FCS960K-N

Hardware Design

Wi-Fi&Bluetooth Module Series

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Status: Preliminary

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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 terminal or mobile incorporating the module. Manufacturers of the cellular 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 cellular 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.
	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. 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 cellular 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 cellular 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 cellular terminals. Areas with explosive or potentially explosive atmospheres include fuelling 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
-	2023-06-29	Wesley WEI	Creation of the document
1.0.0	2023-06-29	Wesley WEI	Preliminary

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1 Introduction

This document describes the FCS960K-N features, performances, and air interfaces and hardware interfaces connected to your applications. The document provides a quick insight into interface specifications, RF performance, electrical and mechanical specifications, and other module information, as well.

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.

Hereby, Quectel Wireless Solutions Co., Ltd. declares that the radio equipment type FCS960K-N is in compliance with Directive 2014/53/EU.
The full text of the EU declaration of conformity is available at the following internet address: http://www.quectel.com/support/technical.htm
The device could be used with a separation distance of 20cm to the human body.

Disposal of old electrical appliances

The European directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE), requires that old household electrical appliances must not be disposed of in the normal unsorted municipal waste stream. Old appliances must be collected separately in order to optimize the recovery and recycling of the materials they contain, and reduce the impact on human health and the environment.
The crossed out "wheeled bin" symbol on the product reminds you of your obligation, that when you dispose of the appliance, it must be separately collected.
Consumers should contact their local authority or retailer for information concerning the correct disposal of their old appliance.

The WLAN function for this device is restricted to indoor use only when operating in the 5150 to 5350 MHz frequency range.

2 Product Overview

FCS960K-N is a low-energy, high-performance IEEE 802.11 a/b/g/n/ac/ax Wi-Fi 6 and Bluetooth 5.3 module. It supports 2.4 GHz and 5 GHz dual-band and 1T1R with maximum data transmission rate up to 286.8 Mbps. It provides SDIO 3.0 interface for Wi-Fi functions and UART and PCM interface for Bluetooth functions.

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

Table 2: Basic Information

FCS960K-N	
Packaging type	LCC
Pin counts	44
Dimensions	(12.0 ±0.15) mm × (12.0 ±0.15) mm × (2.0 ±0.2) mm
Weight	Approx. 0.6 g

2.1. Key Features

Table 3: Key Features

Basic Information	
Protocols and Standard	● Wi-Fi protocols: IEEE 802.11 a/b/g/n/ac/ax ● Bluetooth protocol: Bluetooth 5.4 ● All hardware components are fully compliant with EU RoHS directive
Power Supplies	**VBAT Power Supply:** ● 3.0–3.6 V ● Typ.: 3.3 V **VDD_IO Power Supply:** ● 1.71–3.63 V ● Typ.: 1.8/3.3 V
Temperature Ranges	● Operating temperature [1]: -20 to +80 °C ● Storage temperature: -25 to +90 °C
EVB Kit	FCS960K-N-M.2
RF Antenna Interface	
Wi-Fi Antenna Interface	● ANT_WIFI/BT ● 50 Ω characteristic impedance
BT Antenna Interface [2]	● ANT_BT (optional) ● 50 Ω characteristic impedance
Application Interface	
Wi-Fi Application Interface	SDIO 3.0
Bluetooth Application Interfaces	UART, PCM

[1] 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 and Bluetooth specification requirements.
[2] The dedicated Bluetooth antenna interface is optional. For more details, contact Quectel Technical Support. FCS960K-N doesn't use ANT_BT in module's CE testing, it's reserved for client's design.

2.2. Functional Diagram

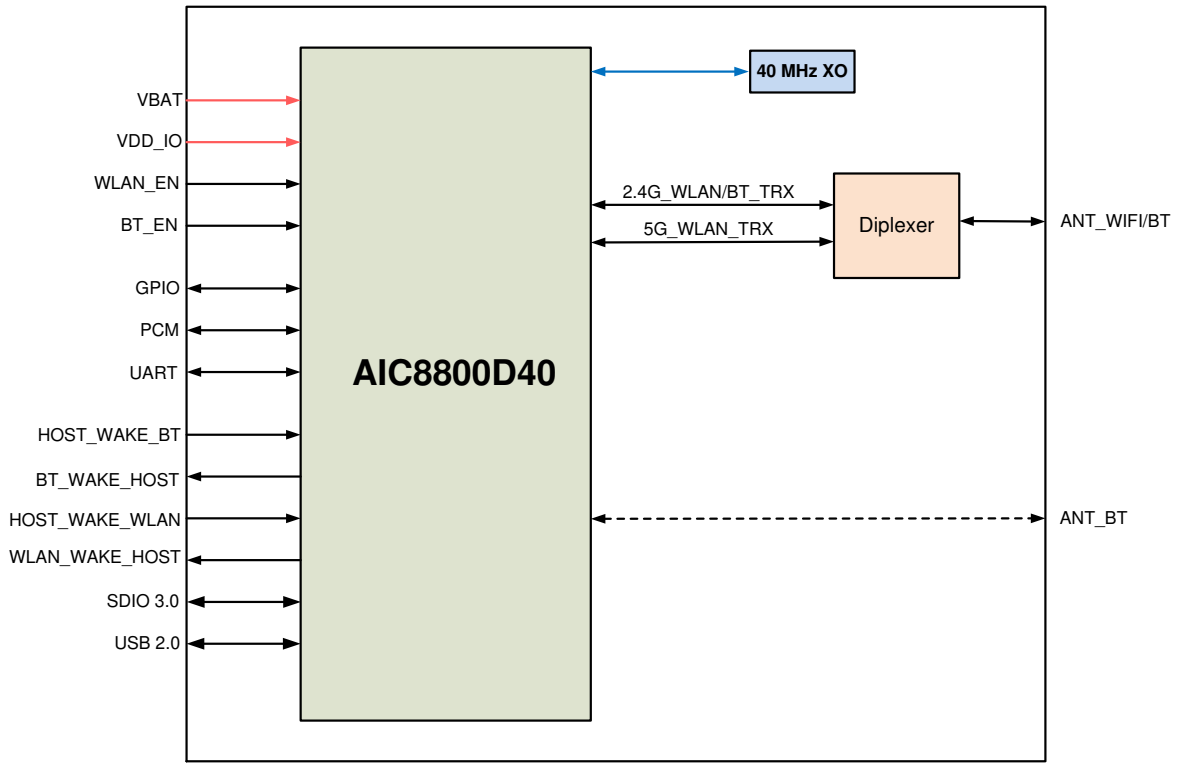


Figure 1: Functional Diagram

3 RF Performances

3.1. Wi-Fi Performances

Table 4: Wi-Fi Performances

Operating Frequency				
2.4 GHz: 2.400–2.4835 GHz **5 GHz:** 5.150–5.850 GHz				
Modulation				
DSSS、CCK、BPSK、QPSK、16QAM、64QAM、256QAM、1024QAM				
Encryption Mode				
WEP, WPA, WPA2, WPA3-SAE				
Operating Mode				
● AP ● STA				
Transmission Data Rate				
● 802.11b: 1 Mbps, 2 Mbps, 5.5 Mbps, 11 Mbps ● 802.11a/g: 6 Mbps, 9 Mbps, 12 Mbps, 18 Mbps, 24 Mbps, 36 Mbps, 48 Mbps, 54 Mbps ● 802.11n: HT20 (MCS 0–7), HT40 (MCS 0–7) ● 802.11ac: VHT20 (MCS 0–8), VHT40 (MCS 0–9) ● 802.11ax: HE20 (MCS 0–11), HE 40(MCS 0–11)				
Condition		**EVM**	**Typ.; Unit: dBm; Tolerance: ±2 dB**	
			Transmitting Power	**Receiving Sensitivity**
2.4 GHz	802.11b @ 1 Mbps	≤ 35 %	19	-96
	802.11b @ 11 Mbps		19	-88
	802.11g @ 6 Mbps	≤ -5 dB	17	-93

	802.11g @ 54 Mbps	≤ -25 dB	15	-77
	802.11n, HT20 @ MCS 0	≤ -5 dB	17	-90
	802.11n, HT20 @ MCS 7	≤ -27 dB	15	-76
	802.11n, HT40 @ MCS 0	≤ -5 dB	17	-90
	802.11n, HT40 @ MCS 7	≤ -27 dB	15	-72
	802.11ax, HE20 @ MCS 0	≤ -5 dB	17	-94
	802.11ax, HE20 @ MCS 11	≤ -35 dB	14	-67
	802.11ax, HE40 @ MCS 0	≤ -5 dB	17	-92
	802.11ax, HE40 @ MCS 11	≤ -35 dB	14	-63
5 GHz	802.11a @ 6 Mbps	≤ -5 dB	17	-93
	802.11a @ 54 Mbps	≤ -25 dB	15	-76
	802.11n, HT20 @ MCS 0	≤ -5 dB	17	-93
	802.11n, HT20 @ MCS 7	≤ -27 dB	15	-74
	802.11n, HT40 @ MCS 0	≤ -5 dB	17	-89
	802.11n, HT40 @ MCS 7	≤ -27 dB	15	-71
	802.11ac, VHT20 MCS 0	≤ -5 dB	17	-92
	802.11ac, VHT20 MCS 8	≤ -30 dB	14	-70
	802.11ac, VHT40 @ MCS 0	≤ -5 dB	17	-89
	802.11ac, VHT40 @ MCS 9	≤ -32 dB	12	-65
	802.11ax, HE20 @ MCS 0	≤ -5 dB	16	-93
	802.11ax, HE20 @ MCS 11	≤ -35 dB	12	-65
	802.11ax, HE40 @ MCS 0	≤ -5 dB	16	-90
	802.11ax, HE40 @ MCS 11	≤ -35 dB	12	-61

3.2. Bluetooth Performances

Table 5: Bluetooth Performances

Operating Frequency	
2.400–2.4835 GHz	
Modulation	
GFSK, π/4-DQPSK, 8-DPSK	
Operating Mode	
• Classic Bluetooth (BR + EDR) • Bluetooth Low Energy (BLE)	
Condition	**Typ.; Unit: dBm; Tolerance: TBD**
	Receiving Sensitivity
BR	-90
EDR (π/4-DQPSK)	-85
EDR (8-DPSK)	-85
BLE (1 Mbps)	-90
BLE (2 Mbps)	-85
BLE Long Range (S = 8) 125 Kbps	-90
BLE Long Range (S = 2) 500 Kbps	-90

4 Application Interfaces

4.1. Pin Assignment

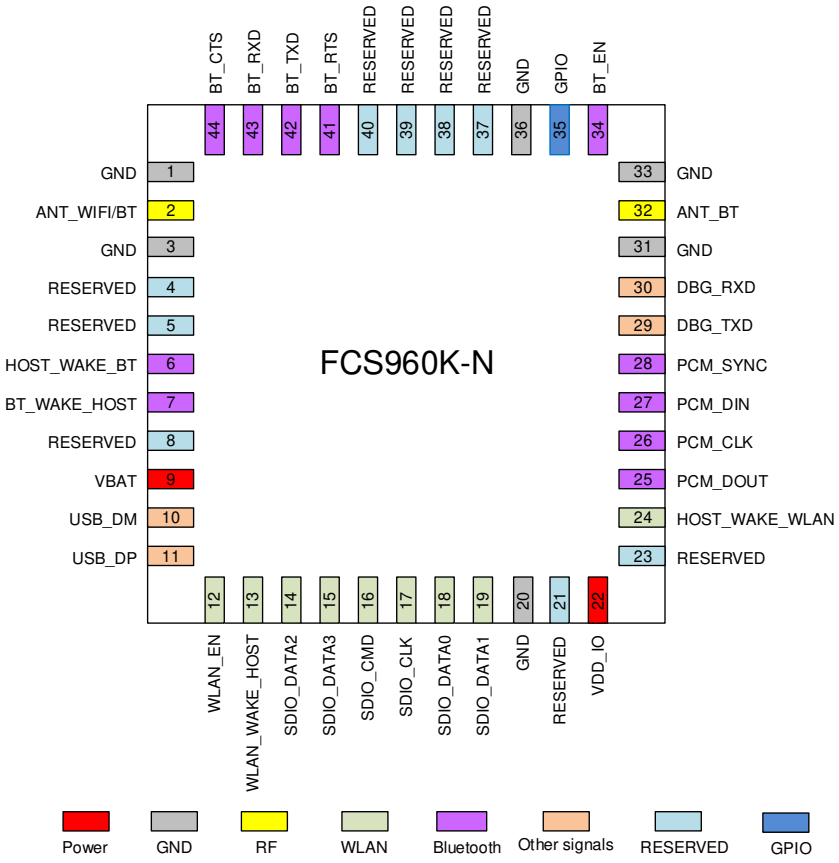


Figure 2: Pin Assignment (Top View)

NOTE

1. Keep all RESERVED and unused pins unconnected.
2. All GND pins should be connected to ground.

4.2. Pin Description

Table 6: I/O Parameters Definition

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

DC characteristics include power domain and rate current.

Table 7: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	9	PI	Power supply for the module	Vmin = 3.0 V Vnom = 3.3 V Vmax = 3.6 V	It must be provided with sufficient current of at least 0.5 A.
VDD_IO	22	PI	Power supply for the module's I/O pins	Vmin = 1.7 V Vnom = 1.8/3.3 V Vmax = 3.6 V	The voltage domain of I/O pins is determined by the VDD_IO.
GND	1, 3, 20, 31, 33, 36				
Wi-Fi Application Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WLAN_EN	12	DI	WLAN enable control	VDD_IO	Active high.
HOST_WAKE_WLAN	24	DI	Host wakes up WLAN		
WLAN_WAKE_HOST	13	DO	WLAN wakes up host		
SDIO_CMD	16	DIO	SDIO command		Requires impedance of

SDIO_CLK	17	DI	SDIO clock		50 Ω. SDIO 3.0 compliant. Reserve 10–100 kΩ resistors to pull each of them up to VDD_IO.
SDIO_DATA0	18	DIO	SDIO data bit 0		
SDIO_DATA1	19	DIO	SDIO data bit 1		
SDIO_DATA2	14	DIO	SDIO data bit 2		
SDIO_DATA3	15	DIO	SDIO data bit 3		
Bluetooth Application Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
BT_EN	34	DI	Bluetooth enable control	VDD_IO	Active high.
BT_RTS	41	DO	Request to send signal from the module		It is recommended to add a 0 Ω series resistor.
BT_CTS	44	DI	Clear to send signal to the module		
BT_TXD	42	DO	Bluetooth UART transmit		
BT_RXD	43	DI	Bluetooth UART receive		
PCM_DOUT	25	DO	PCM data output		If unused, keep them open.
PCM_CLK	26	DI	PCM clock		
PCM_DIN	27	DI	PCM data input		
PCM_SYNC	28	DI	PCM data frame sync		
HOST_WAKE_BT	6	DI	Host wakes up Bluetooth		Active high.
BT_WAKE_HOST	7	DO	Bluetooth wakes up host		
RF Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_WIFI/BT	2	AIO	Wi-Fi/Bluetooth antenna interface		50 Ω characteristic impedance.
ANT_BT [3]	32	AIO	Bluetooth antenna interface (optional)		

[3] The dedicated Bluetooth antenna interface is optional. For more details, contact Quectel Technical Support. FCS960K-N doesn't use ANT_BT in module's CE testing, it's reserved for client's design.

Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_DM	10	AIO	USB differential data (-)		If unused, keep them open.
USB_DP	11	AIO	USB differential data (+)		
DBG_TXD	29	DO	Debug UART transmit	VDD_IO	Test points must be reserved.
DBG_RXD	30	DI	Debug UART receive		
GPIO Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GPIO	35	DIO	General-purpose input/output	VDD_IO	If unused, keep it open.
RESERVED Pins					
Pin Name	**Pin No.**				**Comment**
RESERVED	4, 5, 8, 21, 23, 37–40				Keep them open.

4.3. Power Supply

The module is powered by VBAT. It is recommended to use a power supply chip with sufficient of at least 0.5 A. For better power supply performance, it is recommended to parallel a 47 µF decoupling capacitor, and 1 µF and 100 nF filter capacitors 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:

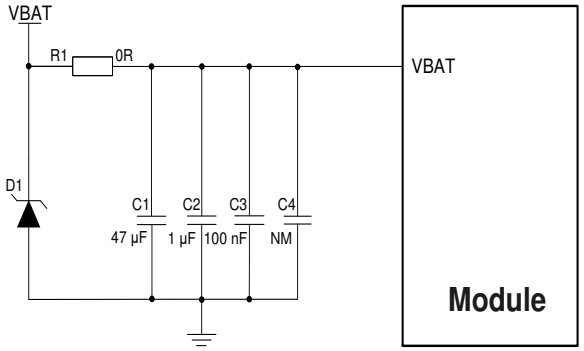


Figure 3 Reference Circuit of Power Supply

The power-up timing of the module is shown below.

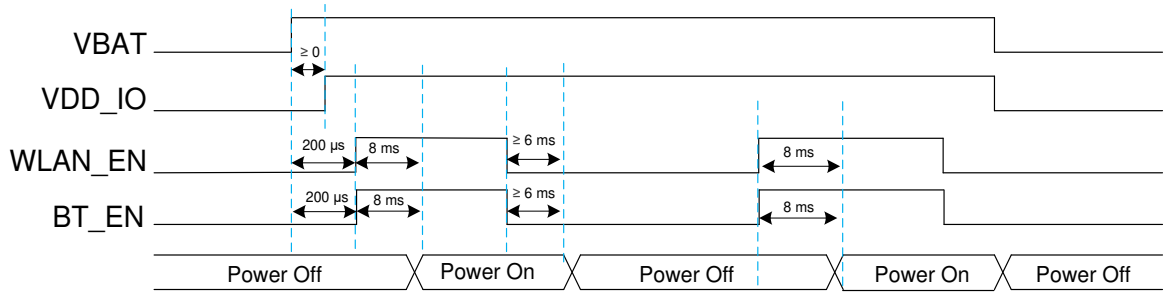


Figure 4: Power-up Timing

NOTE

1. VDD_IO's power on time ≥ VBAT's power on time.
2. WLAN_EN or BT_EN's high time ≥ VDD_IO's power on time + 200 µs.
3. Module all power on ready time ≥ WLAN_EN or BT_EN's high time + 8 ms.
4. WLAN_EN or BT_EN's low time to module all power off time ≥ 6 ms.

4.4. Wi-Fi Application Interfaces

The Wi-Fi application interface connection between the module and the host is illustrated in the following figure

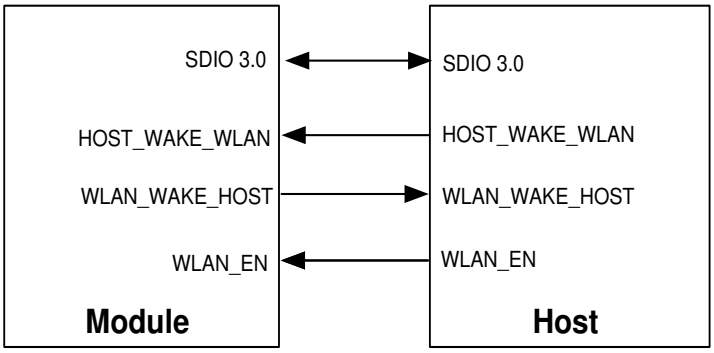


Figure 5 Wi-Fi Application Interface Connection

4.4.1. SDIO Interface

The module provides SDIO 3.0 interface communicating with the host for Wi-Fi functions. SDIO interface connection between the module and the host is illustrated in the following figure.

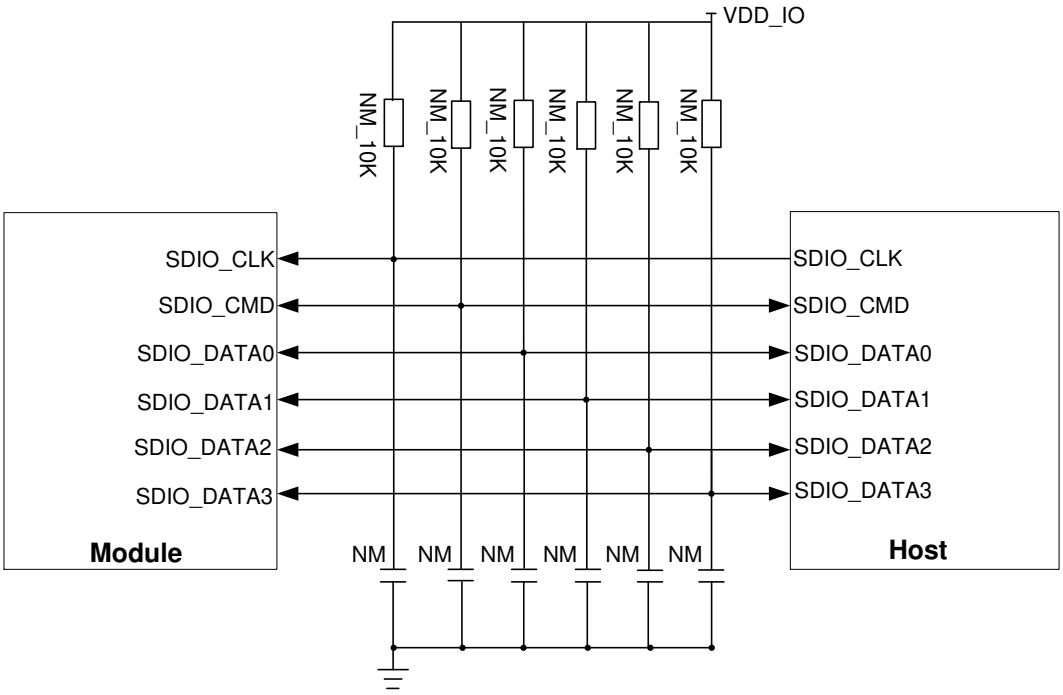


Figure 6: SDIO Interface Connection

To ensure compliance of interface design with the SDIO 3.0 specification, it is recommended to adopt the following principles:

- To avoid jitter of bus, pull up SDIO_CLK and SDIO_DATA_[0:3]/SDIO_CMD to VDD_IO with resistors respectively. Value range of these resistors should be 10–100 kΩ and the recommended value is 10 kΩ.
- The impedance of SDIO signal trace is 50 Ω ±10 %. Route the SDIO traces in inner layer of the PCB, and surround the traces with ground on that 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.
- 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.
- Route the SDIO traces on the same floor as much as possible and surround them with ground without crossing with each other.

4.5. Bluetooth Application Interfaces

The Bluetooth application interface connection between the module and the host is illustrated in the following figure

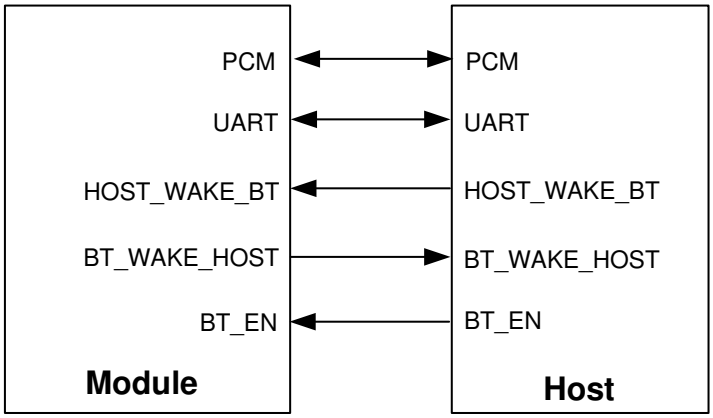


Figure 7: Bluetooth Application Interface Connection

4.5.1. UART

The module supports Bluetooth HCI (Host Controller Interface) UART which supports hardware flow control (RTS/CTS) and can be used for data transmission with the host. The baud rate can be up to 3.25 Mbps.

Table 8: UART Parameters

Parameter	Description
Data Bits Per Frame	8 bits
Parity	None
Number of Stop Bits	1 bit
Hardware Flow Control	RTS/CTS

4.5.2. PCM Interface

The module provides a PCM interface for Bluetooth audio application. It supports the following features:

- Supports Master and Slave mode
- Programmable Long/Short Frame Sync
- Supports 8-bit A-law/u-law, and 13/16-bit linear PCM formats
- Supports sign-extension
- PCM Master Clock Output: 64 kHz, 128 kHz, 256 kHz, or 512 kHz
- Supports SCO/eSCO link

4.6. RF 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 provides two antenna pins (ANT_WIFI/BT and ANT_BT) among which the ANT_BT is optional. The impedance of antenna port is 50 Ω.

Table 9: Antenna Design Requirements

Parameter	Requirement [4]
Frequency Ranges (GHz)	● 2.4 GHz: 2.400–2.4835 ● 5 GHz: 5.150–5.850
Cable Insertion Loss (dB)	< 1
VSWR	≤ 2 (Typ.)
Gain (dBi)	2.4GHZ : ≤0.73 dBi 5G HZ: ≤ 1.14dBi
Max Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Vertical

4.6.1. Reference Design

A reference circuit for the RF antenna interface is shown below. It is recommended to reserve a π-type matching circuit and add ESD protection components 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.

The following reference design is based on ANT_WIFI/BT as an example, the reference design of other RF antenna interfaces is the same.

[4] For more details about the RF performances, see ***Chapter 3***.

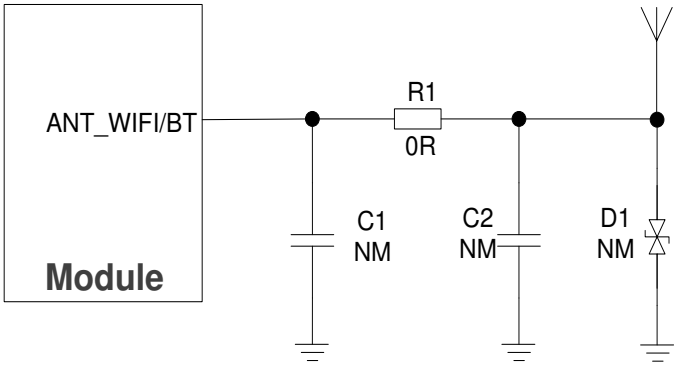


Figure 8: Reference Circuit for RF Antenna Interface

4.6.2. 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.

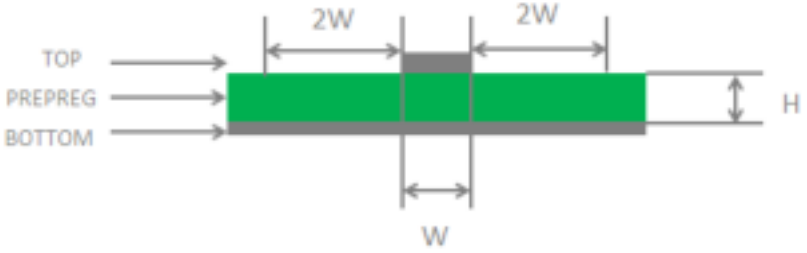


Figure 9: Microstrip Design on a 2-layer PCB

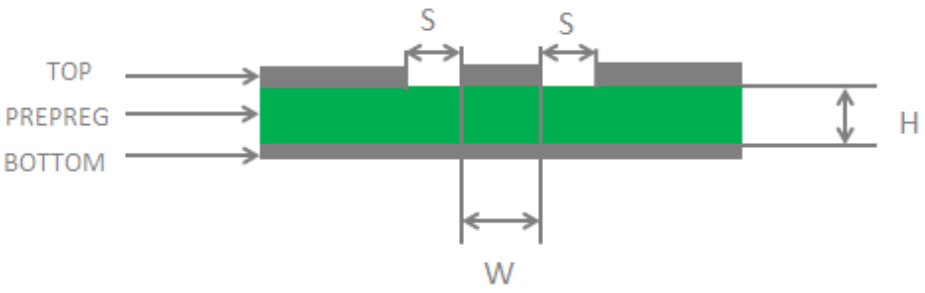


Figure 10: Coplanar Waveguide Design on a 2-layer PCB

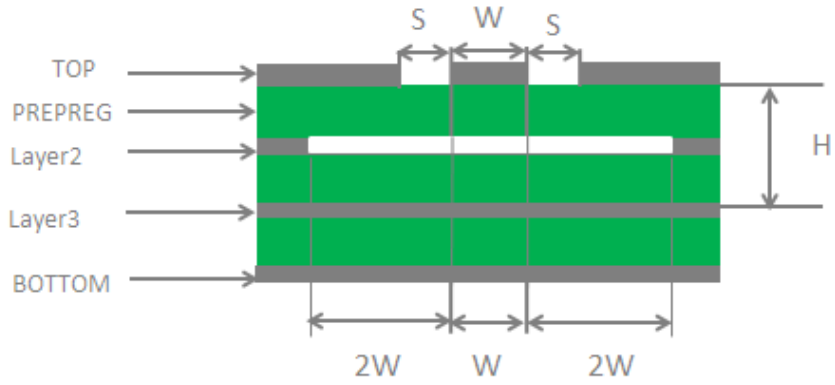


Figure 11: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

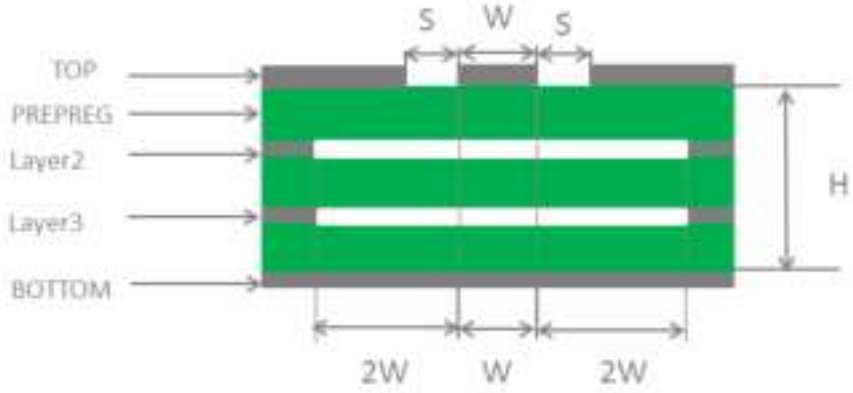


Figure 12: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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 Ω.
- The GND pins adjacent to RF pins should not be designed as thermal relief pads, and should be fully connected to ground.
- 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 not less than 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 [1]***.

4.6.3. 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.

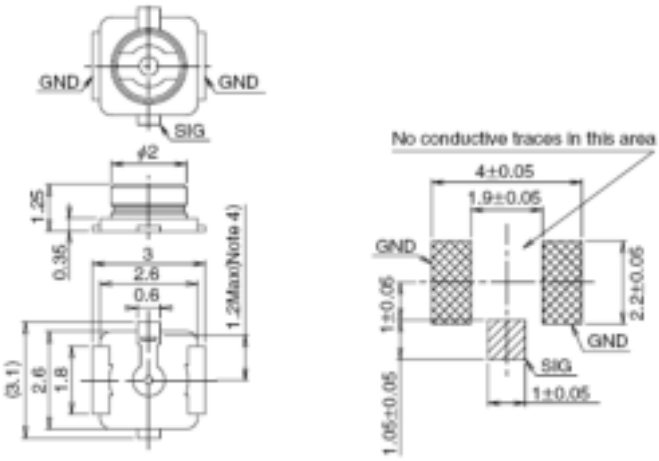


Figure 13: Dimensions of the Receptacle (Unit: mm)

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

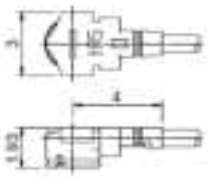
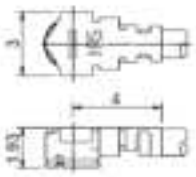
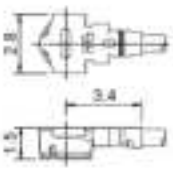
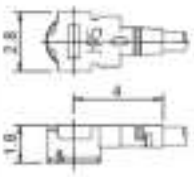
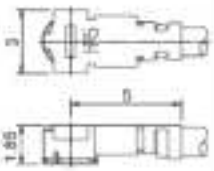
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 14: Specifications of Mated Plugs

The following figure describes the space factor of mated connectors.

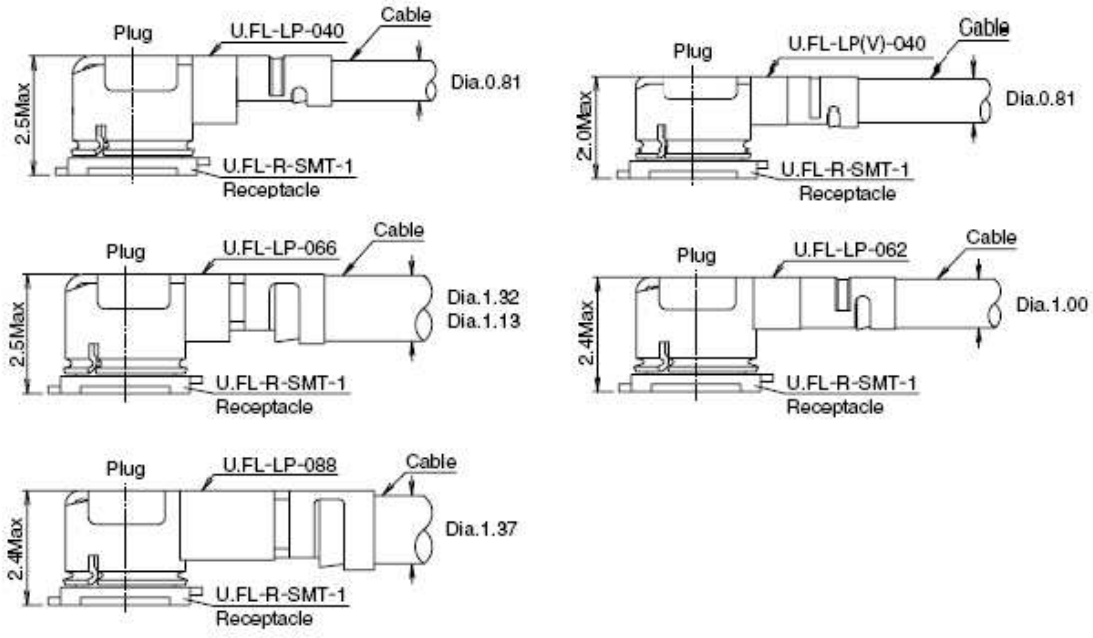


Figure 15: Space Factor of Mated Connectors (Unit: mm)

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

5 Electrical Characteristics & Reliability

5.1. Absolute Maximum Ratings

Table 10: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VBAT	-0.3	3.6
VDD_IO	-0.3	3.6
Voltage at Digital Pins	-0.3	3.6

5.2. 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.	3.0	3.3	3.6
VDD_IO	Power supply for the module's I/O pins	-	1.71	1.8/3.3	3.63

5.3. Power Consumption

5.3.1. Wi-Fi Power Consumption

Table 12: Wi-Fi Power Consumption

Condition			I_{VDD_IO}	I_{VBAT}	Unit
2.4 GHz	802.11b	Tx @ 1 Mbps	1.94	302.809	mA
		Tx @ 11 Mbps	4.084	178.482	mA
	802.11g	Tx @ 6 Mbps	3.384	206.316	mA
		Tx @ 54 Mbps	6.706	96.536	mA
	802.11n	Tx HT20 @ MCS 0	2.811	274.119	mA
		Tx HT20 @ MCS 7	5.812	139.41	mA
		Tx HT40 @ MCS 0	3.418	277.887	mA
		Tx HT40 @ MCS 7	6.465	143.633	mA
	802.11ax	Tx HE20 @ MCS 0	4.612	262.744	mA
		Tx HE20 @ MCS 11	8.697	106.781	mA
		Tx HE40 @ MCS 0	4.914	269.08	mA
		Tx HE40 @ MCS 11	9.645	110.919	mA
5 GHz	802.11a	Tx @ 6 Mbps	7.027	241.489	mA
		Tx @ 54 Mbps	10.777	114.905	mA
	802.11n	Tx HT20 @ MCS 0	7.08	306.718	mA
		Tx HT20 @ MCS 7	9.921	163.578	mA
		Tx HT40 @ MCS 0	7.776	275.664	mA
		Tx HT40 @ MCS 7	10.517	134.32	mA
	802.11ac	Tx VHT20 @ MCS 0	7.874	307.566	mA
		Tx VHT20 @ MCS 8	11.105	148.076	mA

		Tx VHT40 @ MCS 0	8.774	309.432	mA
		Tx VHT40 @ MCS 9	12.114	144.725	mA
	802.11ax	Tx HE20 @ MCS 0	9.271	297.141	mA
		Tx HE20 @ MCS 11	13.301	122.743	mA
		Tx HE40 @ MCS 0	10.596	302.692	mA
		Tx HE40 @ MCS 11	14.321	125.739	mA

5.3.2. Bluetooth Power Consumption

Table 13: Bluetooth Power Consumption in Non-signalling Modes

Condition	Transmitting Power	I_{VDD_IO}	I_{VBAT}
BR	5.02	16.32	102.54
EDR (π/4-DQPSK)	1.45	16.714	93.90
EDR (8-DPSK)	1.45	16.814	93.59
BLE (1 Mbps)	4.97	17.134	110.63
BLE (2 Mbps)	4.99	16.854	81.13
BLE Long Range (S = 8) 125 Kbps	4.67	17.23	123.58
BLE Long Range (S = 2) 500 Kbps	5.00	17.267TBD	116.96

5.4. Digital I/O Characteristics

Table 14: VDD_IO I/O Requirements (Unit: V)

Parameter	Description	Min.	Max.
V_{IH}	High-level input voltage	0.7 × VDD_IO	VDD_IO
V_{IL}	Low-level input voltage	0	0.3 × VDD_IO

V_{OH}	High-level output voltage	0.7 × VDD_IO	-
V_{OL}	Low-level output voltage	-	0.3 × VDD_IO

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.

Table 15: Electrostatics Discharge Characteristics (Unit: kV)

Model	Test Result	Standard
Human Body Model (HBM)	±3	*ESDA/JEDEC JS-001-2017*
Charged Device Model (CDM)	±0.8	*ESDA/JEDEC JS-002-2018*

5.6. Thermal Dissipation

The module offers the best performance when all internal IC chips are working within their operating temperatures. When the IC chip reaches or exceeds the maximum junction temperature, the module may still work but the performance and function (such as RF output power, data rate, etc.) will be affected to a certain extent. Therefore, the thermal design should be maximally optimized to ensure all internal IC chips always work within the recommended operating temperature range.

The following principles for thermal consideration are provided for reference:

- Keep the module away from heat sources on your PCB, especially high-power components such as processor, power amplifier, and power supply.
- Maintain the integrity of the PCB copper layer and drill as many thermal vias as possible.
- Follow the principles below when the heatsink is necessary:
  - Do not place large size components in the area where the module is mounted on your PCB to reserve enough place for heatsink installation.
  - Attach the heatsink to the shielding cover of the module; In general, the base plate area of the heatsink should be larger than the module area to cover the module completely;
  - Choose the heatsink with adequate fins to dissipate heat;

- Choose a TIM (Thermal Interface Material) with high thermal conductivity, good softness and good wettability and place it between the heatsink and the module;
- Fasten the heatsink with four screws to ensure that it is in close contact with the module to prevent the heatsink from falling off during the drop, vibration test, or transportation.

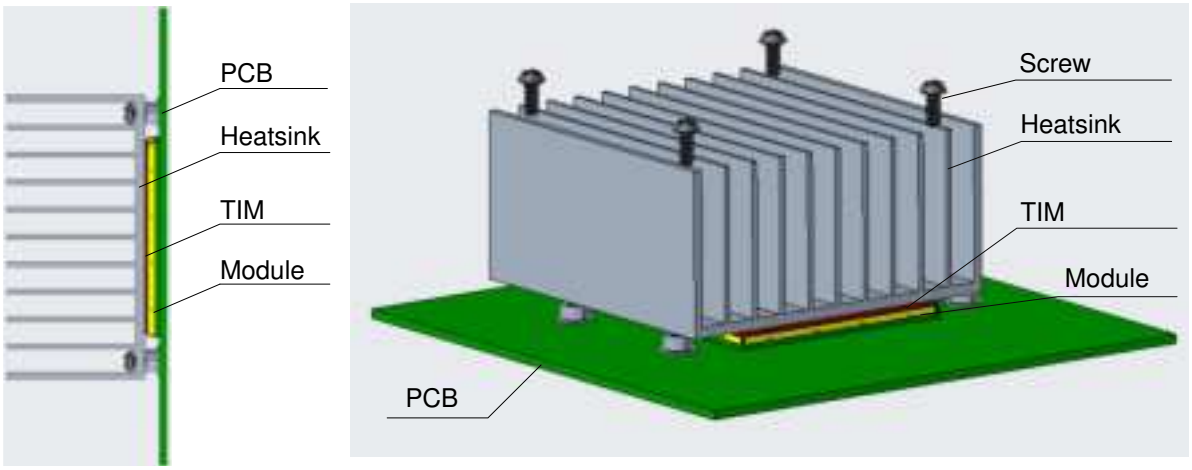


Figure 16: Placement and Fixing of the Heatsink

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

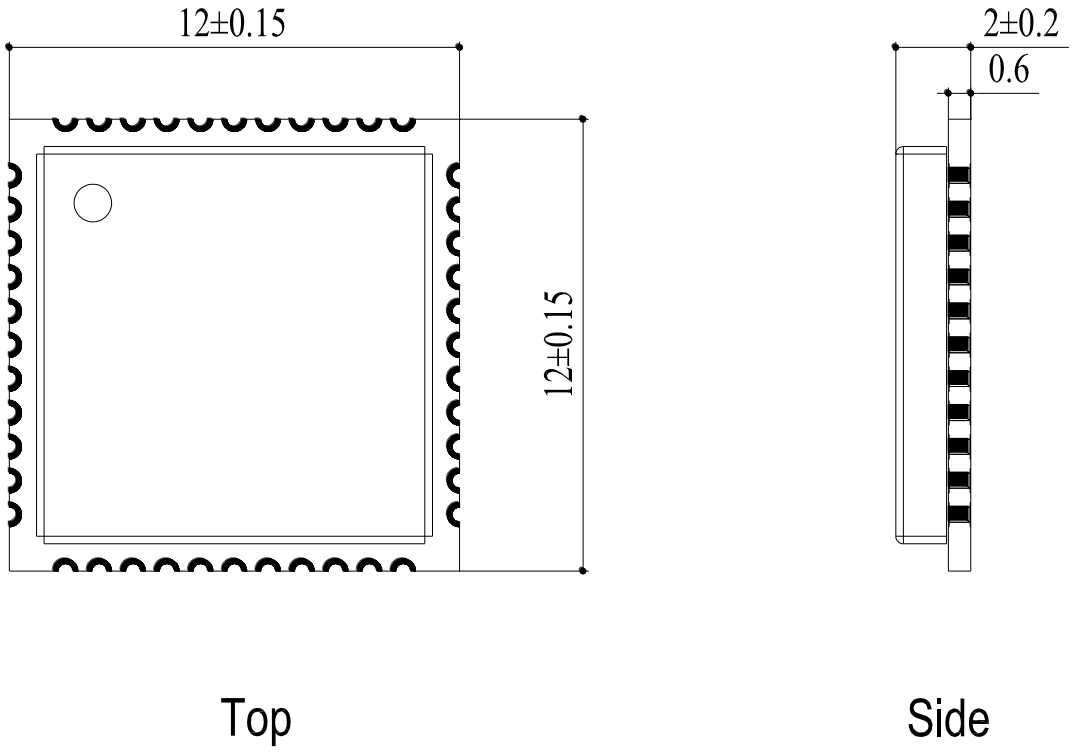


Figure 17: Top and Side Dimensions

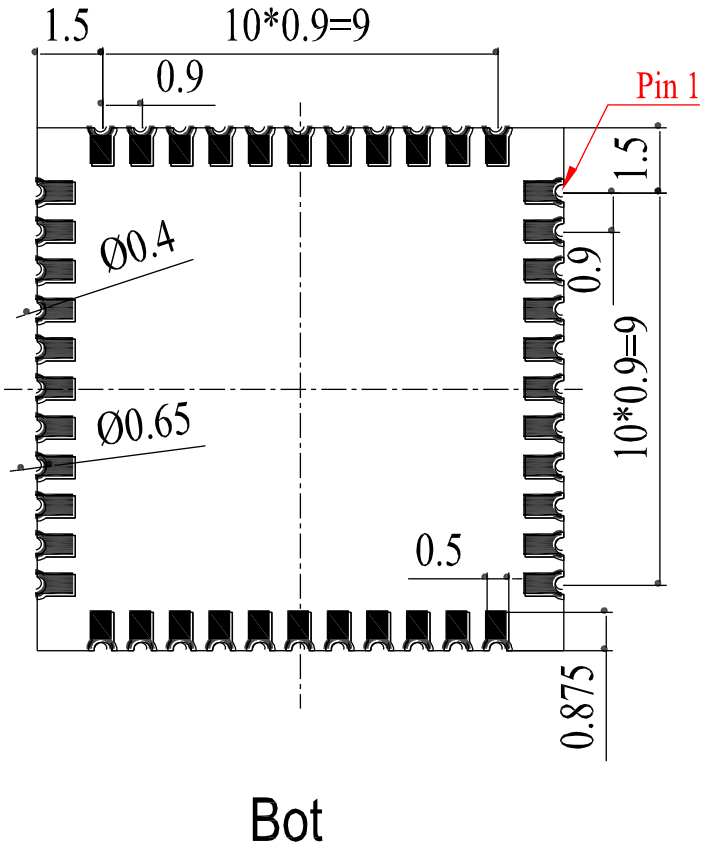


Figure 18: Bottom Dimensions (Bottom View)

NOTE

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

6.2. Recommended Footprint

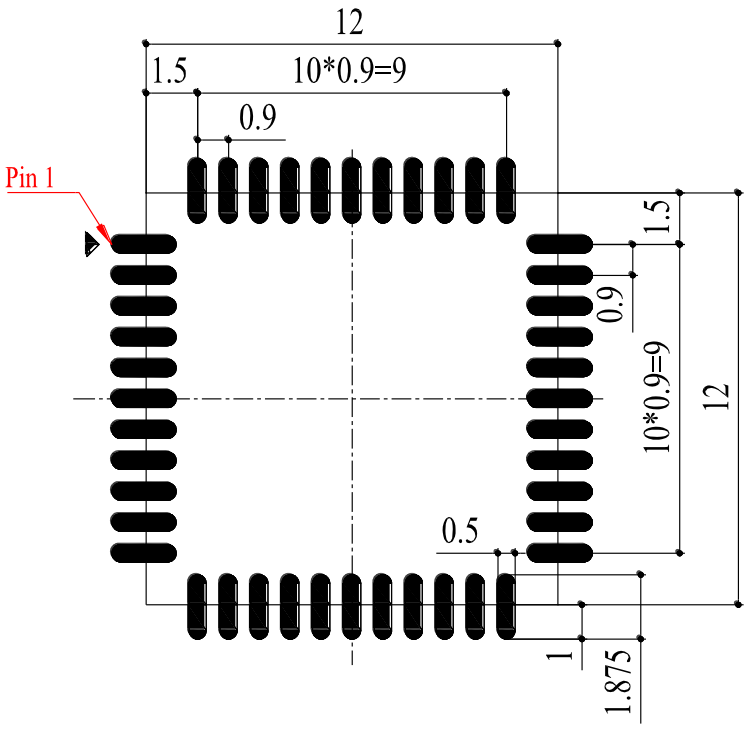


Figure 19: Recommended Footprint

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 & 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 [5] 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.

[5] 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 0.15–0.18 mm. For more details, see ***document [2]***.

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.

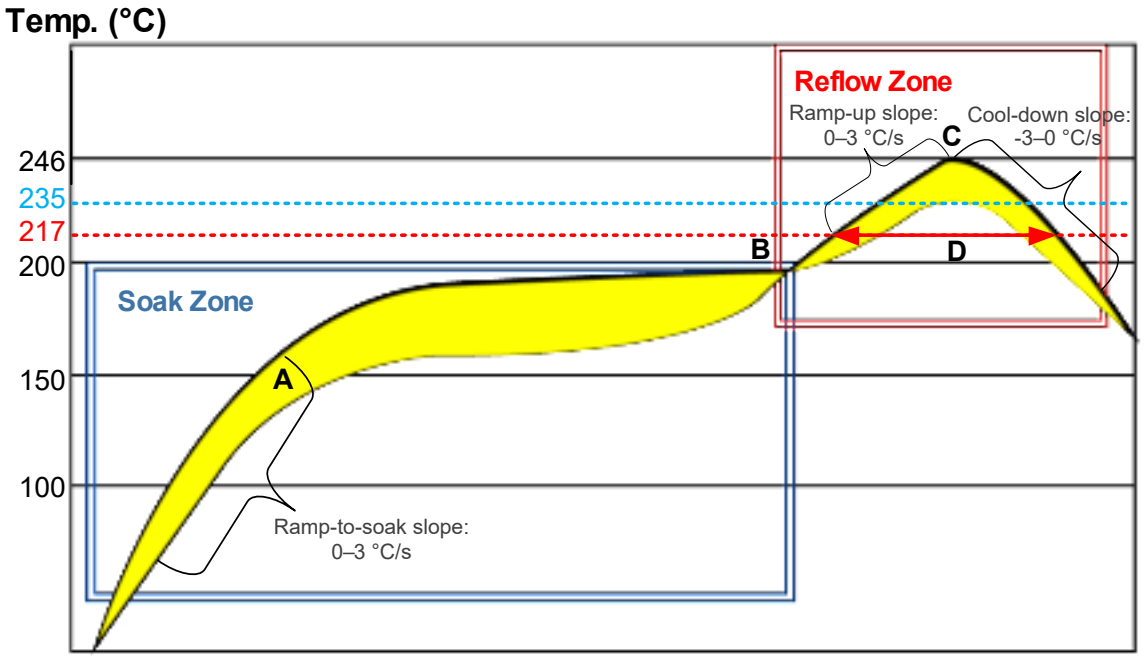


Figure 21: Recommended Reflow Soldering Thermal Profile

Table 16: 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, 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 [2]***.

7.3. 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:

7.3.1. Carrier Tape

Dimension details are as follow:

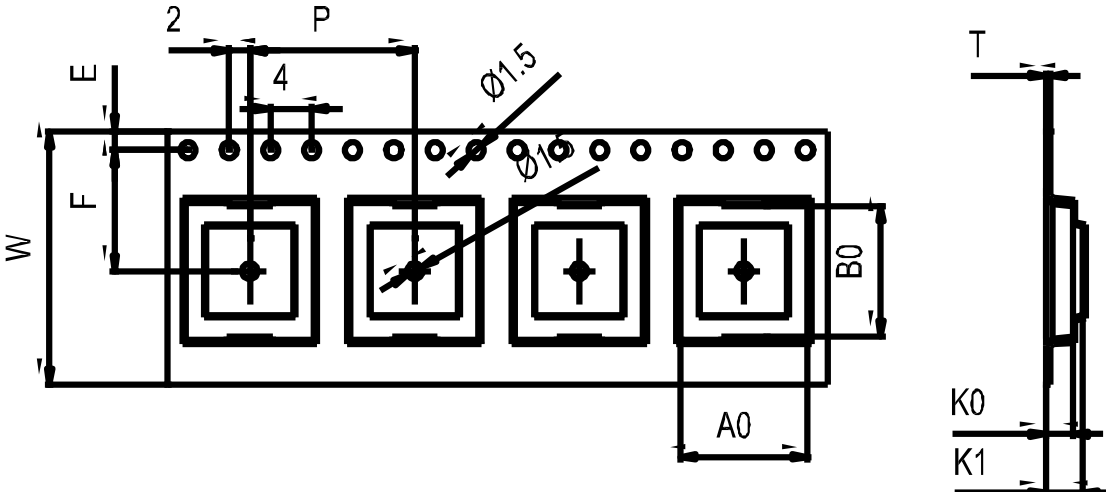


Figure 22: Carrier Tape Dimension Drawing

Table 17: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
24	16	0.35	12.4	12.4	2.6	3.6	11.5	1.75

7.3.2. Plastic Reel

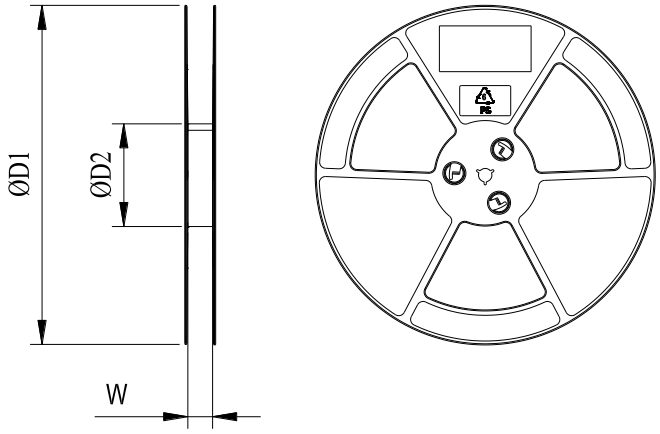


Figure 23: Plastic Reel Dimension Drawing

Table 18: Plastic Reel Dimension Table (Unit: mm)

øD1	øD2	W
330	100	24.5

7.3.3. Mounting Direction

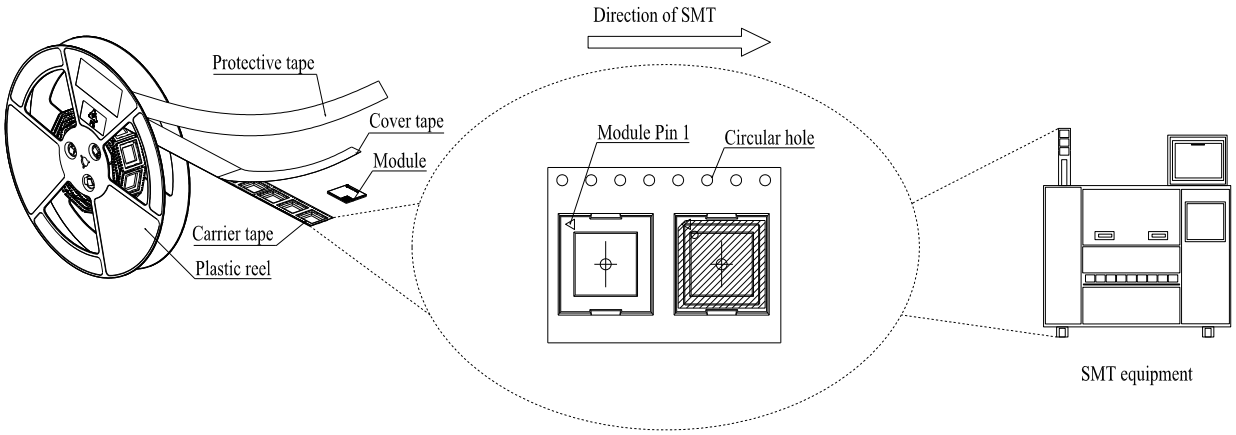
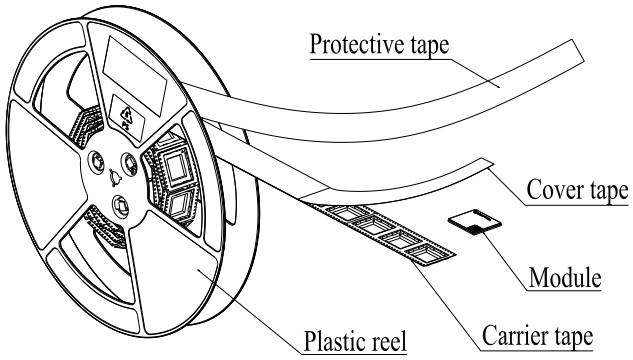


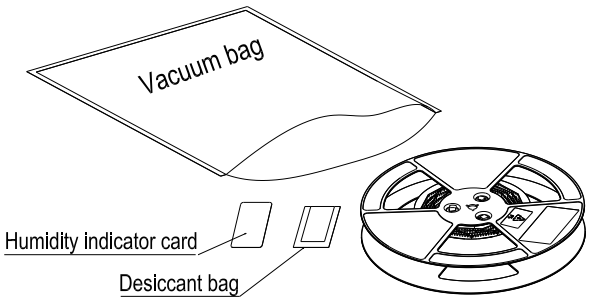
Figure 24: Mounting Direction

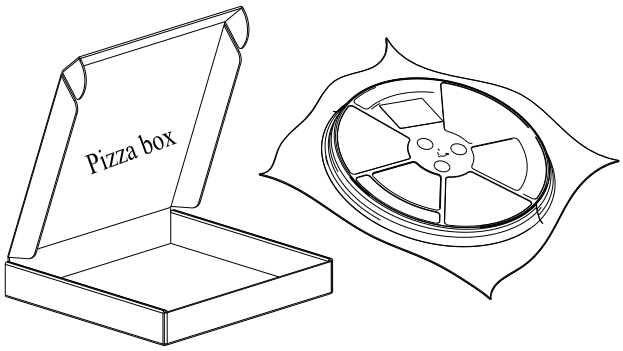
7.3.4. Packaging Process



Place the 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.

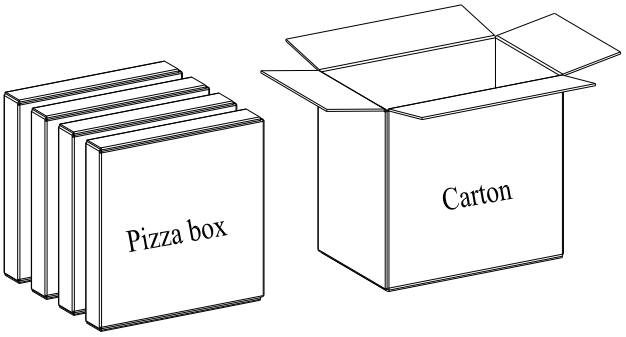


Figure 25: Packaging Process

8 Appendix References

Table 19: Related Documents

Document Name
[1] Quectel_RF_Layout_Application_Note
[2] Quectel_Module_SMT_Application_Note

Table 20: Terms and Abbreviations

Abbreviation	Description
1T1R	One Transmit One Receive
AP	Access Point
BLE	Bluetooth Low Energy
BPSK	Binary Phase Shift Keying
BR	Basic Rate
CCK	Complementary Code Keying
CTS	Clear To Send
DPSK	Differential Phase Shift Keying
DQPSK	Differential Quadrature Phase Shift Keying
DSSS	Direct Sequence Spread Spectrum
EDR	Enhanced Data Rate
eSCO	Extended Synchronous Connection-Oriented
ESD	Electrostatic Discharge

EVM	Error Vector Magnitude
GFSK	Gauss Frequency Shift Keying
GND	Ground
HCI	Host Controller Interface
HE	High Efficiency
HBM	Human Body Model
HT	High Throughput
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
LCC	Leadless Chip Carrier (package)
Mbps	Million Bits Per Second
MCS	Modulation and Coding Scheme
MSL	Moisture Sensitivity Levels
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RTS	Request to Send
Rx	Receive
SAE	Simultaneous Authentication of Equals
SCO	Synchronous Connection-Oriented
SDIO	Secure Digital Input/Output
SMD	Surface Mount Device

SMT	Surface Mount Technology
STA	Station
TBD	To Be Determined
TVS	Transient Voltage Suppressor
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
USB	Universal Serial Bus
VHT	Very High Throughput
V_{IH}	High-level Input Voltage
V_{IL}	Low-level Input Voltage
Vmax	Maximum Voltage
Vmin	Minimum Voltage
Vnom	Nominal Voltage
V_{OH}	High-level Output Voltage
V_{OL}	Low-level Output Voltage
VSWR	Voltage Standing Wave Ratio
WEP	Wired Equivalent Privacy
Wi-Fi	Wireless Fidelity
WPA	Wi-Fi Protected Access

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 time-averaging 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: XMR2023FCS960KN.

4.To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed:

- Bluetooth/Bluetooth LE/Wi-Fi 2.4G:≤0.73 dBi
- U-NII-1: ≤1.14 dBi
  U-NII-2A: ≤1.00 dBi
  U-NII-2C: ≤ 0.60 dBi
  U-NII-3: ≤0.95 dBi

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: XMR2023FCS960KN." or "Contains FCC ID: XMR2023FCS960KN." 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.
IC Certification Requirements.

This device contains licence-exempt transmitteris)/receivers) that comply with Innovation, Science and EconomicDevelopment Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:
1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device.

To comply with IC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed:
❒ Bluetooth/Bluetooth LE/Wi-Fi 2.4G:≤0.73 dBi
❒ U-NII-1: ≤1.14 dBi
U-NII-2A: ≤1.00 dBi
U-NII-2C: ≤ 0.60 dBi
U-NII-3: ≤0.95 dBi

L'appareil contient un émetteur / récepteur exempté de licence conforme au CNR exempté de licence d'innovation, sciences et développement économique Canada. Les opérations sont soumises aux deux conditions suivantes:

1. Cet appareil peut ne pas causer d'interférence.

L'appareil doit accepter toute interférence, y compris celles qui peuvent entraîner un fonctionnement indésirable de l'appareil.

This equipment complies with ISED radiation exposure limits set forth for an uncontrolled environment. To comply with RSS-102 RF Exposure compliance requirements, this grant is applicable to only Mobile Configurations. The antennas used for the transmitter must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

The host product shall be properly labelled 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-023FCS960KN” or “where: 10224A-023FCS960KNis the module’s certification number”.