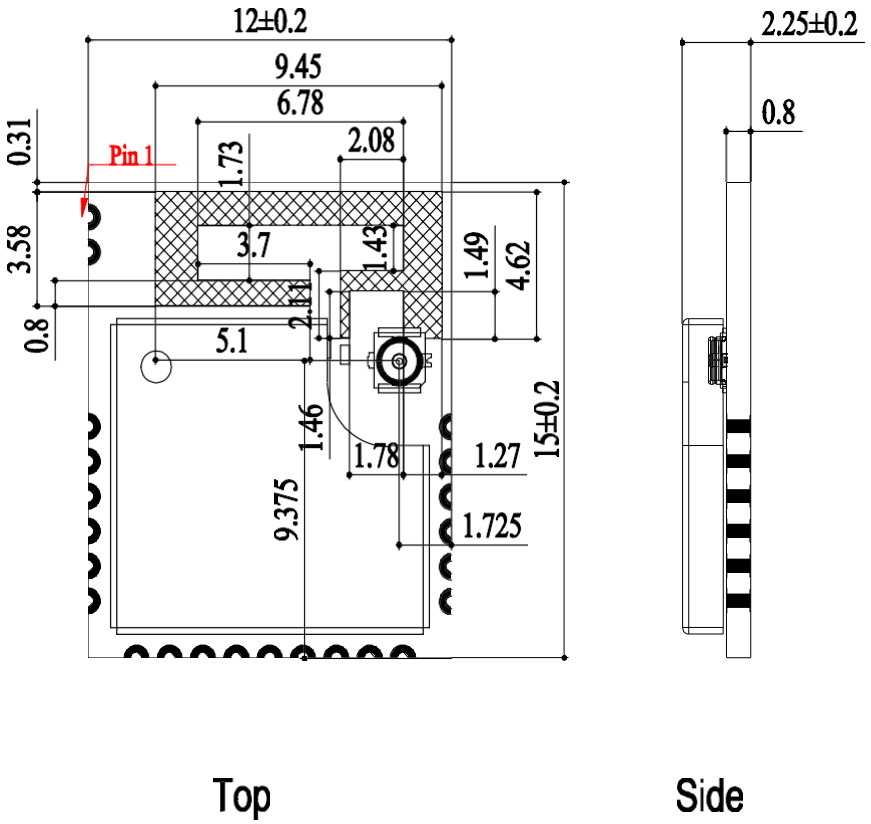



Figure 25: Top and Side Dimensions

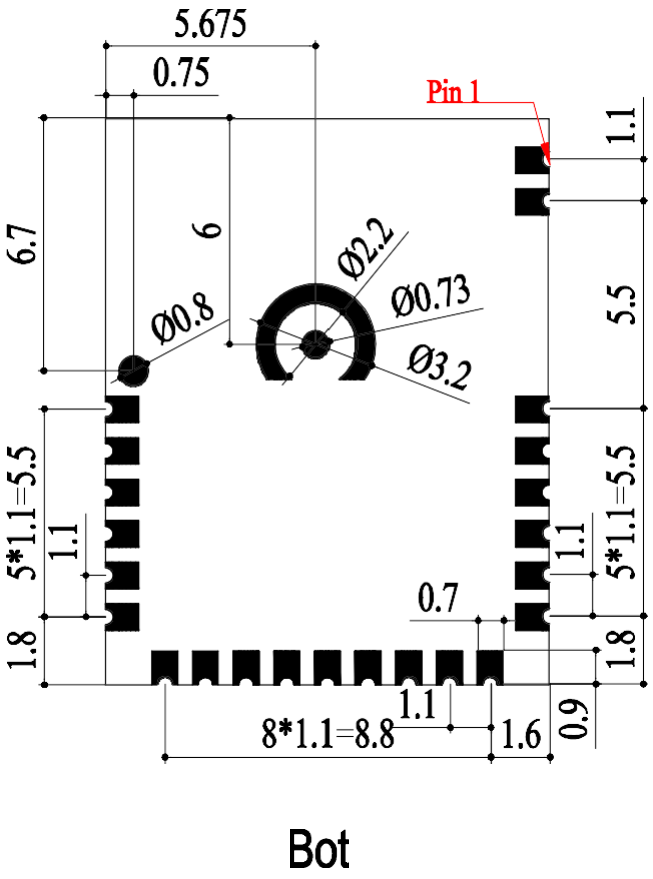



**Figure 26: Bottom Dimensions (Bottom View)**

**NOTE**

The package warpage level of the module conforms to the *JEITA ED-7306* standard.

## 7.2. Recommended Footprint

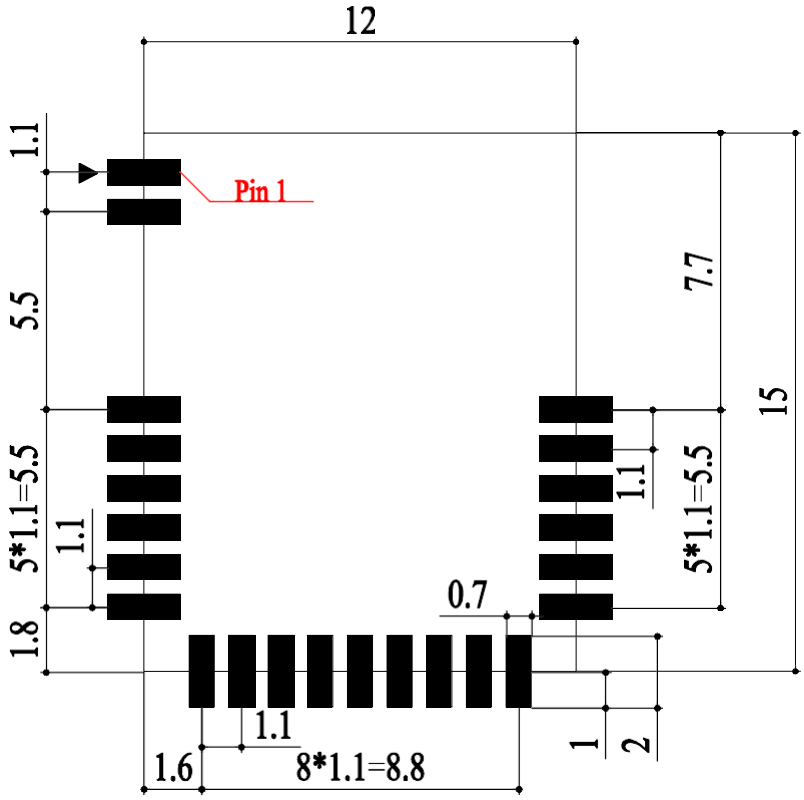



**Figure 27: Recommended Footprint**

**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

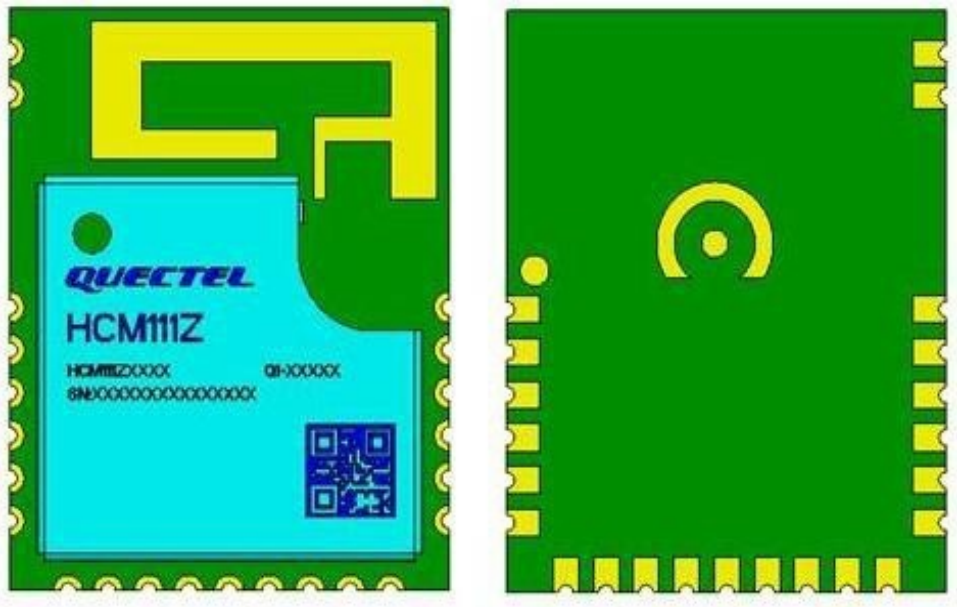



Figure 28: Top and Bottom Views (Pin Antenna Interface)

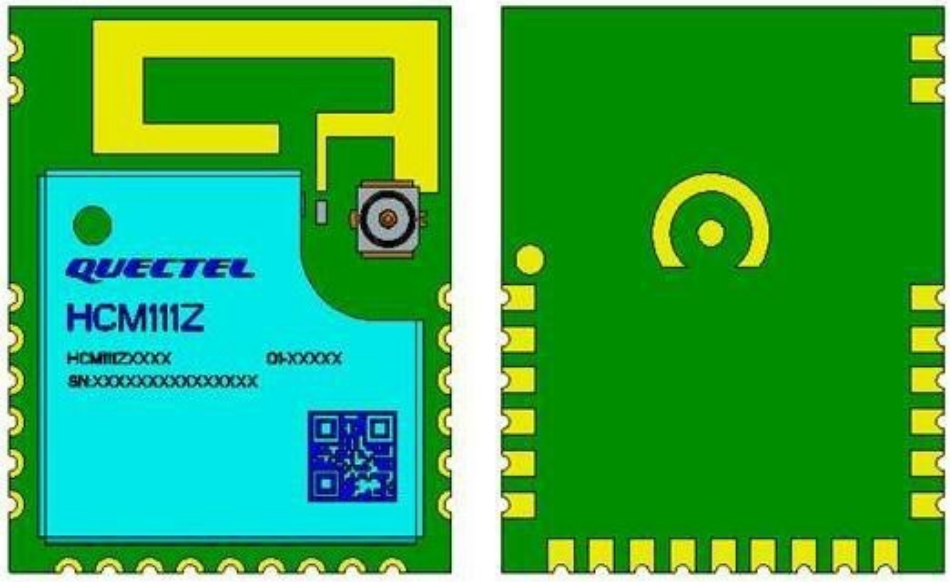



Figure 29: Top and Bottom Views (Coaxial RF Connector)

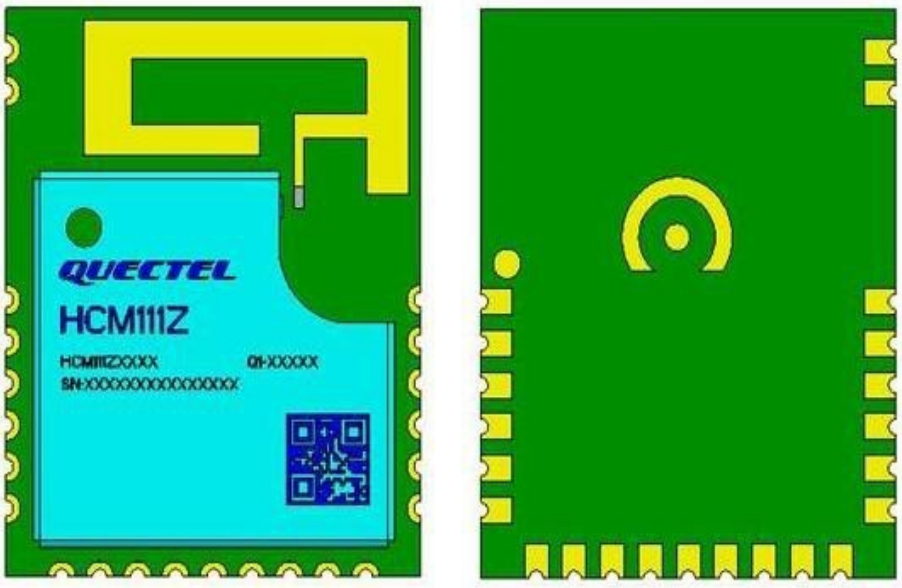



**Figure 30: Top and Bottom Views (PCB Antenna)**

**NOTE**

1. 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.
2. The coaxial RF connector is not available when the module is designed with pin antenna interface (ANT_BT) or PCB antenna.

# 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 [8] 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 8 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.

[8] 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 ºC, with 246 ºC 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.

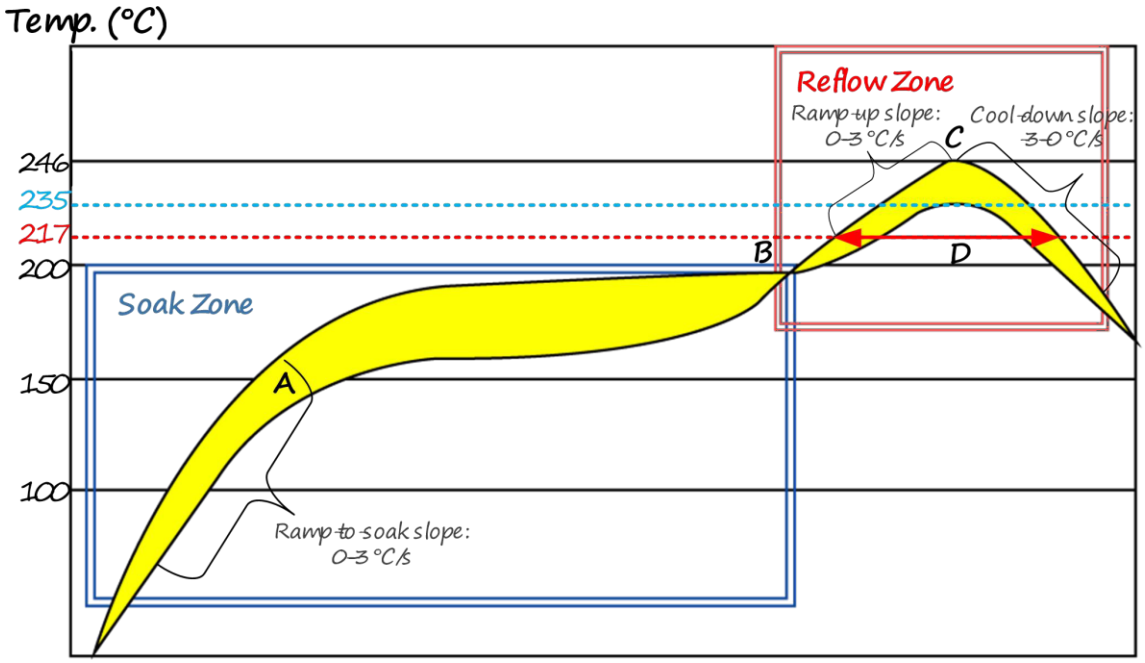



**Figure 31: Recommended Reflow Soldering Thermal Profile**

**Table 26: 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, etc. 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. 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 [3]***.

## 8.3. Packaging Specifications

This chapter describes only the key parameters and process of packaging. All figures below are for reference only. The appearance and structure of the packaging materials are subject to the actual delivery.

The module adopts carrier tape packaging and details are as follow:

### 8.3.1. Carrier Tape

Dimension details are as follow:

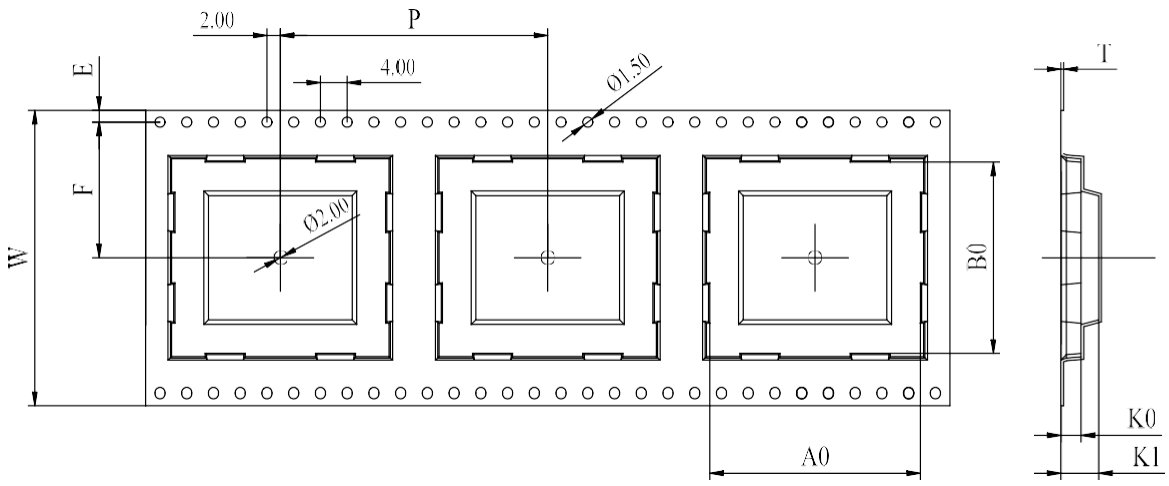



**Figure 32: Tape Specifications**

**Table 27: Carrier Tape Dimension Table (Unit: mm)**

| W | P | T | A0 | B0 | K0 | K1 | F | E |
|---|---|---|---|---|---|---|---|---|
| 32 | 24 | 0.4 | 12.4 | 15.4 | 2.75 | 4.5 | 14.2 | 1.75 |

### 8.3.2. Plastic Reel

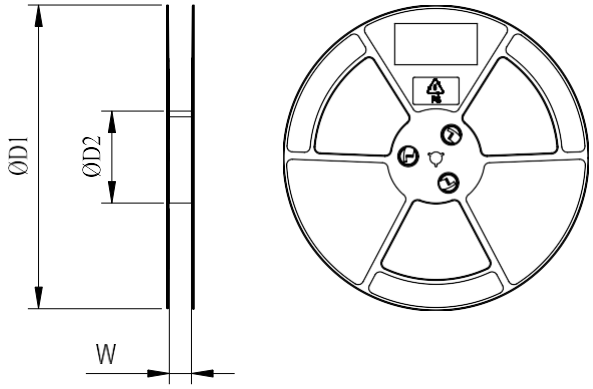



**Figure 33: Plastic Reel Dimension Drawing**

**Table 28: Plastic Reel Dimension Table (Unit: mm)**

| øD1 | øD2 | W |
|---|---|---|
| 330 | 100 | 32.5 |

### 8.3.3. Mounting Direction

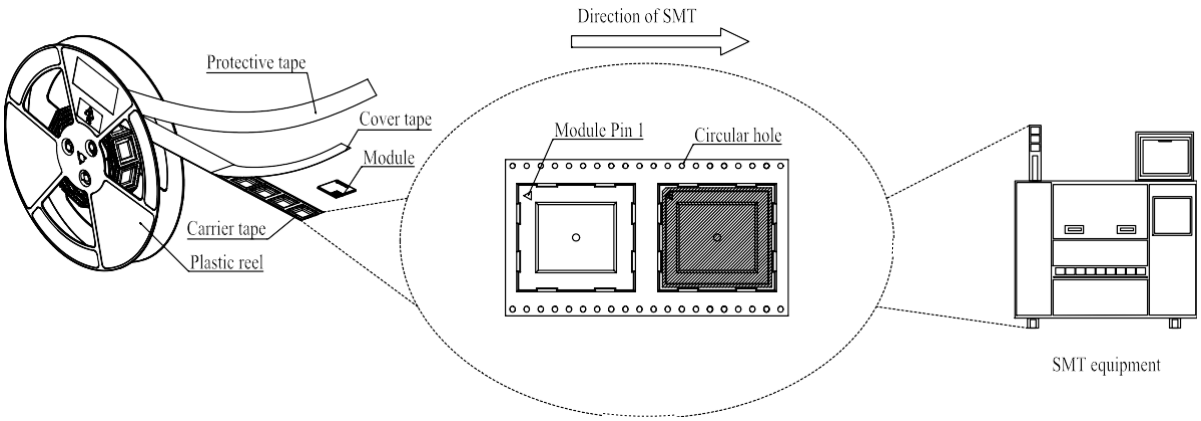
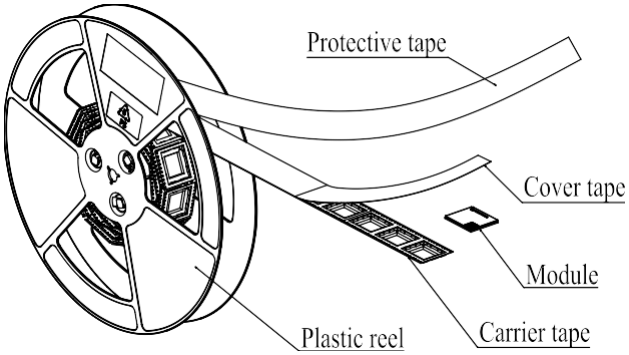


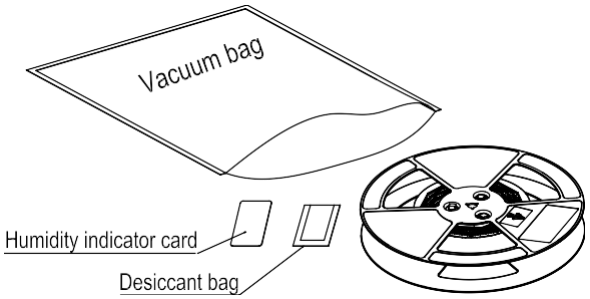

**Figure 34: Mounting Direction**

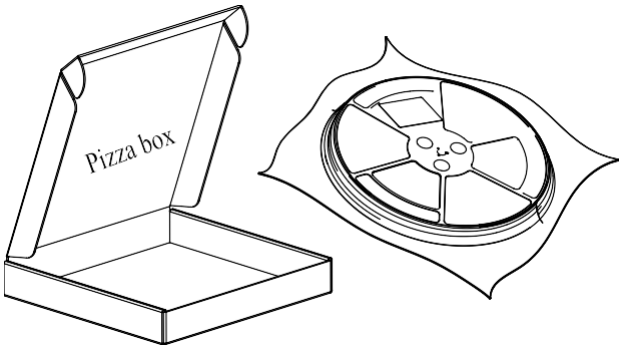
### 8.3.4. Packaging Process




Place the module into the carrier tape and use the cover tape to cover it; then wind the heat-sealed carrier tape to the plastic reel and use the protective tape for protection. 1 plastic reel can load 500 modules.

Place the packaged plastic reel, 1 humidity indicator card and 1 desiccant bag into a vacuum bag, vacuumize it.




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

Put 4 packaged pizza boxes into 1 carton box and seal it. 1 carton box can pack 2000 modules.

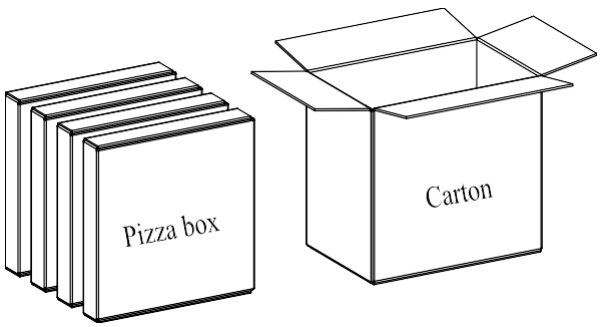



**Figure 35: Packaging Process**

# 9 Appendix References

**Table 29: Reference Documents**

| Document Name |
|---|
| [1] Quectel_HCM111Z_TE-B_User_Guide |
| [2] Quectel_RF_Layout_Application_Note |
| [3] Quectel_Module_SMT_Application_Note |

**Table 30: Terms and Abbreviations**

| Abbreviation | Description |
|---|---|
| ADC | Analog-to-Digital Converter |
| AMBA | Advanced Microcontroller Bus Architecture |
| APB | Advanced Peripheral Bus |
| ARM | Advanced RISC Machine |
| BLE | Bluetooth Low Energy |
| CDM | Charged Device Model |
| DAC | Digital-to-Analog Converter |
| DMA | Direct Memory Access |
| DSP | Digital Signal Processor |
| ESD | Electrostatic Discharge |
| EVB | Evaluation Board |
| GFSK | Gauss frequency Shift Keying |
| GND | Ground |

| | |
|---|---|
| GPIO | General-Purpose Input/Output |
| HBM | Human Body Model |
| I/O | Input/Output |
| I2C | Inter-Integrated Circuit |
| I2S | Inter-IC Sound |
| LCC | Leadless Chip Carrier (package) |
| LDO | Low-dropout Regulator |
| LED | Light Emitting Diode |
| Mbps | Million Bits Per Second |
| MCU | Microcontroller Unit |
| OTA | Over-The-Air |
| PCB | Printed Circuit Board |
| PWM | Pulse Width Modulation |
| RF | Radio Frequency |
| RoHS | Restriction of Hazardous Substances |
| SPI | Serial Peripheral Interface |
| SRAM | Static Random-Access Memory |
| SWD | Serial Wire Debug |
| TBD | To Be Determined |
| TVS | Transient Voltage Suppressor |
| UART | Universal Asynchronous Receiver/Transmitter |
| $V_{IH}$ | High-level Input Voltage |
| $V_{IL}$ | Low-level Input Voltage |
| Vmax | Maximum Voltage |
| Vmin | Minimum Voltage |

| | |
|---|---|
| Vnom | Nominal Voltage Value |
| $V_{OH}$ | High-level Output Voltage |
| $V_{OL}$ | Low-level Output Voltage |
| VSWR | Voltage Standing Wave Ratio |

**Modifications:**

Any changes or modifications not expressly approved by Quectel or the party responsible for compliance could void the user's authority to operate the equipment and invalidate the regulatory approval.

Host manufacturer must follow KDB Publication 996369 D04 Modulen Integration Guide.

Host manufacturer is responsible for regression tests to show compliance to the applicable standards due to the following actions:

1. any modification done to the module.
2. Integration of the module into a host device

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.

Final host product is required to show compliance to Part 15 Subpart B with the modular transmitter installed

**Product Marketing Name：Quectel HCM111Z**

FCC Certification Requirements.

According to the definition of mobile and fixed device is described in Part 2.1091(b), this device is a mobile device.

This device has been tested in accordance with FCC Part 15.247.

For more detailed test mode configuration, OEM can contact manufacture for specific instruction.

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based timeaveraging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.
2. The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body and must not transmit simultaneously with any other antenna or transmitter.
3. A label with the following statements must be attached to the host end product:

This device contains FCC ID: XMR2023HCM111Z

**4. Antenna Requirements:**

- The following antennae were approved with the modules:

| Operating Band | Frequency (MHz) | Antenna Gain (dBi) |
|---|---|---|
| Bluetooth | 2400~2483.5 | -3.70 dBi |

- The product is provided with an approved antenna. Use only supplied or approved antenna by Quectel. Any changes or modifications to the Antenna may void the regulatory approvals obtained for the product.
- Host device must comply with FCC Part 15 antenna requirements
- The OEM must design the host so that the antenna will be installed as an integrated antenna for the host containing the HCM111Z and the end user shall not be able to access, remove or replace the antenna.

5. This module must not transmit simultaneously with any other antenna or transmitter
6. The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093

If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.

For this device, OEM integrators must be provided with labeling instructions of finished products.

Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

A certified modular has the option to use a permanently affixed label, or an electronic label. For a permanently affixed label, the module must be labeled with an FCC ID - Section 2.926 (see 2.2 Certification (labeling

requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labeling requirements, options and OEM user manual instructions that are required (see next paragraph).
For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module: "Contains Transmitter Module FCC ID: XMR2023HCM111Z" or "Contains FCC ID: XMR2023HCM111Z" must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.
The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.
The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.
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 manufacturer could void the user's authority to operate the equipment.
To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Supplier's Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that the after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.

**Manual Information To the End User**

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 show in this manual.

### IC Statement

IRSS-GEN
"This device complies with Industry Canada's licence-exempt RSSs. 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." or "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; 2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."
Déclaration sur l'exposition aux rayonnements RF
L'autre utilisé pour l'émetteur doit être installé pour fournir une distance de séparation d'au moins 20 cm de toutes les personnes et ne doit pas être colocalisé ou fonctionner conjointement avec une autre antenne ou un autre émetteur.
The host product shall be properly labeled to identify the modules within the host product.
The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labeled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word "Contains" or similar wording expressing the same meaning, as follows:
"Contains IC: 10224A-2023HCM111Z" or "where: 10224A-2023HCM111Z is the module's certification number".
Le produit hôte doit être correctement étiqueté pour identifier les modules dans le produit hôte.
L'étiquette de certification d'Innovation, Sciences et Développement économique Canada d'un module doit être clairement visible en tout temps lorsqu'il est installédans le produit hôte; sinon, le produit hôte doit porter une étiquette indiquant le numéro de certification d'Innovation, Sciences et Développement économique Canada pour le module, précédé du mot «Contient» ou d'un libellé semblable exprimant la même signification, comme suit:
"Contient IC: 10224A-2023HCM111Z " ou "où: 10224A-2023HCM111Z est le numéro de certification du module".