

FGH200M Hardware Design

Short-Range Products

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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 given 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

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1 Introduction

This document defines the FGH200M and describes its air interfaces and hardware interfaces which are connected with your applications. With this document, you can quickly understand module interface specifications, RF performance, electrical and mechanical details, as well as other related information of the module.

1.1. Special Mark

Table 1: Special Mark

Mark	Definition
[...]	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

FGH200M is a long-range and low-power Wi-Fi HaLow module compliant with IEEE 802.11ah Wi-Fi standard. It operates in Sub-1 GHz frequency band, features 43.3 Mbps maximum transmission rate ¹ and provides an SDIO 2.0 and a USB 2.0 interface for Wi-Fi application, and a JTAG interface for module testing.

It is an SMD module with compact packaging. Related information is listed in the table below:

Table 2: Basic Information

FGH100M	
Packaging type	LGA
Pin counts	38
Dimensions	(10.0 +0.3/-0.15) mm × (11.0 +0.3/-0.15) mm × (2.0 ±0.2) mm
Weight	Approx. 0.51 g

¹ Optional. Different models of the module correspond to different maximum physical layer transmission rates. For details, please consult Quectel Technical Support.

2.1. Key Features

Table 3: Key Features

Basic Information	
Protocol and Standards	● Wi-Fi Protocol: IEEE 802.11ah ● All hardware components are fully compliant with EU RoHS directive
Power Supplies	VBAT Power Supply:
	● 3.0–3.6 V ● Typ.: 3.3 V
	VBAT_TX Power Supply:
	● 3.0–3.6 V ● Typ.: 3.3 V
	VDD_USB Power Supply:
	● 3.0–3.6 V ● Typ.: 3.3 V
	VDD_IO Power Supply ²:
	● 2.25–3.6 V ● Typ.: 3.3 V
Temperature Ranges	● Normal operating temperature: -40 °C to +85 °C ³
	● Storage temperature: -45 °C to +95 °C
EVB Kit	FGH200M-M.2, RK3568-WF EVB ⁴
RF Antenna Interface	
Antenna Interface	● ANT_WIFI
	● 50 Ω characteristic impedance
Application Interface	
Application Interfaces	SDIO 2.0/SPI, USB 2.0

² The VDD_IO power supply should not exceed VBAT.

³ To meet the normal operating temperature range requirements, it is necessary to ensure effective thermal dissipation, e.g., by adding passive or active heatsinks, heat pipes, vapor chambers, etc. Within this range, the module's indicators comply with IEEE requirements.

3 RF Specifications

3.1. Wi-Fi Performances

Table 4: Wi-Fi Performances

Operating Frequency			
Sub-1 GHz: 850–950 MHz			
Modulation			
OFDM, BPSK, QPSK, 16QAM, 64QAM, 256QAM			
Operating Mode			
- AP - STA			
Encryption Mode			
AES, SHA-256, SHA-384, SHA-512, WPA3, OWE			
Transmission Data Rate			
1 MHz: MCS 0–MCS 9, MCS 10 2 MHz: MCS 0–MCS 8 4 MHz: MCS 0–MCS 9 8 MHz: MCS 0–MCS 9			
Condition (VBAT = 3.3 V, VBAT_TX = 3.3 V, VDD_USB = 3.3 V, VDD_IO = 3.3 V; EVM Temp. = 25 °C)		Typ.; Unit: dBm; Tolerance: ±2 dB	
		Transmit Power	Receiver Sensitivity
Sub-1 GHz	802.11ah, 1 MHz @ MCS 0, BPSK	TBD	TBD
	802.11ah, 2 MHz @ MCS 0, BPSK	TBD	TBD
	802.11ah, 4 MHz @ MCS 0, BPSK	TBD	TBD
	802.11ah, 8 MHz @ MCS 0, BPSK	TBD	TBD

BPSK				
802.11ah, 1 MHz @ MCS 9, 256QAM	≤ -32 dB	TBD		TBD
802.11ah, 2 MHz @ MCS 8, 256QAM	≤ -30 dB	TBD		TBD
802.11ah, 4 MHz @ MCS 9, 256QAM	≤ -32 dB	TBD		TBD
802.11ah, 8 MHz @ MCS 9, 256QAM	≤ -32 dB	TBD		TBD
802.11ah, 1 MHz @ MCS 10, 1024QAM	≤ -5 dB	TBD		TBD

NOTE

The module supports the above frequency bands in hardware, but actual applications may be subject to local regulations.

4 Application Interface

4.1. Pin Assignment

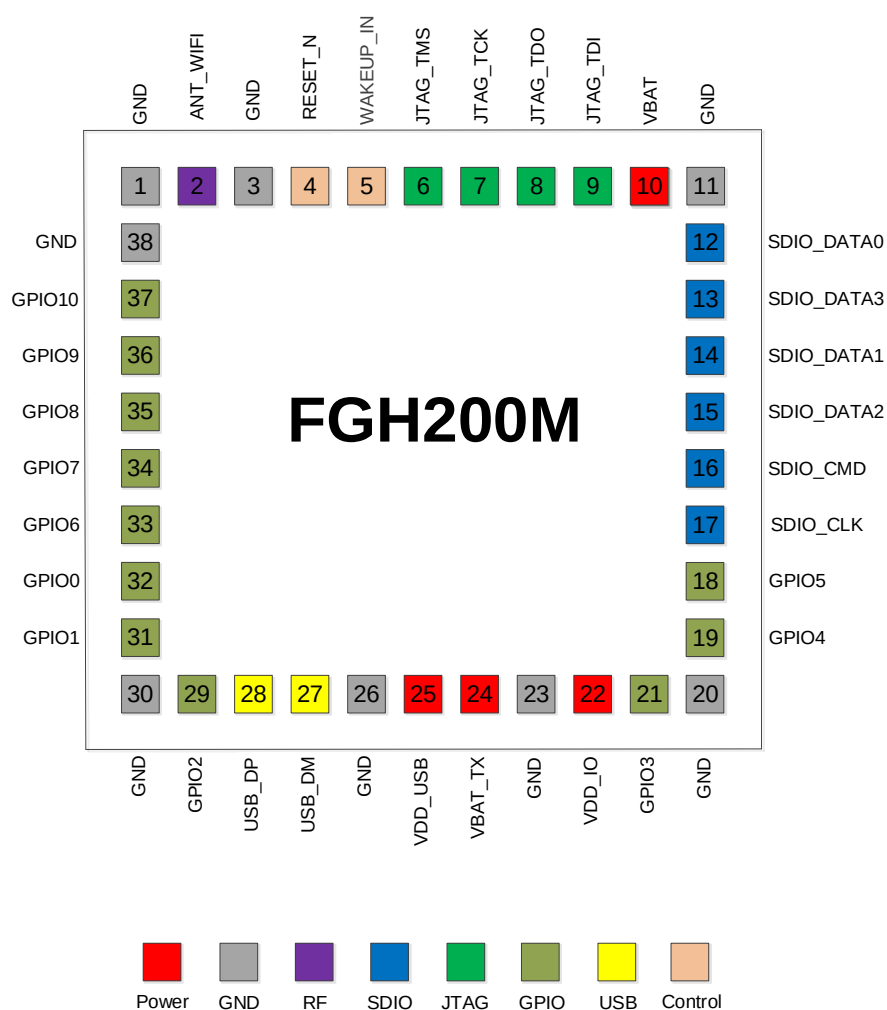


Figure 1: Pin Assignment (Top View)

NOTE

1. All GND pins should be connected to ground.
2. Keep all unused GPIO pins (GPIO0–GPIO10) pulled down to GND via 10 kΩ resistors.
3. All unused digital I/O pins must be pulled up or down to ensure they are connected, otherwise more leakage current in VDD_IO power supply will be generated.
4. Ensure that there is no current sink on the module's pins before the module turns on.

4.2. Pin Definitions

Table 5: Parameter Definition

Parameter	Description
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.

Table 6: Pin Description

Power Supply and GND Pins					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
VBAT	10	PI	Power supply for the module	Vmax = 3.6 V Vmin = 3.0 V Vnom = 3.3 V	It should be provided with sufficient current of at least 0.5 A.
VDD_IO	22	PI	Power supply for the module's I/O pins	Vmax = 3.6 V Vmin = 3.0 V Vnom = 3.3 V	
VBAT_TX	24	PI	Power supply for RF	Vmax = 3.6 V Vmin = 3.0 V	It should be provided with sufficient current of at least

				Vnom = 3.3 V	1.0 A.
VDD_USB	25	PI	Power supply for the USB interface	Vmax = 3.6 V Vmin = 3.0 V Vnom = 3.3 V	
GND	1, 3, 11, 20, 23, 26, 30, 38				Connect these pins to ground.

Wi-Fi Application Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
SDIO_CLK	17	DI	SDIO clock SPI clock	VDD_IO	SDIO 2.0 compliant. SDIO mode: Require differential impedance of 50 Ω. SPI mode (Slave mode only): Switch to SPI mode by controlling SDIO_DATA3 and SDIO_CMD. For details, please consult Quectel Technical Support.
SDIO_CMD	16	DIO	SDIO command		
		DI	SPI master-out slave-in		
SDIO_DATA0	12	DIO	SDIO data bit 0		
		DO	SPI master-in slave-out		
SDIO_DATA1	14	DIO	SDIO data bit 1		
		DI	SPI interrupt		
SDIO_DATA3	13	DIO	SDIO data bit 3		
		DI	SPI chip select		
SDIO_DATA2	15	DIO	SDIO data bit 2 -		Pulled up to VDD_IO via a 47 kΩ resistor in SPI mode.

JTAG Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
JTAG_TDO	8	DO	JTAG test data output	VDD_IO	Externally pulled down to GND with 10 kΩ resistors.
JTAG_TMS	6	DI	JTAG test mode select		
JTAG_TDI	9	DI	JTAG test data input		
JTAG_TCK	7	DI	JTAG test clock		

GPIO Interfaces					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
GPIO0	32	DIO	General-purpose input/output	VDD_IO	If unused, pull them down to GND with 10 kΩ resistors.
GPIO1	31	DIO	General-purpose input/output		
GPIO2	29	DIO	General-purpose input/output		
GPIO3	21	DIO	General-purpose input/output		
GPIO4	19	DIO	General-purpose input/output		
GPIO5	18	DIO	General-purpose input/output		
GPIO6	33	DIO	General-purpose input/output		
GPIO7	34	DIO	General-purpose input/output		
GPIO8	35	DIO	General-purpose input/output		
GPIO9	36	DIO	General-purpose input/output		
GPIO10	37	DIO	General-purpose input/output		
RF Antenna Interface					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
ANT_WIFI	2	AIO	Wi-Fi antenna interface		50 Ω characteristic impedance.
Control Signals					
Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
WAKEUP_IN	5	DI	Wake up the module	VDD_IO	If power-saving mode is not used, pull it up to VDD_IO through a 10 kΩ resistor.
RESET_N	4	DI	Reset the module		Active low.

NOTE

To reduce the probability of module damage and extend module service life, do not power up and down frequently.

4.3. Reference Design for Power Supply

The module is powered by VBAT, VBAT_TX, VDD_USB, and VDD_IO, and it is recommended to use a power supply chip that provides at least 0.5 A to ensure sufficient current. For better power supply performance, it is recommended to parallel a 10 μ F decoupling capacitor and 100 nF filter capacitor near VBAT, VBAT_TX, and VDD_USB. C3, C6, and C9 are reserved for debugging and not mounted by default. In addition, it is recommended to add a TVS near VBAT, VBAT_TX, VDD_USB, and VDD_IO to improve the surge voltage bearing capacity of the module. In principle, the longer the power traces are, the wider they should be.

VDD_USB supplies power for the USB, and VDD_IO supplies power for the I/O pins of the module. Both power supply designs can be consistent with VBAT and VBAT_TX's. The circuit reference design is shown below:

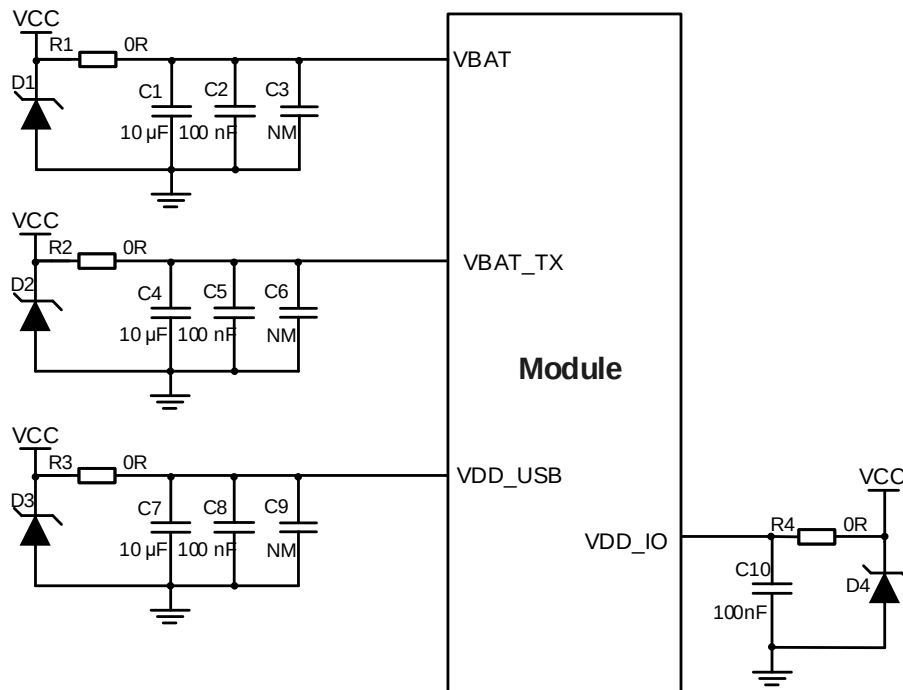


Figure 2: Reference Circuit of Power Supply

VBAT, VBAT_TX, and VDD_USB do not have strict power-on sequence requirements, but the voltage of VDD_IO should not exceed VBAT. In addition, it is necessary to confirm that the level of module power supply interfaces corresponds to the host level.

4.4. Wi-Fi Application Interfaces

The module provides one SDIO 2.0/SPI and USB 2.0 interface for Wi-Fi applications. At the same time, the power saving mode can be enabled or disabled by controlling the WAKEUP_IN and BUSY(GPIO2) pins.

- If power saving mode is used, a GPIO of the host is needed to be set as a CMOS input pin to receive the BUSY signal from the pin 29 (GPIO2) of the module.
- If power-saving mode is not used, WAKEUP_IN of the module should be pulled up to VDD_IO through a 10 kΩ resistor. For more details, please contact Quectel Technical Support.

The Wi-Fi application interface connection between the module and the host in different modes is shown below:

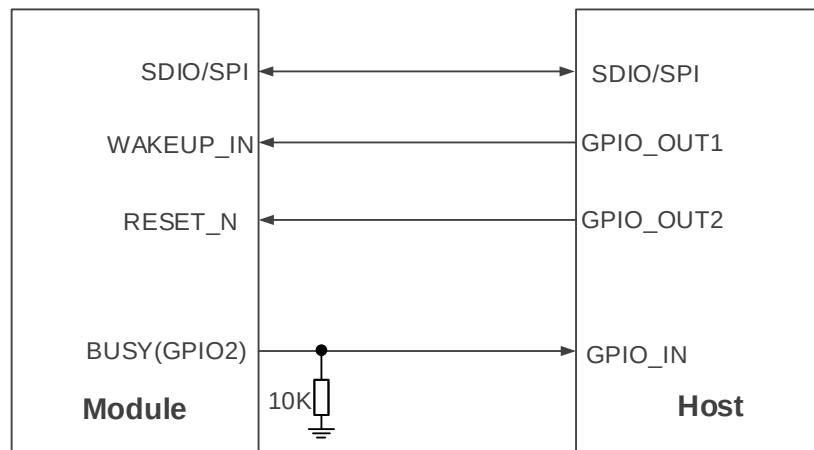


Figure 3: Wi-Fi Application SDIO/SPI Interface Connection (Power-Saving Mode)

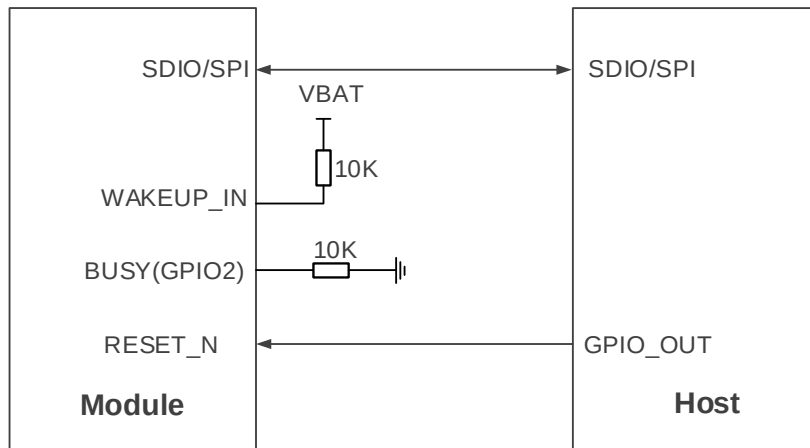


Figure 4: Wi-Fi Application SDIO/SPI Interface Connection (Non-Power-Saving Mode)

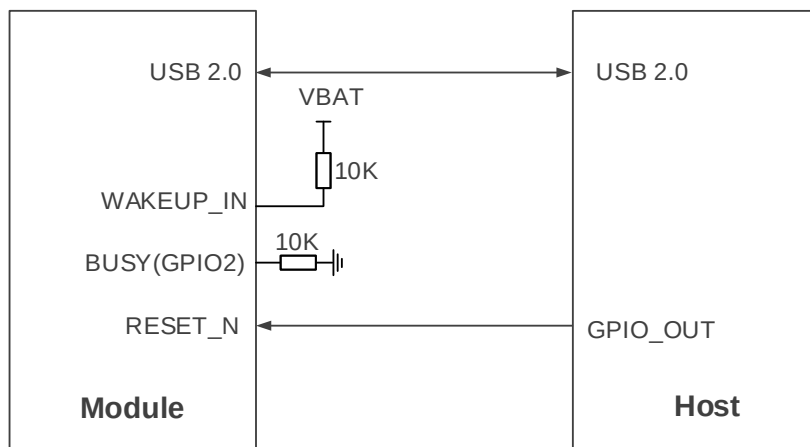


Figure 5: Wi-Fi Application USB Interface Connection

4.4.1. SDIO Interface

In SDIO mode, SDIO interface connection between the module and the host is illustrated in the following figure.

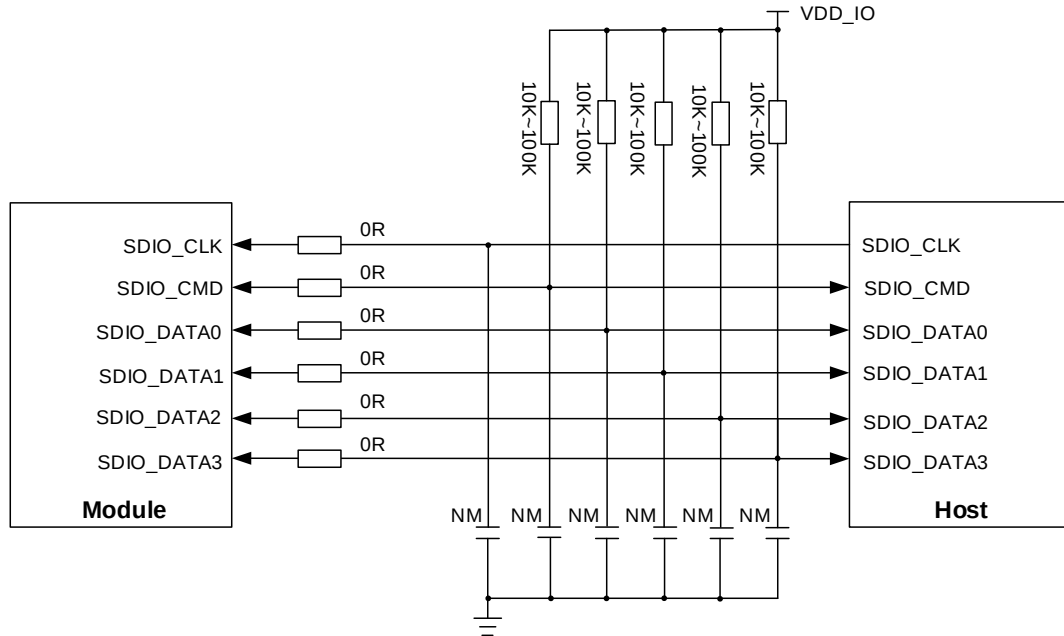


Figure 6: SDIO Interface Connection

To ensure compliance of interface design with the SDIO 2.0 specification, it is recommended to adopt the following principles:

- To minimize bus jitter, connect 10–100 k Ω pull-up resistors (with a recommended value of 47 k Ω) on the SDIO_CMD and SDIO_DATA[0:3] signal traces and pull them up to VDD_IO of the module.
- The impedance of SDIO signal traces is 50 $\Omega \pm 10\%$. Route the SDIO traces in inner layer of the PCB, and surround the traces with ground on the same layer and with ground planes above and below. And the SDIO_CLK signal trace should be routed with ground surrounded separately.
- Keep SDIO signals far away from other sensitive circuits/signals such as RF circuits and analog signals, as well as noise signals such as clock signals and DC-DC signals.
- Depending on the transmission mode, the total trace length (including the module's internal traces and the external traces from the module to the CPU pins) must follow the rules below: the recommended total trace length is less than 150 mm, with a tolerance of $\pm 1\%$.
- The distance between SDIO signals and other signals must be greater than twice the trace width, and the bus load capacitance must be less than 15 pF.
- SDIO_CLK, SDIO_DATA[0:3], and SDIO_CMD signal traces need to be of equal length (the distance between the traces should be less than {num} mm). Route SDIO traces on the same layer of the PCB as much as possible, keeping them parallel and ensuring that there are enough ground vias around the SDIO traces and connecting them to a ground plane. The lengths of internal signal traces within the module are as follows:

Table 7: Trace Length of Interface Inside the Module (Unit: mm)

Pin No.	Pin Name	Length
16	SDIO_CMD	3.79
17	SDIO_CLK	3.17
13	SDIO_DATA3	4.95
15	SDIO_DATA2	4.00
14	SDIO_DATA1	3.91
12	SDIO_DATA0	5.34

The SDIO interface can be switched to SPI mode by controlling SDIO_DATA3 and SDIO_CMD. Only SPI slave mode is supported. For details, please contact Quectel Technical Support. Pull up the unused SDIO_DATA2 to VDD_IO through a 47 kΩ resistor.

Table 8: Pin Description of SDIO Interface in SPI Mode

Pin Name	Pin No.	I/O	Description
SDIO_CLK	17	DI	SPI clock
SDIO_CMD	16	DI	SPI master-out slave-in
SDIO_DATA0	12	DO	SPI master-in slave-out
SDIO_DATA1	14	DI	SPI interrupt
SDIO_DATA3	13	DI	SPI chip select

In SPI mode, SDIO interface connection between the module and the host is illustrated in the following figure.

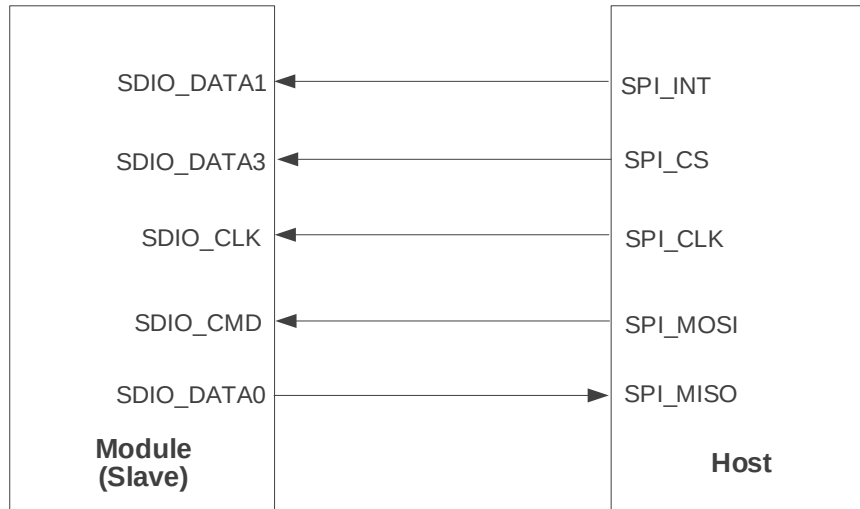


Figure 7: SDIO Interface Connection in SPI Mode

Consider the following recommendations to achieve the best throughput:

- The host must support level-triggered interrupts.
- The host must support full-duplex mode.
- If the SPI bus requires higher throughput, the host must support DMA transactions. The standard SPI interface has a transmission rate of up to 25 Mbps when the clock frequency is 50 MHz. But if the host does not support DMA transactions, the transfer rate will be significantly reduced. For example, for an SPI interface with an 8-byte DMA transaction buffer, the transfer rate may only reach 2 Mbps.

4.4.2. USB Interface

USB interface connection between the module and the host is illustrated in the following figure.

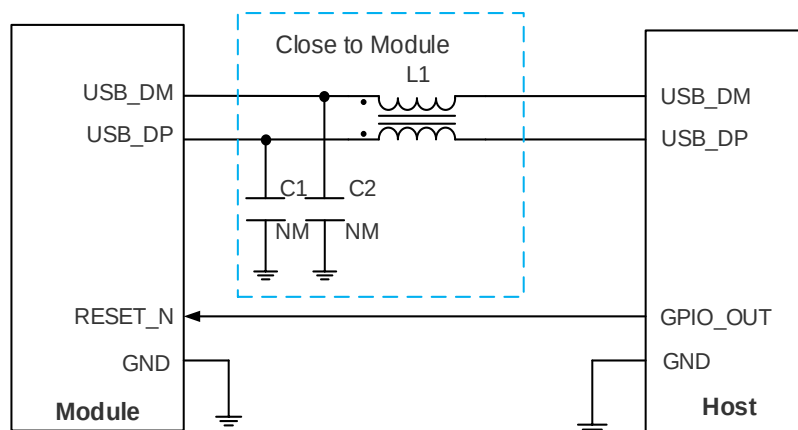


Figure 8: USB Interface Connection

To ensure compliance of interface design with the USB 2.0 specification, it is recommended to adopt the following principles:

- The impedance of USB signal trace is $90\ \Omega \pm 10\%$. Route the USB traces in inner layer of the PCB, and surround the traces with ground on the same layer and with ground planes above and below.
- Keep USB signals far away from power supply traces, crystal-oscillators, magnetic devices, sensitive signals such as RF signals, analog signals, as well as noise signals generated by clock and DC-DC. And ensure the USB signals on the different layers with RF signals.
- USB signal traces (USB_DP and USB_DM) need to be equal in length, width and distance (the distance between the traces should be less than 1 mm).
- The distance between USB signal traces and other signals must be greater than twice the trace width, and the bus load capacitance must be less than 15 pF.
- If there is no built-in pull-down resistor inside the host, a 15 k Ω resistor should be used to pull down the USB_DP and USB_DM to the ground near the host side.
- Junction capacitance of the ESD protection components might influence on USB data traces, so you should pay attention to the selection of the device. Typically, the junction capacitance should be less than 0.5 pF for USB 2.0.

4.5. RF Antenna Interface

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 supports one antenna interface (ANT_WIFI). The impedance of antenna port is 50 Ω .

4.5.1. Reference Design

A reference circuit for the RF antenna interface is shown below. It is recommended to reserve a dual L-type matching circuit and add an ESD protection component for better RF performance. Reserved matching components (R1, C1, C2, and D1) shall 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 R1 is recommended to be 0 Ω .

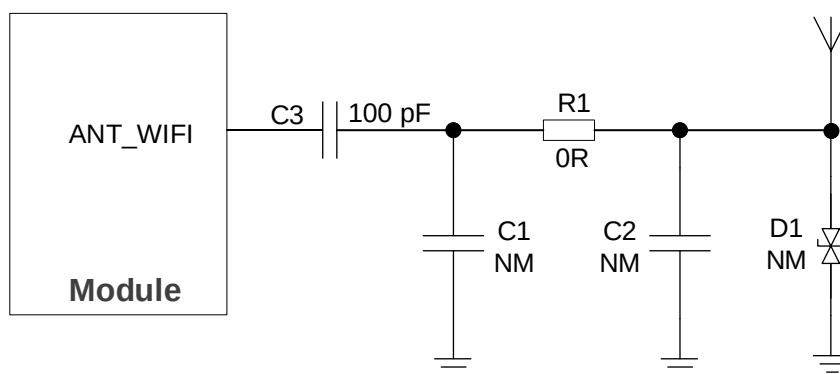


Figure 9: Reference Circuit for RF Antenna Interface

NOTE

1. It is recommended to reserve ESD protection components for the antenna interfaces and the junction capacitance should not exceed 0.05 pF.
2. Notes on C3:
 - 1) If there is DC power at the antenna ports, place a capacitor on C3 to prevent short circuit to ground. The capacitance value is recommended to be 100 pF, which can be adjusted according to the debugging results.
 - 2) If there is no DC power in the peripheral design:
 - a) Do not reserve C3.
 - b) If C3 has already been reserved, it should be mounted with a component, and it is recommended to use a 0 Ω resistors. You can also match the component according to the debugging results.

4.5.2. Requirements for Antenna Design

Table 9: Requirements for Antenna Design

Parameter	Requirement ⁵
Frequency Range (MHz)	Sub-1 GHz: 850–950 MHz
Cable Insertion Loss (dB)	< 1
VSWR	≤ 2 (Typ.)
Max. Input Power (W)	50

⁵ For more details about the RF performances, see **Chapter 3**.

Input Impedance (Ω)	50
Polarization	Vertical polarization

4.5.3. 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.

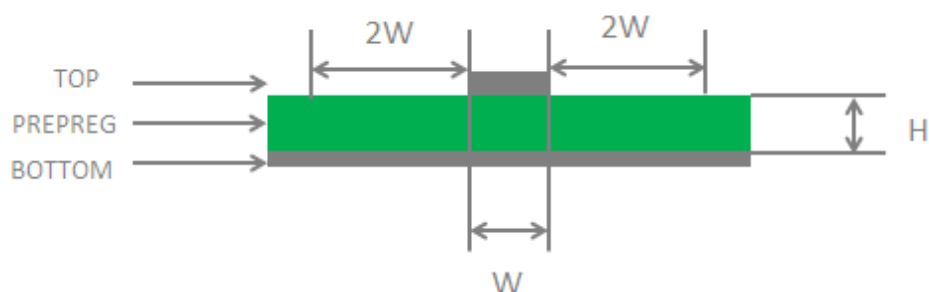


Figure 10: Microstrip Design on a 2-layer PCB

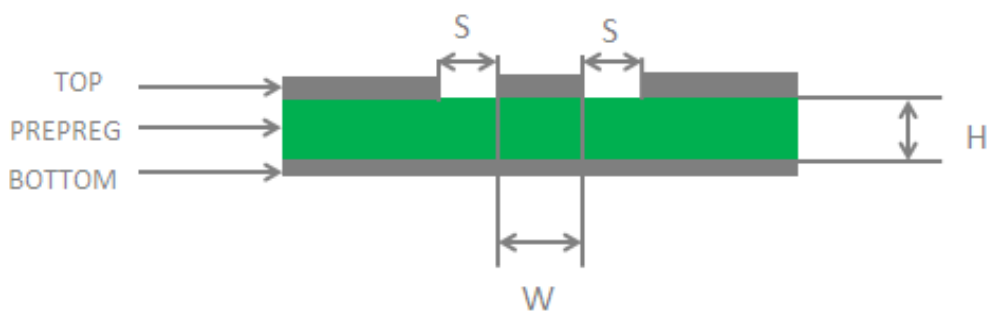


Figure 11: Coplanar Waveguide Design on a 2-layer PCB

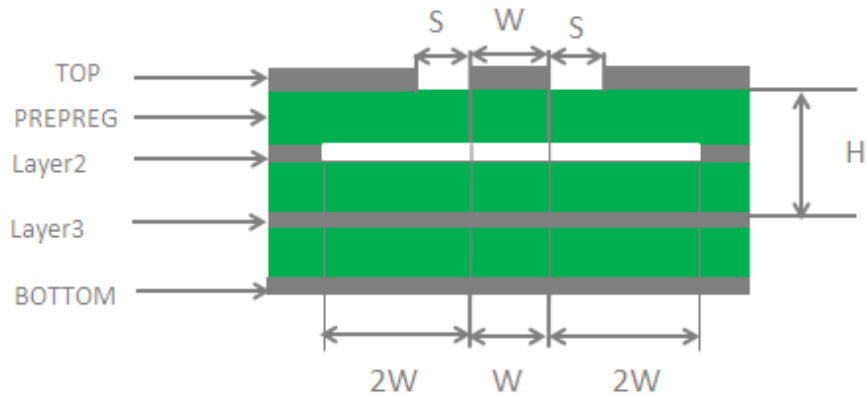


Figure 12: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

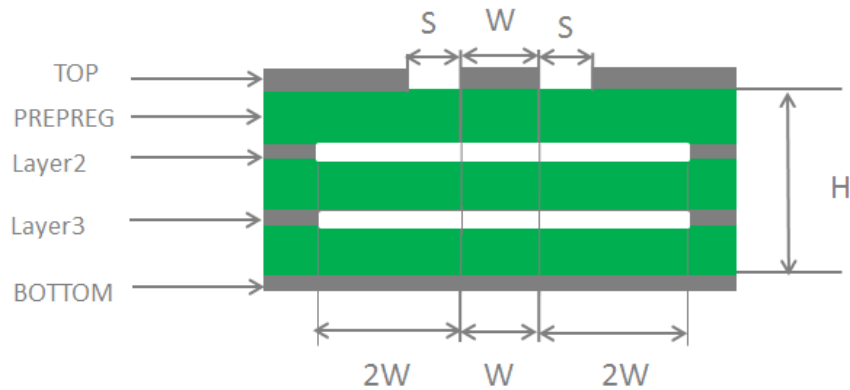


Figure 13: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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

- Use an impedance simulation tool to accurately control the characteristic impedance of RF traces to $50\ \Omega$.
- The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
- The traces of RF pin should be typically routed with ground clearance and have a $50\ \Omega$ characteristic impedance.
- The distance between the RF pins and the RF connector should be as short as possible and all the 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. Meanwhile, 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 ($2 \times W$).
- Keep RF traces away from interference sources (such as DC-DC, (U)SIM/USB/SDIO high frequency digital signals, display signals, and clock signals), and avoid intersection and paralleling between

traces on adjacent layers.

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

4.5.4. RF Connector Recommendation

If RF connector is used for antenna connection, it is recommended to use the U.FL-R-SMT connector provided by Hirose.

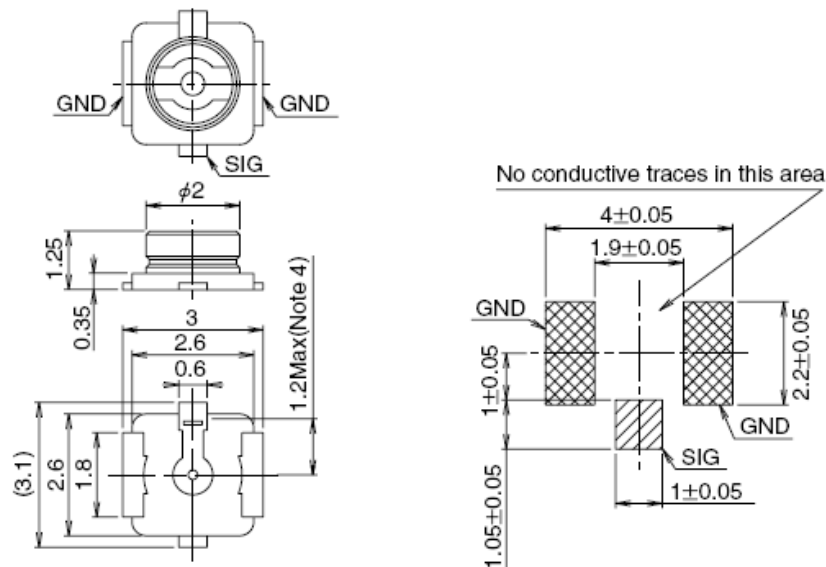


Figure 14: Dimensions of the Receptacle (Unit: mm)

U.FL-LP series mated plugs listed in the following figure can be used to match the U.FL-R-SMT connector.

Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7
RoHS	YES				

Figure 15: Specifications of Mated Plugs

The following figure describes the space factor of mated connectors.

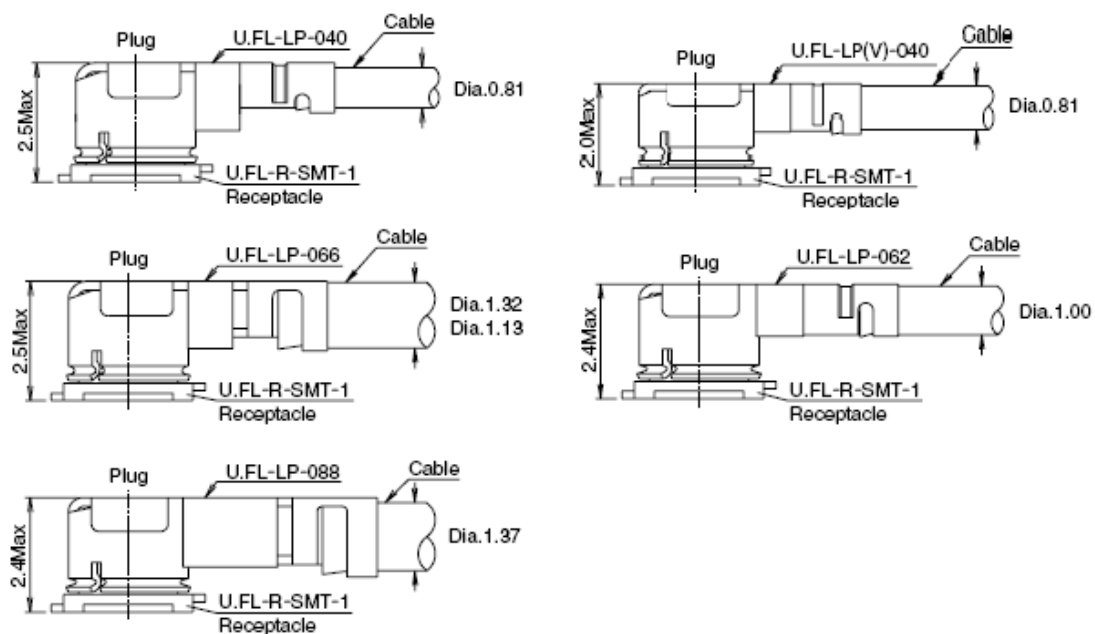


Figure 16: Space Factor of Mated Connectors (Unit: mm)

For more details, please visit <http://www.hirose.com>.

5 Electrical Characteristics and Reliability

5.1. Absolute Maximum Ratings

Table 10: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VBAT	-0.3	3.6
VBAT_TX	-0.3	3.6
VDD_USB	-0.3	3.6
VDD_IO	-0.3	3.6

NOTE

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

5.2. Power Supply Ratings

Table 11: Module's 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.	3.0	3.3	3.6

VBAT_TX	Power supply for RF	-	3.0	3.3	3.6
VDD_USB	Power supply for the USB interface	-	3.0	3.3	3.6
VDD_IO	Power supply for the module's I/O pins	-	2.25	3.3	3.6

5.3. Power Consumption

Test conditions for module power consumption are as follows:

- Ambient temperature 25 °C
- Typical power domain
- 50 Ω impedance

The following power consumption data are the typical values 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.

Table 12: Wi-Fi Power Consumption in Non-signaling Mode (Typ.; Unit: mA)

Condition		I _{VBAT}	I _{VBAT_TX}	I _{VDD_USB}	I _{VDD_IO}
802.11ah, Tx @ 915 MHz	1 MHz @ MCS 0	TBD	TBD	TBD	TBD
	2 MHz @ MCS 0	TBD	TBD	TBD	TBD
	4 MHz @ MCS 0	TBD	TBD	TBD	TBD
	8 MHz @ MCS 0	TBD	TBD	TBD	TBD
	1 MHz @ MCS 9	TBD	TBD	TBD	TBD
	2 MHz @ MCS 8	TBD	TBD	TBD	TBD
	4 MHz @ MCS 9	TBD	TBD	TBD	TBD
	8 MHz @ MCS 8	TBD	TBD	TBD	TBD
	1 MHz @ MCS 10	TBD	TBD	TBD	TBD
802.11ah, Rx	1 MHz @ MCS 0	TBD	TBD	TBD	TBD

@ 915 MHz	2 MHz @ MCS 0	TBD	TBD	TBD	TBD
	4 MHz @ MCS 0	TBD	TBD	TBD	TBD
	8 MHz @ MCS 0	TBD	TBD	TBD	TBD
	1 MHz @ MCS 9	TBD	TBD	TBD	TBD
	2 MHz @ MCS 8	TBD	TBD	TBD	TBD
	4 MHz @ MCS 9	TBD	TBD	TBD	TBD
	8 MHz @ MCS 9	TBD	TBD	TBD	TBD
	1 MHz @ MCS 10	TBD	TBD	TBD	TBD

5.4. Digital I/O Characteristics

Table 13: VDD_IO I/O Requirements (Unit: V)

Parameter	Description	Min.	Max.
V _{IH}	High-level input voltage	2.0	3.6
V _{IL}	Low-level input voltage	-0.3	0.8
V _{OH}	High-level output voltage	3.07	3.23
V _{OL}	Low-level output voltage	0.08	0.18

5.5. ESD Protection

Static electricity occurs naturally and it 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.

6 Mechanical Information

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

6.1. Mechanical Dimensions

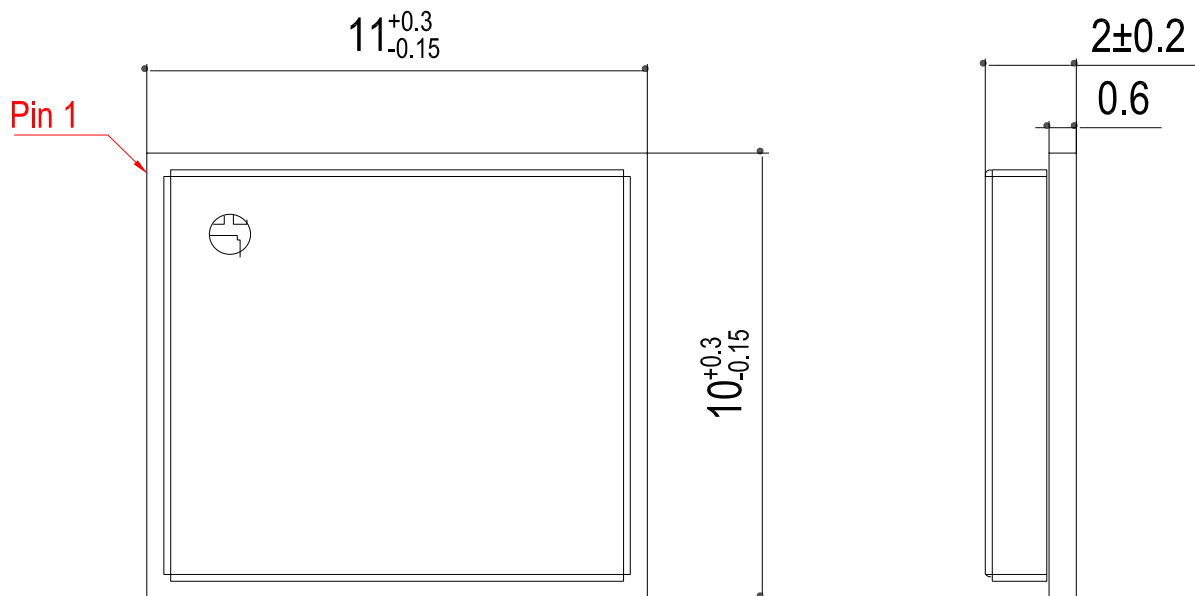


Figure 17: Top and Side Dimensions

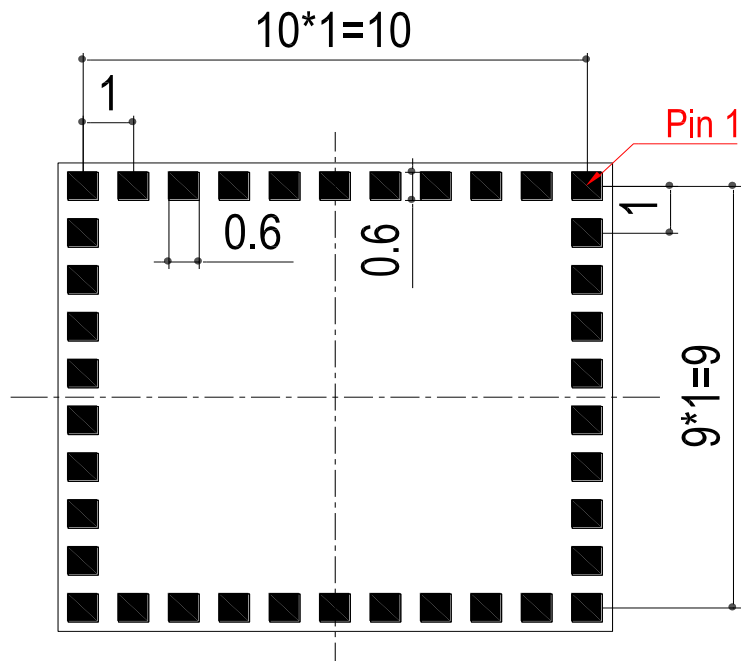


Figure 18: Bottom Dimensions (Bottom View)

NOTE

The module's coplanarity standard: ≤ 0.13 mm.

6.2. Recommended Footprint

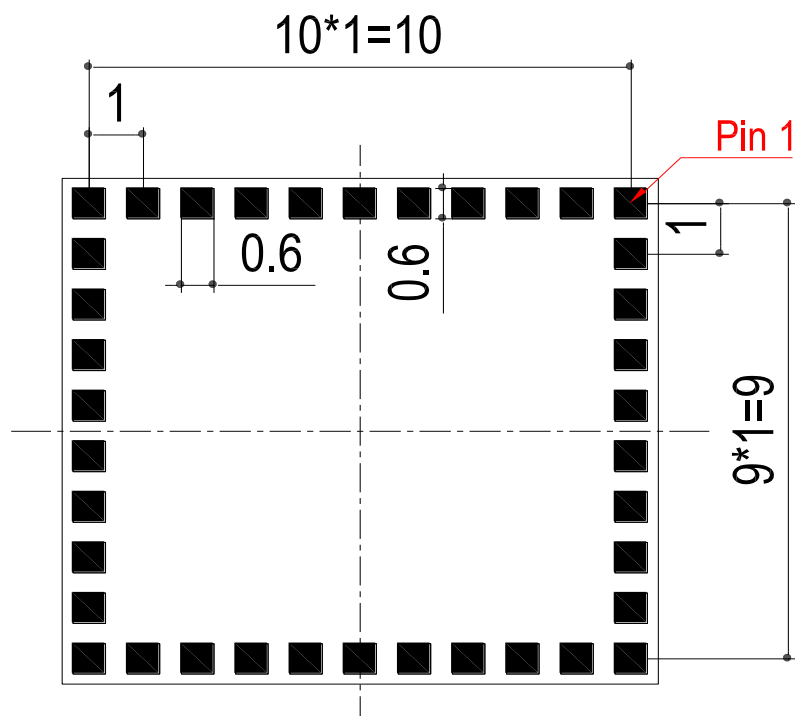


Figure 19: Recommended Footprint

NOTE

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

6.3. Top and Bottom Views

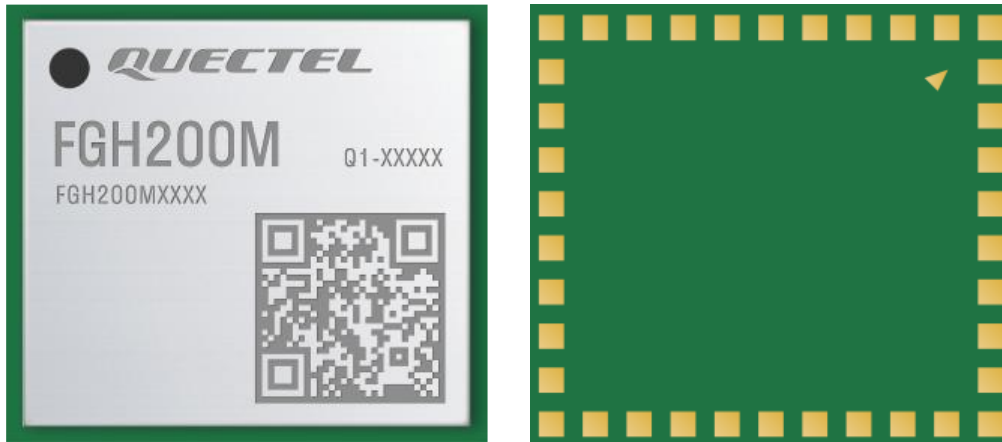


Figure 20: Top and Bottom Views

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.

7 Storage, Manufacturing and Packaging

7.1. 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 ⁶ 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.

⁶ 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.

7.2. 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 0.10–0.13 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.

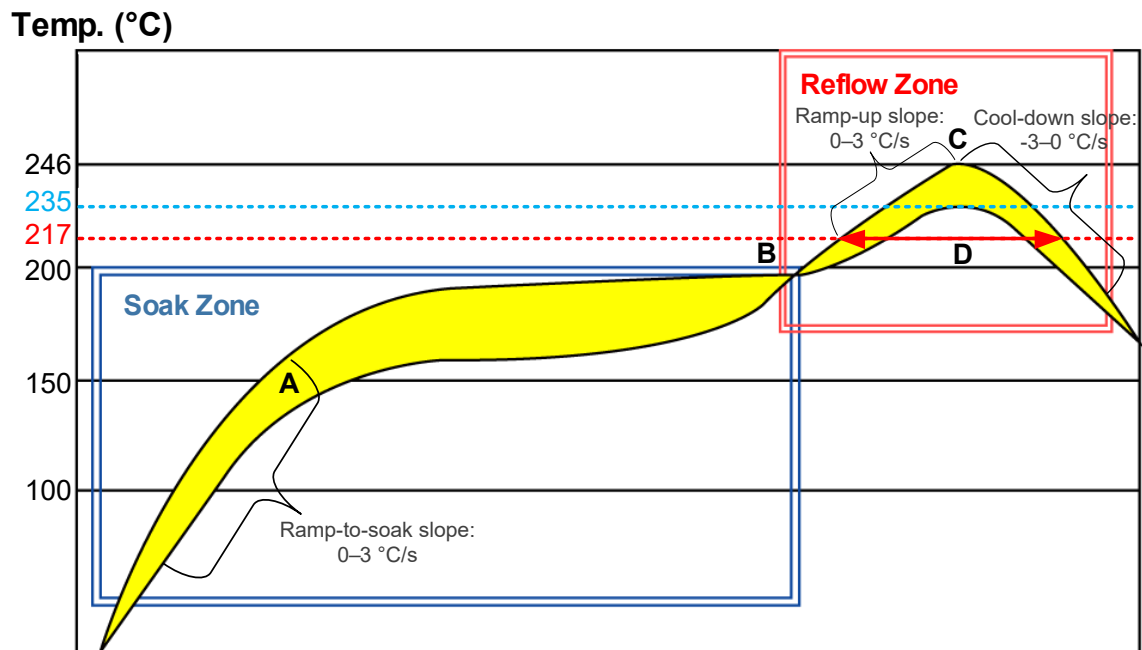


Figure 21: Recommended Reflow Soldering Thermal Profile

Table 14: 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 the 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]**.

7.3. 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.

7.3.1. Carrier Tape

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

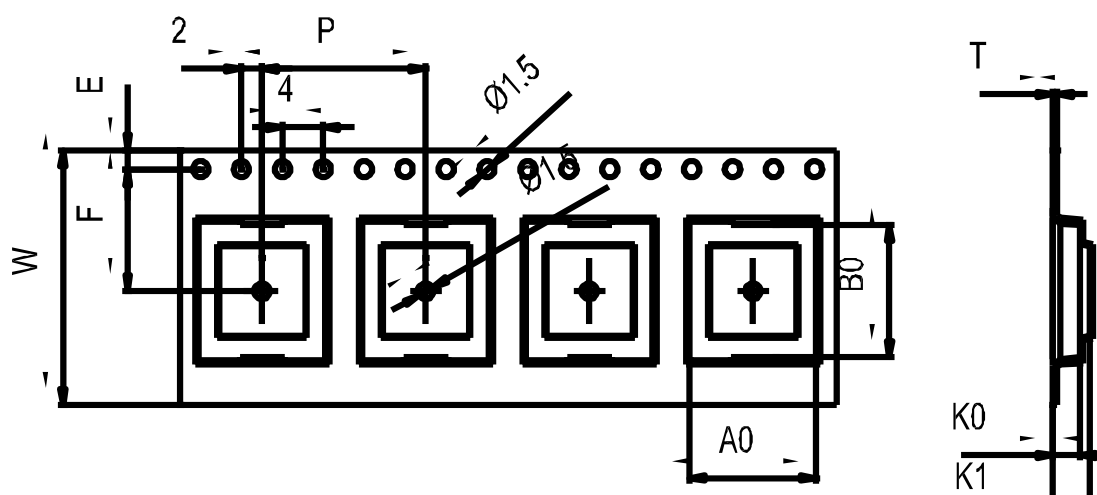


Figure 22: Carrier Tape Dimension Drawing (Unit: mm)

Table 15: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
24	20	0.4	11.4	12.4	2.5	2.9	11.5	1.75

7.3.2. Plastic Reel

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

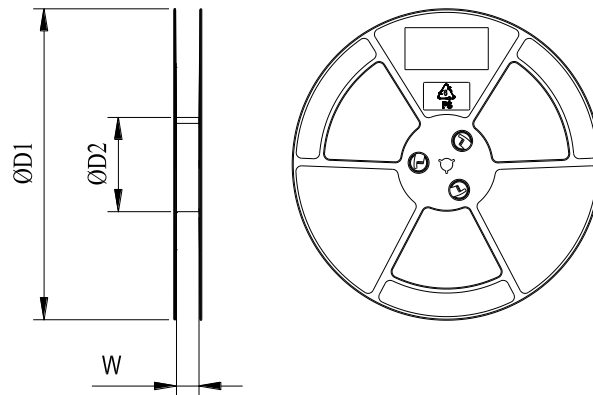


Figure 23: Plastic Reel Dimension Drawing

Table 16: Plastic Reel Dimension Table (Unit: mm)

ØD1	ØD2	W
330	100	24.5

7.3.3. Mounting Direction

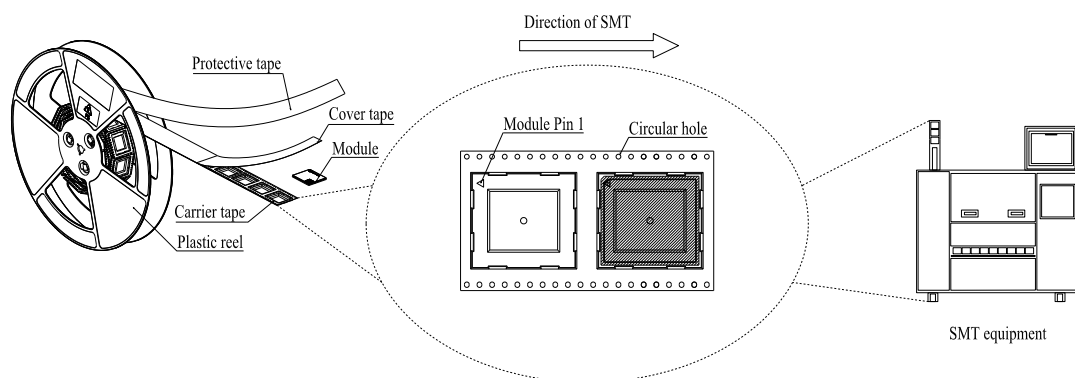
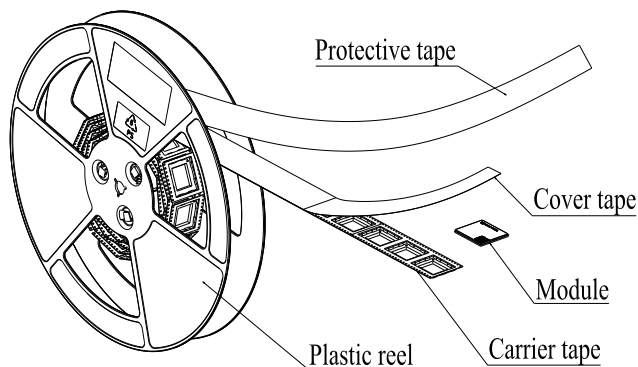


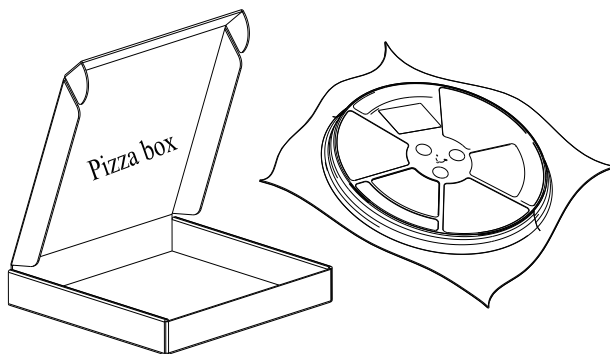
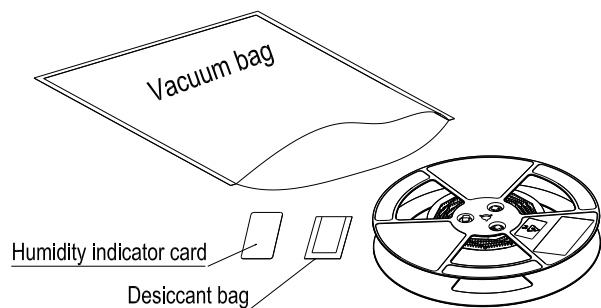
Figure 24: Mounting Direction

7.3.4. 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 1000 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 4000 modules.

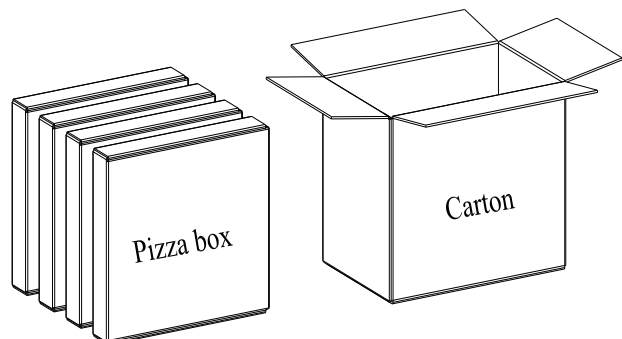


Figure 25: Packaging Process

8 Appendix References

Table 17: Related Documents

Document Name
[1] Quectel_RK3568-WF_EVB_User_Guide
[2] Quectel_RF_Layout_Application_Note
[3] Quectel_Module_Stencil_Design_Requirements
[4] Quectel_Module_SMT_Application_Note

Table 18: Terms and Abbreviations

Abbreviation	Description
AES	Advanced Encryption Standard
AP	Access Point
BPSK	Binary Phase Shift Keying
CMOS	Complementary Metal Oxide Semiconductor
CPU	Central Processing Unit
DMA	Direct Memory Access
ESD	Electrostatic Discharge
EVB	Evaluation Board
EVM	Error Vector Magnitude
GND	Ground
GPIO	General-Purpose Input/Output

I/O	Input/Output
IEEE	Institute of Electrical and Electronics Engineers
JTAG	Joint Test Action Group
LGA	Land Grid Array
Mbps	Million Bits Per Second
MCS	Modulation and Coding Scheme
MSL	Moisture Sensitivity Levels
OFDM	Orthogonal Frequency-Division Multiplexing
OWE	Opportunistic Wireless Encryption
PCB	Printed Circuit Board
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
Rx	Receive
SDIO	Secure Digital Input/Output
SHA	Secure Hash Algorithm
SMT	Surface Mount Technology
SPDT	Single-Pole Double-Throw
SPI	Serial Peripheral Interface
STA	Station
TVS	Transient Voltage Suppressor
Tx	Transmit
(U)SIM	(Universal) Subscriber Identity Module
VBAT	Voltage at Battery (Pin)

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
WPA	Wi-Fi Protected Access
XO	Crystal Oscillator

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 & 15.407.

2.3 Specific operational use conditions

The module can be used for mobile applications with a maximum 0.2dBi 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: External Antenna

Gain: 2.5dBi

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: XMR2025FGH200M" 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 & 15.407 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: XMR2025FGH200M**"

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.

ISED Statement

This device complies with ISED 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'ISED 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.

ISED Radiation Exposure Statement

This equipment complies with ISED 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 ISED 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-2025FGH200M".

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-2025FGH200M".

This radio transmitter [10224A-2025FGH200M] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a greater gain than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Antenna Specification are as follows:

Type: External Antenna

Gain: 2.5 dBi

Ce émetteur radio [10224A-2025FGH200M] a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antennes énumérés ci-dessous, avec le gain maximal autorisé indiqué. Les types d'antennes non inclus dans cette liste et dont le gain est supérieur au gain maximal indiqué pour tout type énuméré sont strictement interdits pour une utilisation avec cet appareil.

Spécifications de l'antenne :

Type : Antenne externe

Gain : 2.5 dBi