HLM311Z 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 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 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 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.
SOS	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 phones 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
-	2023-07-19	Janson CHEN/ Vic CHENG	Creation of the document
1.0.0	2023-07-19	Janson CHEN/ Vic CHENG	Preliminary

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1 Introduction

This document defines HLM311Z 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.

2 Product Overview

HLM311Z is a power-optimized system-on-chip (SoC) solution 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 UART for Bluetooth applications.

It is a 4-pin DIP 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

HLM311Z	
Packaging type	DIP
Pin counts	4
Dimensions	(10.16 ±0.38) mm × (18 ±0.2) mm × (8.5 ±0.4) mm
Weight	Approx. 0.82 g

2.1. Key Features

Table 3: Key Features

Basic Information		
Protocol and Standard	● Bluetooth protocol: BLE 5.0 ● All hardware components are fully compliant with EU RoHS directive	
Power Supply	**VBAT Power Supply:** ● 1.8–4.3 V ● Typ.: 3.3 V	
Temperature Ranges	● Operating temperature [1]: -40 to +85 °C ● Storage temperature: -45 to +95 °C	
RF Antenna		
RF Antenna	● PCB antenna ● 50 Ω characteristic impedance	
Application Interface		
Application Interface	UART	

---

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

2.2. Functional Diagram

The main components of the block diagram are explained below.

Main chip
Radio frequency
Peripheral interfaces

3 Application Interfaces

3.1. Pin/Test Point Assignment
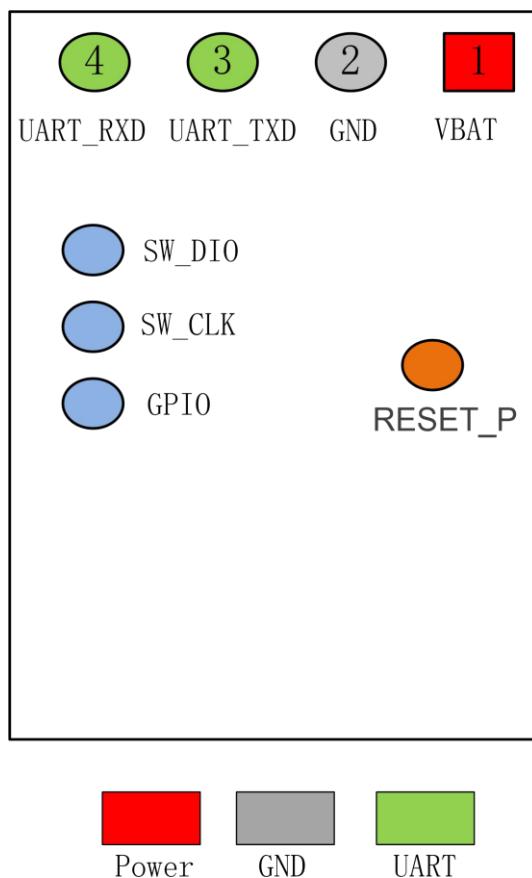
Figure 2: Pin/Test Point Assignment (Top View)

> **NOTE**
>
> The pins RESET_P, GPIO, SW_CLK, SW_DIO are all test points for debugging.

3.2. Pin/Test Point Description

Table 4: I/O Parameter Description

Type	Description
DI	Digital Input
DO	Digital Output
DIO	Digital Input/Output
PI	Power Input

DC characteristics include power domain and rated current.

Table 5: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	1	PI	Power supply for the module	Vmin = 1.8 V Vnom = 3.3 V Vmax = 4.3 V	The power supply must be provided with sufficient current of more than 100mA.
GND	2				
UART					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
UART_TXD	3	DO	UART transmit	VBAT	
UART_RXD	4	DI	UART receive		

Table 6: Test Point Description

SWD Interface				
TP Name	**I/O**	**Description**	**DC Characteristics**	**Comment**

SW_DIO	DIO	Serial wire input/output	VBAT	Used for debug only.
SW_CLK	DI	Serial wire clock		

GPIO Interface				
TP Name	**I/O**	**Description**	**DC Characteristics**	**Comment**
GPIO	DIO	General-purpose input/output	VBAT	Interrupt wakeup. Used for debug only.
Reset				
TP Name	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESET_P	DI	Reset the module	VBAT	Hardware enable. Active high. Used for debug only.

3.3. Application Interface

3.3.1. UART

The module supports 1 UART with self-configurable baud rate. It can be used for AT communication and data transmission at baud rate of 38400 bps, and used for firmware upgrading at baud rate of 115200 bps.

Table 7: Pin Definition of UART

Pin Name	Pin No.	I/O	Description
UART_TXD	3	DO	UART transmit
UART_RXD	4	DI	UART receive

The UART connection between the module and MCU is illustrated below.
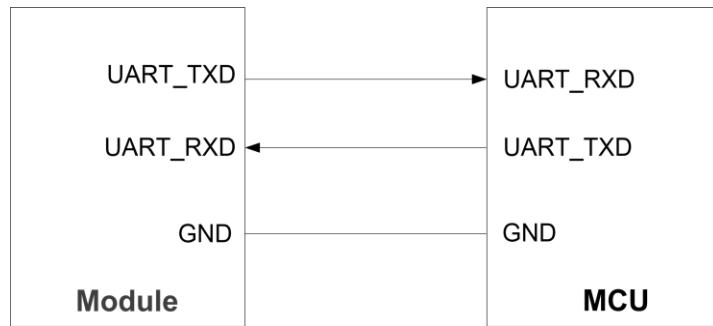
Figure 3: UART0 Connection

The UART can be used as debug UART for outputting partial logs with debugging tools and supports 115200 bps baud rate by default. The following is a reference design for debug UART.
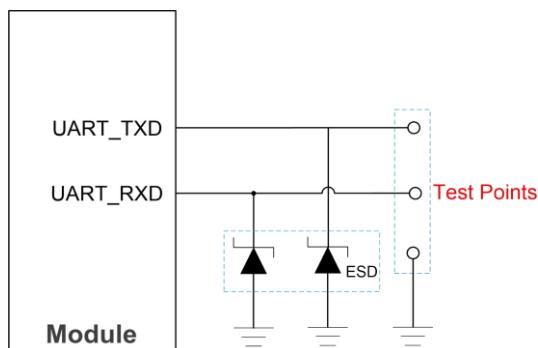

Figure 4: Debug UART Reference Circuit

4 Operating Characteristics

4.1. Power Supply

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

Table 8: Pin Definition of Power Supply and GND Pins

Pin Name	Pin No.	I/O	Description	Min.	Typ.	Max.	Unit
VBAT	1	PI	Power supply for the module	1.8	3.3	4.3	V
GND	2						

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 100 mA 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:
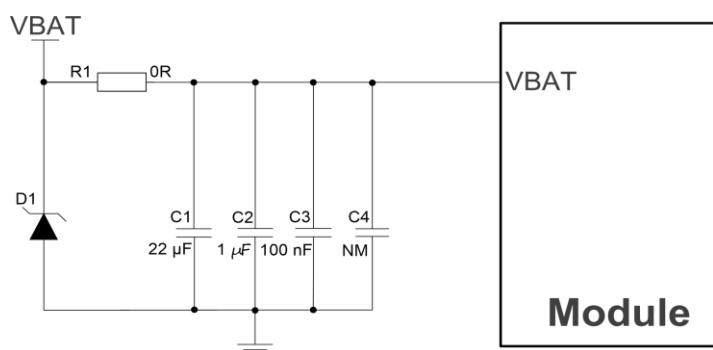
Figure 5: VBAT Reference Circuit

4.2. Turn On

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

The turn-on timing is shown below:
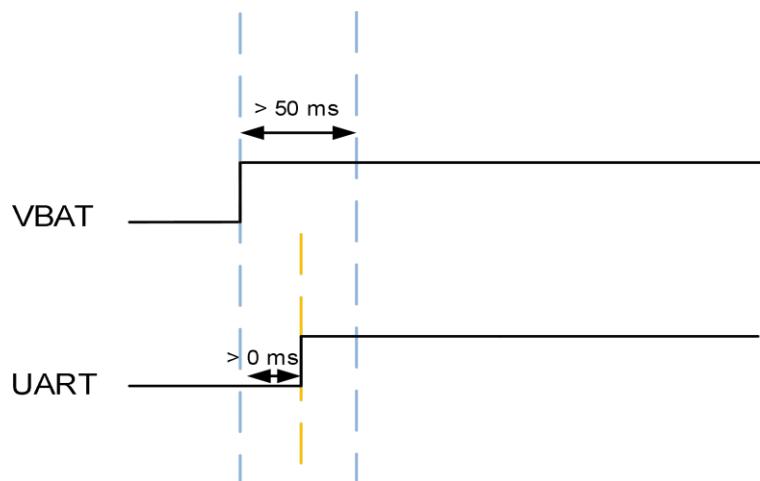
Figure 6: Turn-on Timing

4.3. Reset

Pull the RESET_P up for at least 50 ms and then release it to reset the module. The module reset timing is illustrated in the following figure.
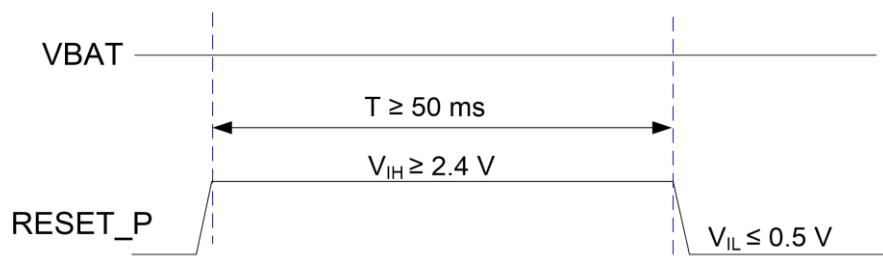
Figure 7: Reset Timing

4.4. Download Mode

Keep the RESET_P at high level during resetting or power-up and the module will enter download mode. In the download mode, the firmware can be download through the UART.

5 RF Performances

5.1. Bluetooth Performances

Table 9: 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)	7.5	-95
BLE (2 Mbps)	7.5	-90

5.2. PCB Antenna

The module is provided with PCB antenna. 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.

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
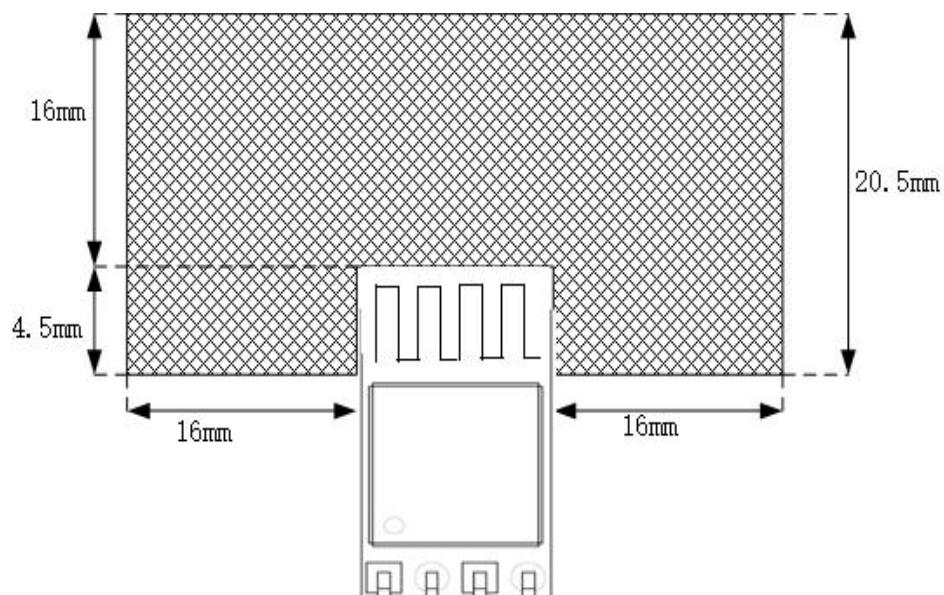
Figure 8: Keepout Area on Motherboard

6 Electrical Characteristics & Reliability

6.1. Absolute Maximum Ratings

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

Table 10: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VBAT	-0.3	4.3
Voltage at Digital Pins	-0.3	3.3

6.2. Power Supply Ratings

Table 11: 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 12: Power Consumption in Low Power Modes

Mode	Typ.	Max.	Unit
Sleep	6.2	-	µA
Shutdown	3.1	-	µA
BLE Tx @ 0 dBm	-	13.4	mA
BLE Rx	-	17.6	mA

6.4. Digital I/O Characteristics

Table 13: 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 14: 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
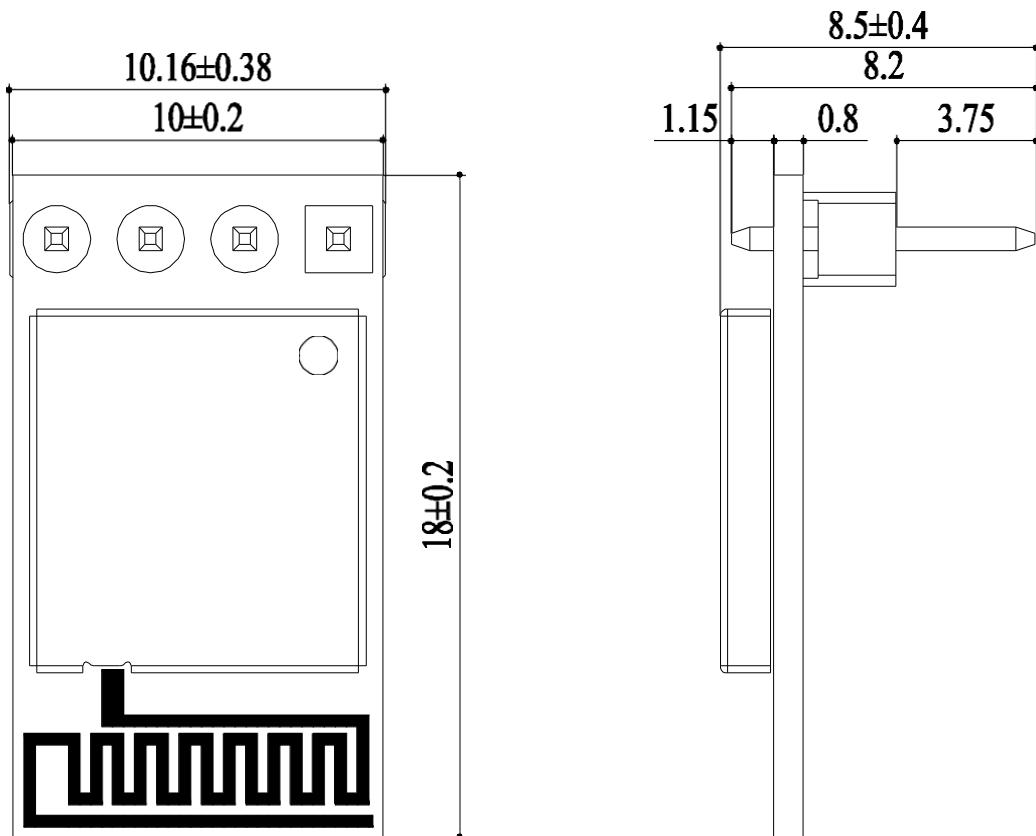
Figure 9: Top and Side Dimensions
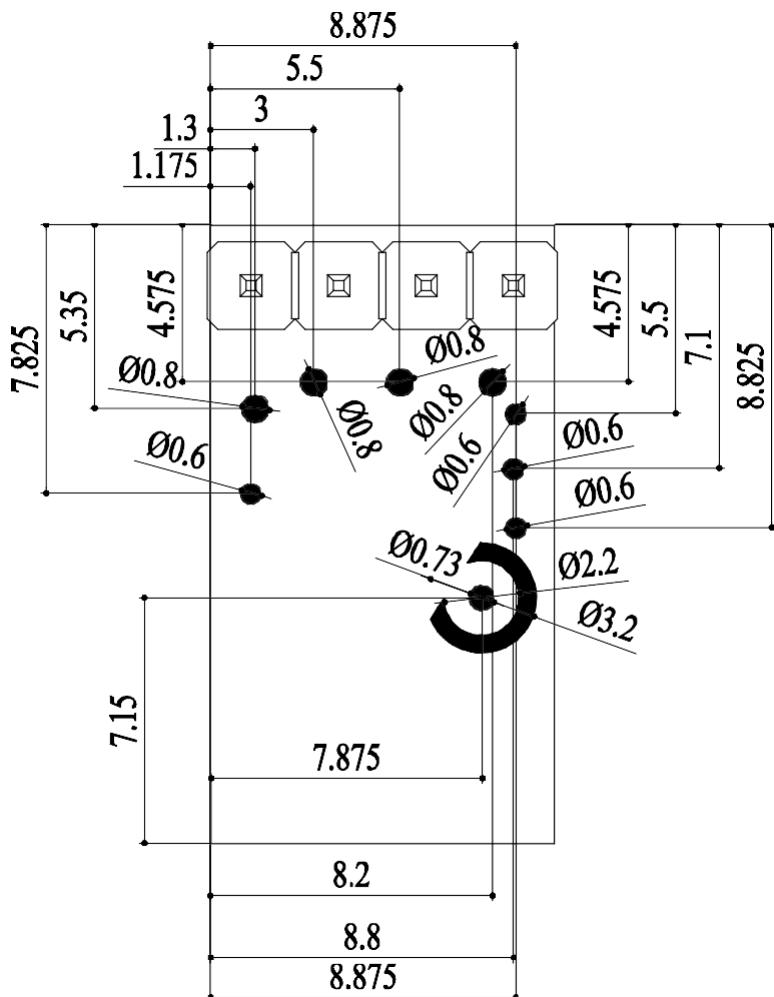
Figure 10: Bottom Dimensions (Bottom View)

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

## 7.2. Top and Bottom Views
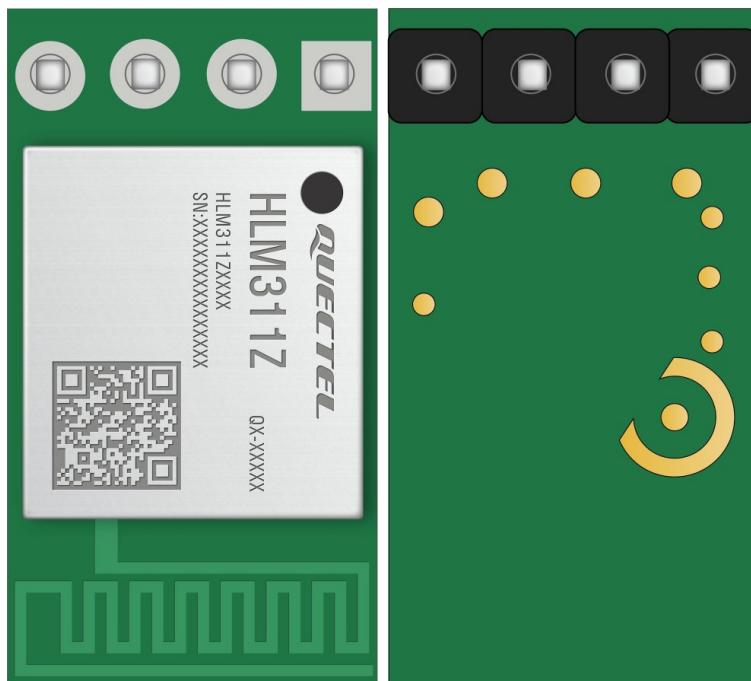
Figure 11: Top and Bottom Views (Pin Antenna Interface)

> **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 [2] 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.

---

[2] 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 [1]**.

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.
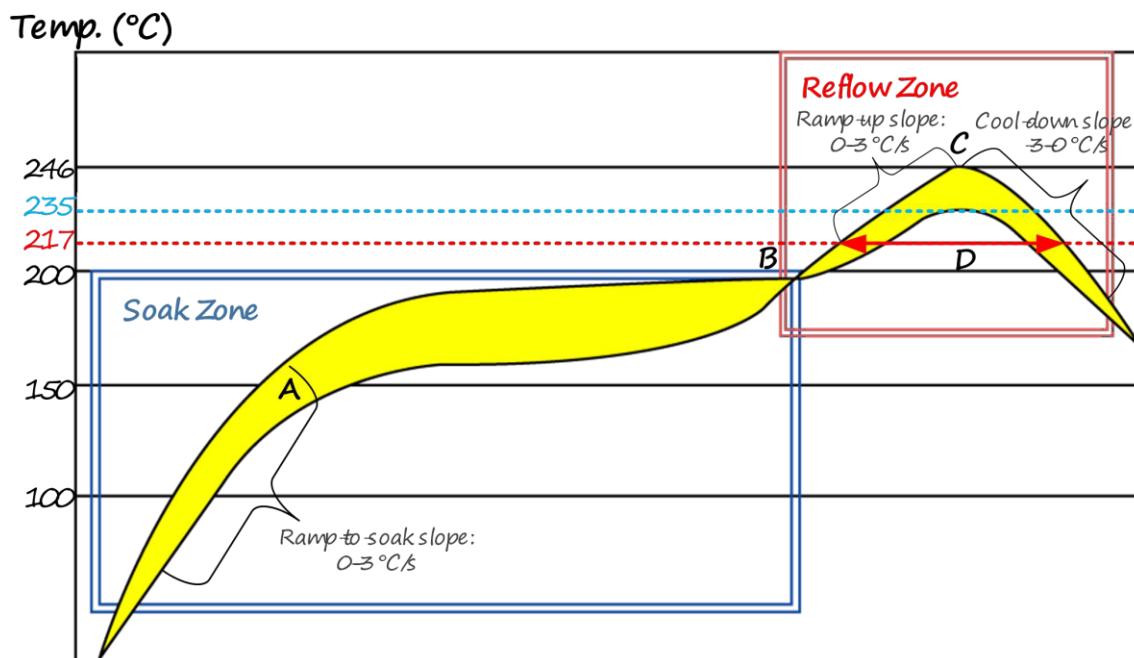

Figure 12: Recommended Reflow Soldering Thermal Profile

Table 15: 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 [1]*.

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:
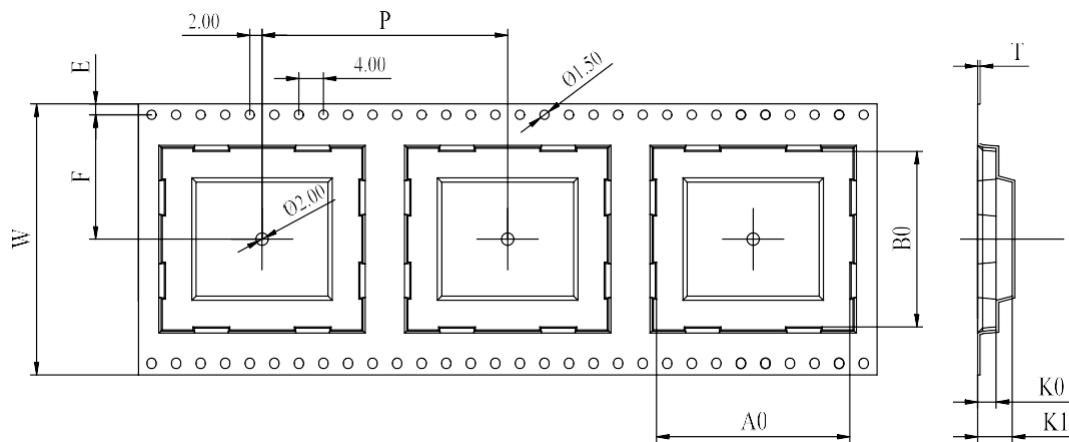
**Figure 13: Tape Specifications**

Table 16: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
32	24	0.5	18.4	10.4	2.75	9.5	14.2	1.75

8.3.2. Plastic Reel
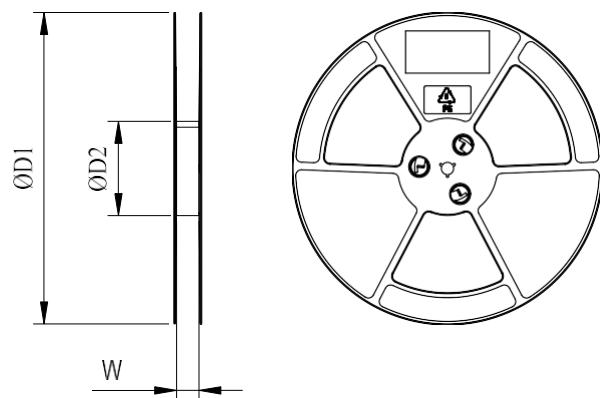
Figure 14: Plastic Reel Dimension Drawing

Table 17: Plastic Reel Dimension Table (Unit: mm)

| øD1	øD2	W
330	100	32.5

8.3.3. Mounting Direction
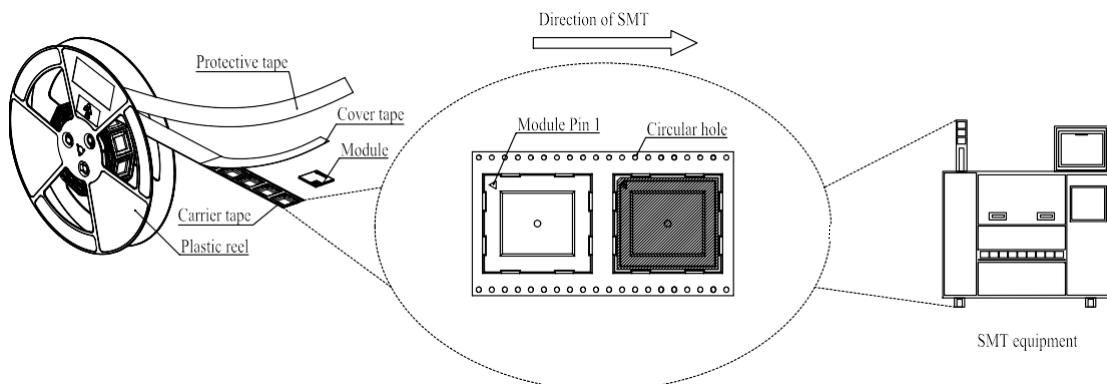
Figure 15: Mounting Direction

8.3.4. Packaging Process
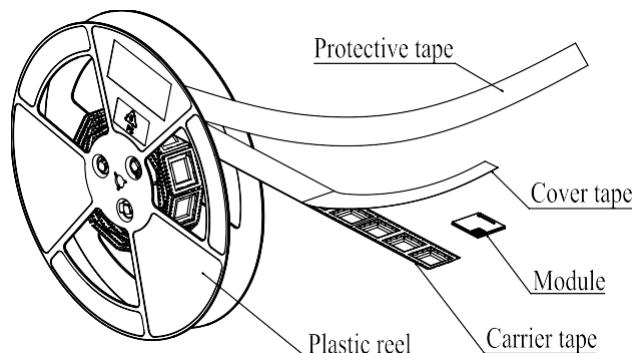
Place the module into the carrier tape and use the cover tape to cover it; then wind the heat-sealed carrier tape to the plastic reel and use the protective tape for protection. 1 plastic reel can load 250 modules.

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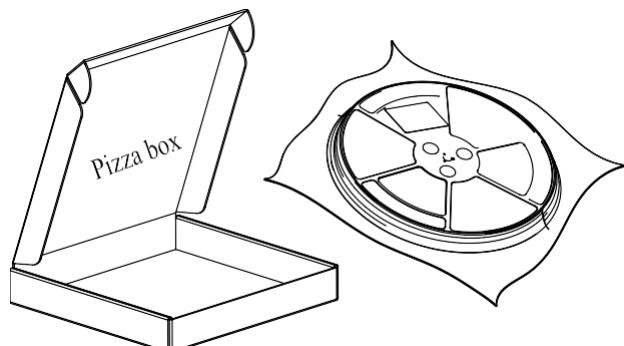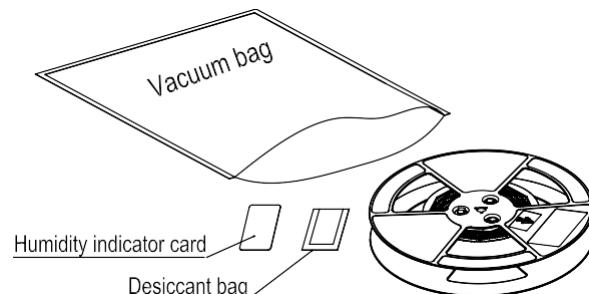
Place the vacuum-packed plastic reel into the pizza box.

Put 4 packaged pizza boxes into 1 carton box and seal it. 1 carton box can pack 1000 modules.
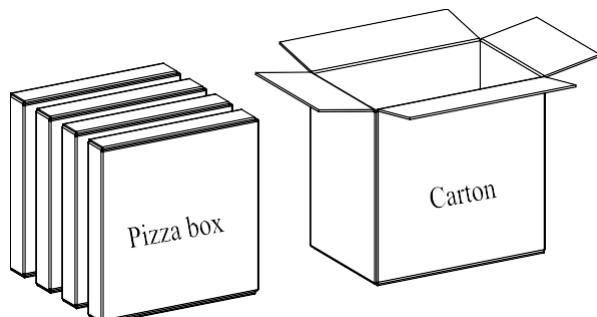
Figure 16: Packaging Process

9 Appendix References

Table 18: Reference Documents

Document Name
[1]   Quectel_Module_SMT_Application_Note

Table 19: Terms and Abbreviations

Abbreviation	Description
ARM	Advanced RISC Machine
BLE	Bluetooth Low Energy
CDM	Charged Device Model
DIP	Dual In-line Package
ESD	Electrostatic Discharge
GFSK	Gauss frequency Shift Keying
GND	Ground
GPIO	General-Purpose Input/Output
HBM	Human Body Model
I/O	Input/Output
Mbps	Million Bits Per Second
MCU	Microcontroller Unit
OTA	Over-The-Air
PCB	Printed Circuit Board

RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
SoC	System on Chip
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 HLM311Z

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.

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: XMR2023HLM311Z

4. Antenna Requirements:

• The following antennae were approved with the modules:

Operating Band	Frequency (MHz)	Antenna Gain (dBi)
Bluetooth	2400~2483.5	0.47 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 HLM311Z 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: XMR2023HLM311Z" or "Contains FCC ID: XMR2023HLM311Z" 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-2023HLM311Z" or "where: 10224A-2023HLM311Z 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-2023HLM311Z " ou "où: 10224A-2023HLM311Z est le numéro de certification du module".