FC65E&FC66E Series
Hardware Design

Wi-Fi&Bluetooth Module Series

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Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any terminal or mobile incorporating the module. Manufacturers of the terminal should notify users and

operating personnel of the following safety information by incorporating these guidelines into all manuals of the product. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be paid to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If there is an Airplane Mode, it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on an aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.
	Terminals or mobiles operating over radio signal and cellular network cannot be guaranteed to connect in certain conditions, such as when the mobile bill is unpaid or the (U)SIM card is invalid. When emergency help is needed in such conditions, use emergency call if the device supports it. In order to make or receive a call, the terminal or mobile must be switched on in a service area with adequate cellular signal strength. In an emergency, the device with emergency call function cannot be used as the only contact method considering network connection cannot be guaranteed under all circumstances.
	The terminal or mobile contains a transceiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.
	In locations with explosive or potentially explosive atmospheres, obey all posted signs and turn off wireless devices such as mobile phone or other terminals. Areas with explosive or potentially explosive atmospheres include fueling areas, below decks on boats, fuel or chemical transfer or storage facilities, and areas where the air contains chemicals or particles such as grain, dust or metal powders.

About the Document

Revision History

Version	Date	Author	Description
-	2020-12-30	Soni RAO/ Michael DU	Creation of the document
1.0.0	2023-08-09	Soni RAO/ Amy HAN	Released

Contents

Table Index

Figure Index

1 Introduction

This document defines the FC65E&FC66E series modules and describes their air interfaces and hardware interfaces which are connected with your applications.

This document provides a quick insight into module interface specifications, electrical and mechanical details, as well as other module-related information. Coupled with application notes and user guides, the document makes it easy for you to use the module to design and set up mobile applications.

NOTE

For conciseness purposes, FC65E and FC66E will hereinafter be referred to collectively as "the module/modules" in parts hereof applicable to both models, and individually as "FC65E" and "FC66E" in parts hereof referring to the differences between them.

Hereby, Quectel Wireless Solutions Co., Ltd. declares that the radio equipment type FC66E is in compliance with Directive 2014/53/EU.

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

Disposal of old electrical appliances

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

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

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

The device could be used with a separation distance of 20cm to the human body.

2 Product Overview

2.1. General Description

FC65E&FC66E series are low-power single-die Wi-Fi and Bluetooth combo solutions supporting IEEE 802.11a/b/g/n/ac/ax 2.4 GHz, 5 GHz and 6 GHz Wi-Fi standards and Bluetooth 5.2 standard, which enables seamless integration of Wi-Fi and Bluetooth low energy technologies.

The module can provide Wi-Fi functions with a low-power PCIe Gen 3 interface and Bluetooth functions with a UART and a PCM interface.

2.2. Key Features

Table 1: Key Features

Feature	Detail
Power Supplies	● Core supply voltage: 1.0 V, 1.8 V, 2.0 V ● I/O supply voltage: 1.8 V ● RF supply voltage: 2.0 V
Operating Frequencies	● 2.4 GHz Wi-Fi: 2.400–2.4835 GHz ● 5 GHz Wi-Fi: 5.150–5.850 GHz ● 6 GHz Wi-Fi: 5.925–7.125 GHz ● Bluetooth: 2.400–2.4835 GHz
Wi-Fi Features	● Compliant with IEEE 802.11a/b/g/n/ac/ax ● Supported channel bandwidths: − 20/40 MHz at 2.4 GHz − 20/40/80/160 MHz at 5 GHz and 6 GHz ● 2 × 2 Multi-User Multiple-Input Multiple-Output (MU-MIMO) **FC66E** ● Dual Band Simultaneous (DBS) with dual MAC, up to 3.0 Gbps data rate (2 × 2 + 2 × 2 802.11ax DBS)
Bluetooth Features	● Adaptive frequency hopping (AFH) for reducing radio frequency interference ● Compliant with *Bluetooth Core Specification Version 5.2* with provisions for

	supporting future specifications ● Supports Bluetooth Class 1 or Class 2 transmitting power ● Supports 2 Mbps Bluetooth Low Energy (BLE), BLE Long Range
Wi-Fi Transmission Data Rates	● 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), VHT80 (MCS 0–9), VHT160 (MCS 0–9) ● 802.11ax: HE20 (MCS 0–11), HE40 (MCS 0–11), HE80 (MCS 0–11), HE160 (MCS 0–11)
Wi-Fi Transmitting Power	**2.4 GHz:** ● 802.11b @ 11 Mbps: 17 dBm ±2 dB ● 802.11g @ 54 Mbps: 14.5 dBm ±2 dB ● 802.11n, HT20 @ MCS 7: 13.5 dBm ±2 dB ● 802.11n, HT40 @ MCS 7: 13 dBm ±2 dB ● 802.11ax, HE20 @ MCS 11: 11 dBm ±2 dB ● 802.11ax, HE40 @ MCS 11: 10 dBm ±2 dB **5 GHz:** ● 802.11a @ 54 Mbps: 13 dBm ±2 dB ● 802.11n, HT20 @ MCS 7: 12 dBm ±2 dB ● 802.11n, HT40 @ MCS 7: 11.5 dBm ±2 dB ● 802.11ac, VHT20 @ MCS 8: 11.5 dBm ±2 dB ● 802.11ac, VHT40 @ MCS 9: 10.5 dBm ±2 dB ● 802.11ac, VHT80 @ MCS 9: 10 dBm ±2 dB ● 802.11ac, VHT160 @ MCS 9: 9.5 dBm ±2 dB ● 802.11ax, HE20 @ MCS 11: 9.5 dBm ±2 dB ● 802.11ax, HE40 @ MCS 11: 9.5 dBm ±2 dB ● 802.11ax, HE80 @ MCS 11: 8.5 dBm ±2 dB ● 802.11ax, HE160 @ MCS 11: 8 dBm ±2 dB **6 GHz:** ● 802.11a @ 54 Mbps: 12 dBm ±2 dB ● 802.11ax, HE20 @ MCS 11: 8.5 dBm ±2 dB ● 802.11ax, HE40 @ MCS 11: 8.5 dBm ±2 dB ● 802.11ax, HE80 @ MCS 11: 7.5 dBm ±2 dB ● 802.11ax, HE160 @ MCS 11: 7 dBm ±2 dB
Wi-Fi Operation Modes	● AP ● STA
Wi-Fi Encryption Mode	WPA3
Wi-Fi Modulations	CCK, DBPSK, DQPSK, BPSK, QPSK, 64QAM, 256QAM, 1024QAM
Bluetooth Transmitting Power	● BR (GFSK): 7 dBm (Typ.) ● EDR (π/4-DQPSK): 4 dBm (Typ.)

	● EDR (8-DPSK): 4 dBm (Typ.) ● BLE (1 Mbps): 7 dBm (Typ.) ● BLE (2 Mbps): 7 dBm (Typ.)
Bluetooth Operation Modes	● Classic Bluetooth (BR + EDR) ● Bluetooth Low Energy (BLE)
Bluetooth Modulations	GFSK, π/4-DQPSK, 8-DPSK
Wi-Fi Application Interface	PCIe 3.0
Bluetooth Application Interfaces	● UART ● PCM
RF Antenna Interfaces	● ANT_WIFI0/BT ● ANT_WIFI1 ● ANT_BT (optional) ● 50 Ω characteristic impedance
Physical Characteristics	● Size: (19.9 ±0.15) mm × (18 ±0.15) mm × (2.1 ±0.2) mm ● Package: LCC ● Weight: approx. 1.6 g
Temperature Ranges	● Operating temperature range [1]: -30 °C to +75 °C ● Storage temperature range: -40 °C to +85 °C
RoHS	All hardware components are fully compliant with EU RoHS directive

2.3. EVB Kit

[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. Thermal dissipation is necessary for the module in soft-AP mode. Within this range, the module's indicators comply with IEEE and Bluetooth specification requirements.

To help you develop applications with the module, Quectel supplies an evaluation board (FC6xE M.2 EVB) with accessories to develop and test the module. For more details, see ***document [1]***.

3 Application Interfaces

3.1. Pin Assignment

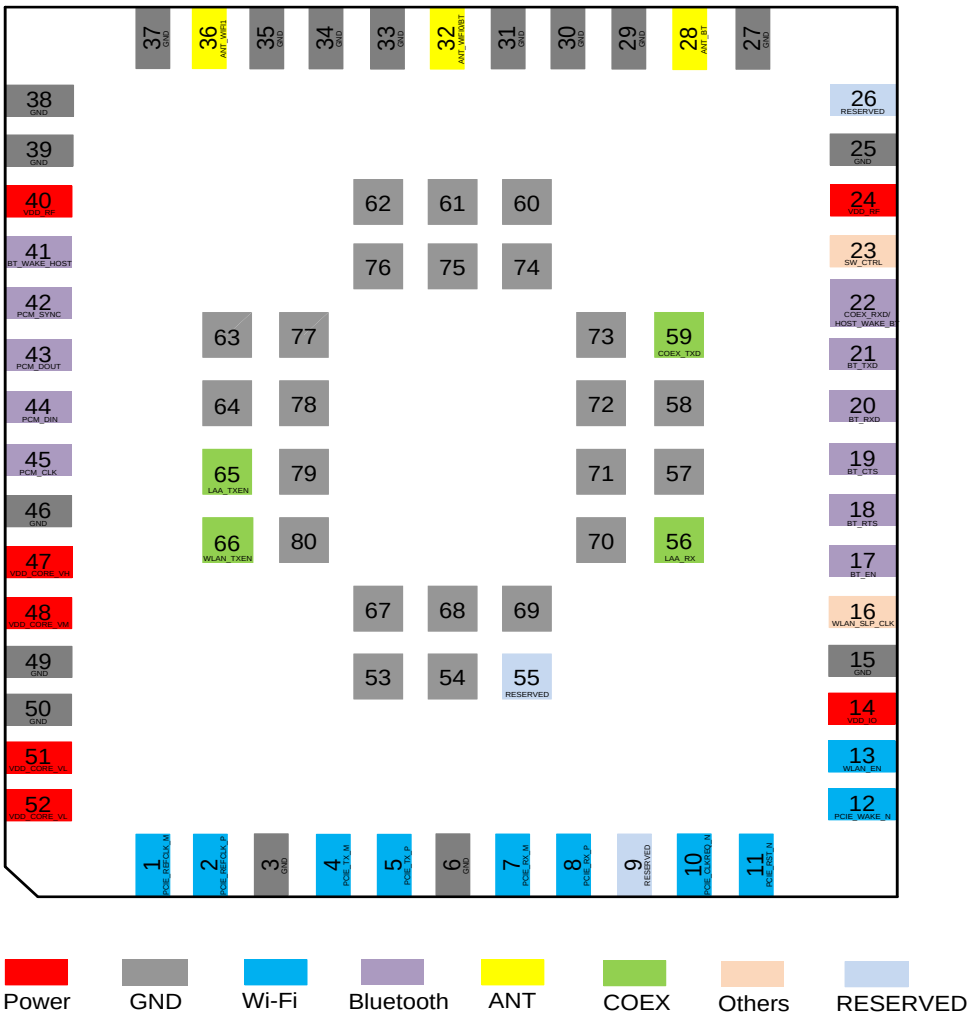


Figure 1: Pin Assignment (Top View)

NOTE

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

3.2. Pin Description

Table 2: Parameters Definition

Parameter	Description
AI	Analog Input
AO	Analog Input
AIO	Analog Input/Output
DI	Digital Input
DO	Digital Output
PI	Power Input

DC characteristics include power domain and rate current.

Table 3: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VDD_CORE_VL	51, 52	PI	Provides 1.0 V for the module's main chip	Vmin = 0.9 V Vnom = 1.0 V Vmax = 1.05 V	It must be provided with sufficient current up to 0.8 A.
VDD_CORE_VM	48	PI	Provides 1.8 V for the module's main chip	Vmin = 1.3 V Vnom = 1.8 V Vmax = 2.1 V	It must be provided with sufficient current up to 0.4 A.
VDD_CORE_VH	47	PI	Provides 2.0 V for the module's main chip	Vmin = 1.85 V Vnom = 2.0 V Vmax = 2.1 V	It must be provided with sufficient current up to 0.4 A.
VDD_IO	14	PI	Provides 1.8 V for the module's I/O pins	Vmin = 1.71 V Vnom = 1.8 V Vmax = 1.89 V	It must be provided with sufficient current up to 0.05 A.
VDD_RF	24, 40	PI	Provides 2.0 V for external RF circuit	Vmin = 1.9 V Vnom = 2.0 V Vmax = 2.4 V	It must be provided with sufficient current up to 2.0 A.
GND	3, 6, 15, 25, 27, 29–31, 33–35, 37–39, 46, 49, 50, 53, 54, 57, 58, 60–64, 67–80				

Wi-Fi Application Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WLAN_EN	13	DI	WLAN function enable control	VDD_IO	Active high.
PCIE_REFCLK_M	1	AI	PCIe reference clock (-)		Require differential impedance of 85 Ω. PCIe Gen 3 compliant.
PCIE_REFCLK_P	2	AI	PCIe reference clock (+)		
PCIE_TX_M	4	AO	PCIe transmit (-)		
PCIE_TX_P	5	AO	PCIe transmit (+)		
PCIE_RX_M	7	AI	PCIe receive (-)		
PCIE_RX_P	8	AI	PCIe receive (+)		
PCIE_CLKREQ_N	10	DO	PCIe clock request	VDD_IO	Active low. Pull each of them up to 1.8 V with an external 10 kΩ resistors respectively.
PCIE_WAKE_N	12	DO	PCIe wake up		
PCIE_RST_N	11	DI	PCIe reset		Active low.
Bluetooth Application Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
BT_EN	17	DI	Bluetooth enable control	VDD_IO	Active high. Pull it down with a 10 kΩ resistor when Bluetooth function is not used.
PCM_DIN	44	DI	PCM data input		If unused, keep them open.
PCM_SYNC	42	DI	PCM data frame sync		
PCM_CLK	45	DI	PCM clock		
PCM_DOUT	43	DO	PCM data output		Do not pull down when Bluetooth function is being enabled.
BT_RTS	18	DO	Request to send signal from the module		If unused, keep them open.

BT_CTS	19	DI	Clear to send signal to the module		
BT_RXD	20	DI	Bluetooth UART receive		
BT_TXD	21	DO	Bluetooth UART transmit		
BT_WAKE_HOST	41	DO	Bluetooth wakes up host		
COEX_RXD/ HOST_WAKE_BT	22	DI	Host wakes up Bluetooth		
RF Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_WIFI0/BT	32	AIO	Wi-Fi 0 and Bluetooth antenna interface		50 Ω characteristic impedance.
ANT_WIFI1	36	AIO	Wi-Fi 1 antenna interface		
ANT_BT [2]	28	AIO	Bluetooth antenna interface		
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WLAN_SLP_CLK	16	DI	WLAN sleep clock input	VDD_IO	32.768 kHz sleep clock input. If unused, pull it down with a 10 kΩ resistor.
SW_CTRL	23	DO	VDD_RF power switch control		Active high. If unused, keep it open.
Coexistence Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
COEX_RXD/ HOST_WAKE_BT	22	DI	LTE & Wi-Fi/ Bluetooth coexistence receive	VDD_IO	If unused, keep them open.
COEX_TXD	59	DO	LTE & Wi-Fi/ Bluetooth coexistence transmit		

[2] The dedicated Bluetooth antenna interface is optional.

LAA_TXEN	65	DI	When it goes high, module places the 5 GHz receiver in a protected state.
WLAN_TXEN	66	DO	Module asserts it to high state when 5 GHz is set to transmit at power greater than 10 dBm.
LAA_RX	56	DI	When it goes high, module allows LAA to receive through the Wi-Fi antennas.
PA_MUTE	55	DI	When it goes high, 2.4 GHz PA is turned off.
RESERVED Pin			
Pin Name	**Pin No.**		**Comment**
RESERVED	9, 26, 55		Keep them open.

3.3. Power Supply

The following table shows the power supply and ground pins of the module.

Table 4: Definition of Power Supply and GND Pins (Unit: V)

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VDD_CORE_VL	51, 52	Provides 1.0 V for the module's main chip	0.9	1.0	1.05	V
VDD_CORE_VM	48	Provides 1.8 V for the module's main chip	1.3	1.8	2.1	V
VDD_CORE_VH	47	Provides 2.0 V for the module's main chip	1.85	2.0	2.1	V
VDD_IO	14	Provides 1.8 V for the module's I/O pins	1.71	1.8	1.89	V
VDD_RF	24, 40	Provides 2.0 V for RF circuit	1.9	2.0	2.4	V
GND	3, 6, 15, 25, 27, 29–31, 33–35, 37–39, 46, 49, 50, 53, 54, 57, 58, 60–64, 67–80					

The following figure shows the recommended power-up timing of the module. All input power supplies must be ON and available before WLAN_EN/BT_EN is asserted. There is no requirement for the timing of input power supplies. For more details about reference design of power supply, see ***document [2]***.

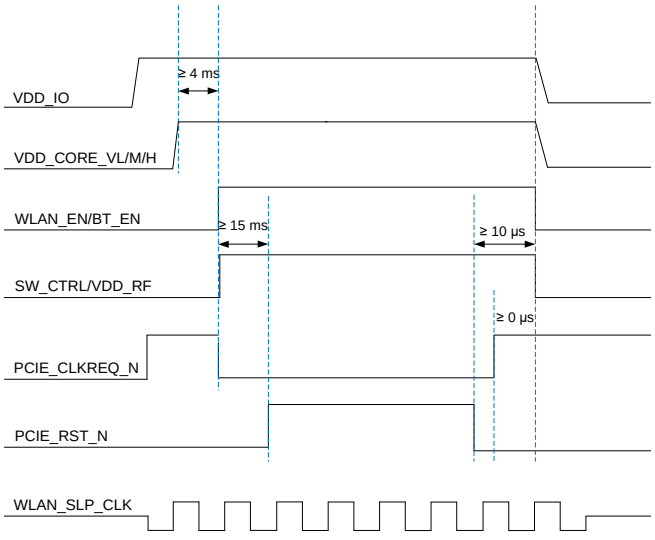


Figure 2: Power-up Timing

3.4. Wi-Fi Application Interfaces

The following figure shows the Wi-Fi application interface connection between the module and the host.

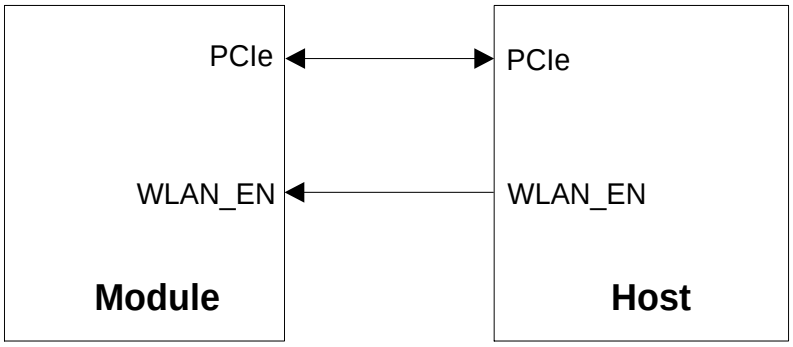


Figure 3: Wi-Fi Application Interface Connection

3.4.1. WLAN_EN

WLAN_EN is used to control the Wi-Fi function of the module. Wi-Fi function will be enabled when WLAN_EN is at high level.

Table 5: Pin Definition of WLAN_EN

Pin Name	Pin No.	I/O	Description	Comment
WLAN_EN	13	DI	WLAN function enable control	Active high.

3.4.2. PCIe Interface

The module provides a PCIe interface with key features listed as below:

- *PCI Express Base Specification Revision 3.0* compliant.
- Data rate up to 8 Gbps/lane.
- Can be used to connect to a host as a Wi-Fi function interface.

Table 6: Pin Definition of PCIe Interface

Pin Name	Pin No.	I/O	Description	Comment
PCIE_REFCLK_M	1	AI	PCIe reference clock (-)	Require differential impedance of 85 Ω. PCIe Gen 3 compliant.
PCIE_REFCLK_P	2	AI	PCIe reference clock (+)	

PCIE_TX_M	4	AO	PCIe transmit (-)	
PCIE_TX_P	5	AO	PCIe transmit (+)	
PCIE_RX_M	7	AI	PCIe receive (-)	
PCIE_RX_P	8	AI	PCIe receive (+)	
PCIE_CLKREQ_N	10	DO	PCIe clock request	Active low. Pull each of them up to 1.8 V with an external 10 kΩ resistors respectively.
PCIE_WAKE_N	12	DO	PCIe wake up	
PCIE_RST_N	11	DI	PCIe reset	Active low.

The following figure shows the PCIe interface connection between the module and the host.

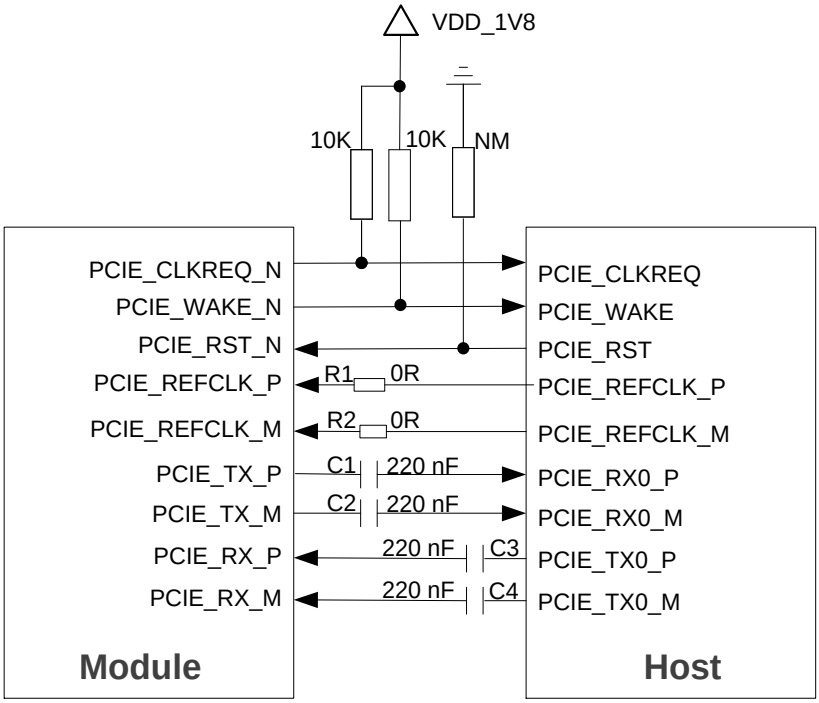


Figure 4: PCIe Interface Connection

To ensure the signal integrity of PCIe interface, C1 and C2 should be placed close to the module, and C3 and C4 should be placed close to the host. The extra stubs of traces must be as short as possible.
The following principles of PCIe interface design should be complied with to meet PCIe Gen 3 specifications.

- It is important to route PCIE_TX_P/M, PCIE_RX_P/M, and PCIE_REFCLK_P/M as differential pairs with total grounding. And the differential impedance should be 85 Ω ±10 %.
- The maximum trace length of each differential pair (PCIE_TX_P/M, PCIE_RX_P/M, and

PCIE_REFCLK_P/M) should be less than 200 mm, and trace length matching within each differential pair should be less than 0.5 mm.

- Space between PCIe signals and all other signals should be four times the trace width.
- Do not route signal traces under crystals, oscillators, magnetic devices, or RF signal traces. It is important to route the PCIe differential traces in inner-layer of the PCB and surround the traces with ground on that layer and with ground planes above and below.

3.5. Bluetooth Application Interfaces

The following figure shows the Bluetooth application interface connection between the module and the host.

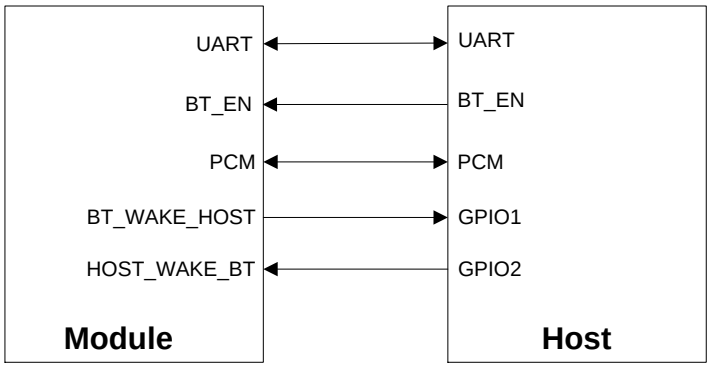


Figure 5: Bluetooth Application Interface Connection

NOTE

The GPIO1 of the host connected to BT_WAKE_HOST must be interruptible.

3.5.1. BT_EN

BT_EN is used to control the Bluetooth function of the module. Bluetooth function will be enabled when BT_EN is at high level.

Table 7: Pin Definition of BT_EN

Pin Name	Pin No.	I/O	Description	Comment
BT_EN	17	DI	Bluetooth enable control	Active high. If unused, pull it down with a 10 kΩ resistor.

3.5.2. UART

The module supports an HCI UART as defined in *Bluetooth Core Specification Version 5.2*. The UART supports hardware flow control, and it is used for data transmission with the host. It supports up to 3.2 Mbps baud rates.

Table 8: Pin Definition of UART

Pin Name	Pin No.	I/O	Description	Comment
BT_RTS	18	DO	Request to send signal from the module	If unused, keep them open.
BT_CTS	19	DI	Clear to send signal to the module	
BT_TXD	21	DO	Bluetooth UART transmit	
BT_RXD	20	DI	Bluetooth UART receive	

The module provides 1.8 V UART. A voltage-level translator should be used if the application is equipped with a 3.3 V UART. A voltage-level translator TXS0104EPWR provided by Texas Instruments is recommended. The following figure shows a reference design.

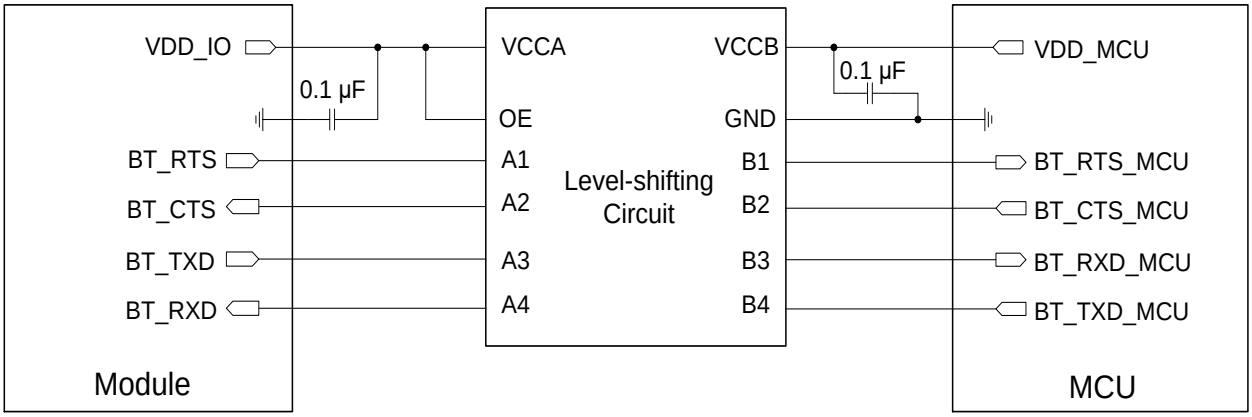


Figure 6: Reference Circuit with a Voltage-level Translator

3.5.3. BT_WAKE_HOST and HOST_WAKE_BT

BT_WAKE_HOST and HOST_WAKE_BT are used to wake up the host and the module respectively.

Table 9: Pin Definition of BT_WAKE_HOST and HOST_WAKE_BT

Pin Name	Pin No.	I/O	Description	Comment

BT_WAKE_HOST	41	DO	Bluetooth wakes up host	If unused, keep them open.
COEX_RXD/ HOST_WAKE_BT	22	DI	Host wakes up Bluetooth	

3.5.4. PCM Interface

The PCM interface is used for Bluetooth audio. The following table shows the pin definition of PCM interface.

Table 10: Pin Definition of PCM Interface

Pin Name	Pin No.	I/O	Description	Comment
PCM_DIN	44	DI	PCM data input	If unused, keep them open.
PCM_SYNC	42	DI	PCM data frame sync	
PCM_CLK	45	DI	PCM clock	
PCM_DOUT	43	DO	PCM data output	Do not pull down when Bluetooth function is being enabled.

The following figure shows the PCM interface connection between the module and the host.

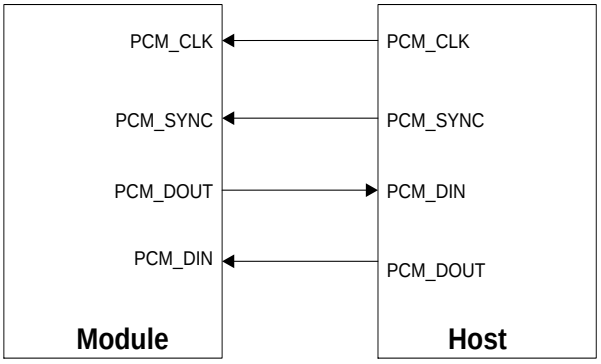


Figure 7: PCM Interface Connection

3.6. Coexistence Interfaces

The module supports 2.4 GHz LTE & Wi-Fi/Bluetooth coexistence and 5 GHz and 6 GHz WWAN & Wi-Fi coexistence.

Table 11: Pin Definition of Coexistence Interfaces

Pin Name	Pin No.	I/O	Description	Comment
COEX_RXD/ HOST_WAKE_BT	22	DI	LTE & Wi-Fi/Bluetooth coexistence receive	If unused, keep them open.
COEX_TXD	59	DO	LTE & Wi-Fi/Bluetooth coexistence transmit	
LAA_TXEN	65	DI	When it goes high, module places the 5 GHz receiver in a protected state.	
WLAN_TXEN	66	DO	Module asserts it to high state when 5 GHz is set to transmit at power greater than 10 dBm.	
LAA_RX	56	DI	When it goes high, module allows LAA to receive through the Wi-Fi antennas.	

3.7. Other Interfaces

3.7.1. WLAN_SLP_CLK

The WLAN_SLP_CLK is 32.768 kHz sleep clock which is used in low power modes, such as IEEE power saving mode and sleep mode. It serves as a timer in various power saving schemes, and can maintain basic logic operations when the module is in sleep mode.

Table 12: Pin Definition of WLAN_SLP_CLK

Pin Name	Pin No.	I/O	Description	Comment
WLAN_SLP_CLK	16	DI	WLAN sleep clock input	32.768 kHz sleep clock input. If unused, pull it down with a 10 kΩ resistor.

Figure and table below show the requirements of sleep clock:

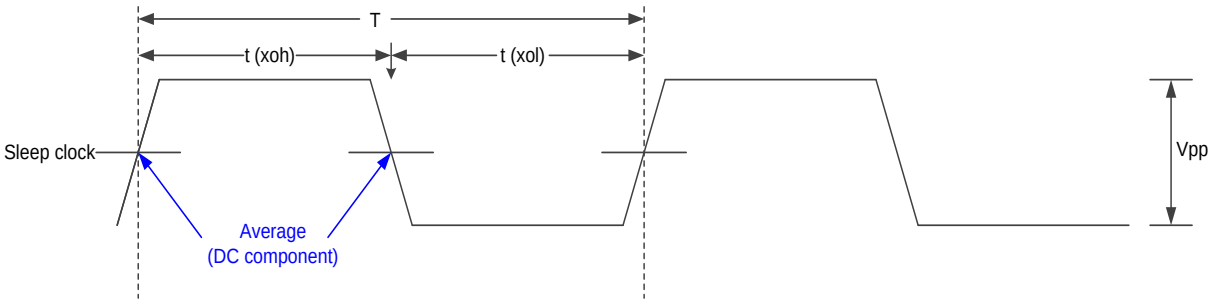


Figure 8: Requirements of WLAN_SLP_CLK

Table 13: Parameters of WLAN_SLP_CLK

Parameter	Comment	Min.	Typ.	Max.	Unit
t (xoh)	Sleep-clock logic high	4.58	4.58	25.94	μs
t (xol)	Sleep-clock logic low	4.58	4.58	25.94	μs
T	Sleep-clock period	-	30.5208	-	μs
F	Sleep-clock frequency (F = 1/T)	-	32.7645	-	kHz
Vpp	Peak-to-peak voltage	-	1.8	-	V

3.7.2. SW_CTRL

SW_CTRL can be used to control external VDD_RF power supply chip. The following table shows the pin definition of SW_CTRL.

Table 14: Pin Definition of SW_CTRL

Pin Name	Pin No.	I/O	Description	Comment
SW_CTRL	23	DO	VDD_RF power switch control	Active high. If unused, keep it open.

3.8. 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.

Table 15: Pin Definition of RF Antenna Interfaces

Pin Name	Pin No.	I/O	Description	Comment
ANT_WIFI0/BT	32	AIO	Wi-Fi 0 and Bluetooth antenna interface	50 Ω characteristic impedance.
ANT_WIFI1	36	AIO	Wi-Fi 1 antenna interface	
ANT_BT [3]	28	AIO	Bluetooth antenna interface	

3.8.1. Operating Frequencies

Table 16: Operating Frequencies (Unit: GHz)

Feature	Frequency
2.4 GHz Wi-Fi	2.400–2.4835
5 GHz Wi-Fi	5.150–5.850
6 GHz Wi-Fi	5.925–7.125
Bluetooth	2.400–2.4835

3.8.2. RF Antenna Reference Design

The module provides three RF antenna interfaces for antenna connection, among which the dedicated Bluetooth antenna interface (ANT_BT) is optional. The following reference design shows an example with ANT_WIFI0/BT. For other RF antenna interfaces, the reference design is the same.

It is recommended to reserve a π-type matching circuit and add ESD protection components for better RF performance. The reserved π-type matching components (C1, C2, R1, D1) should be placed as close to the antenna as possible. C1, C2 and D1 are not mounted by default. The parasitic capacitance of TVS should be less than 0.05 pF and R1 is recommended to be 0 Ω.

[3] Bluetooth antenna interface is optional.

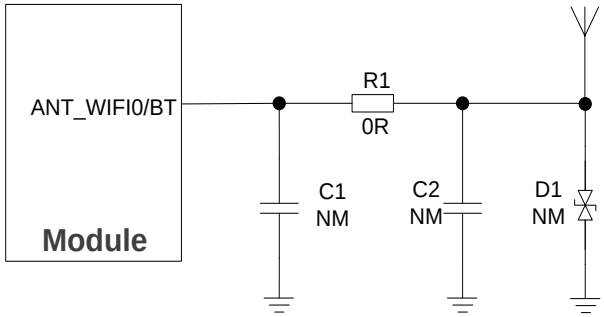


Figure 9: RF Antenna Reference Design

3.8.3. 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.

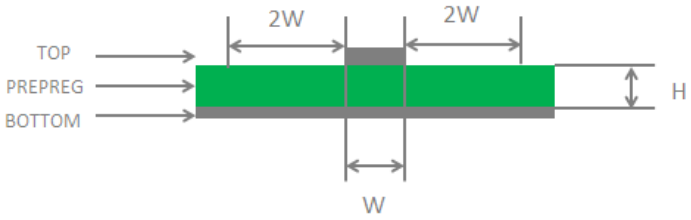


Figure 10: Microstrip Design on a 2-layer PCB

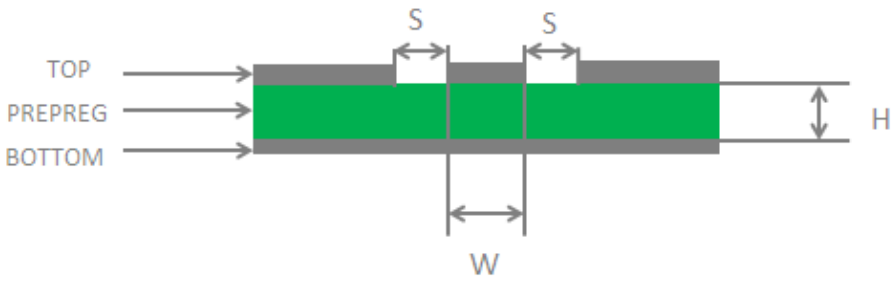


Figure 11: Coplanar Waveguide Design on a 2-layer PCB

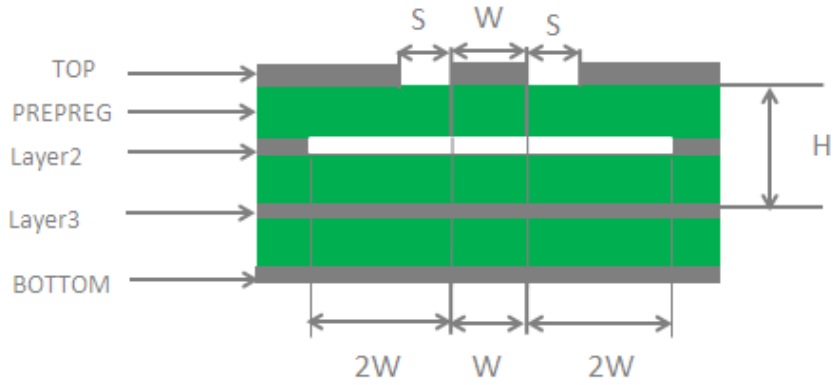


Figure 12: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

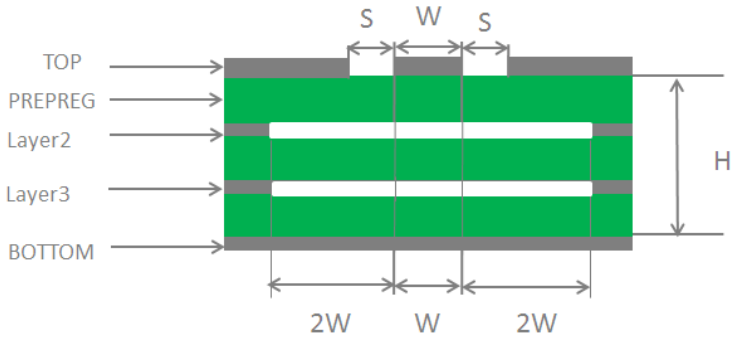


Figure 13: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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 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 [3]***.

3.8.4. Antenna Design Requirements

Table 17: Antenna Design Requirements

Parameter	Requirement
Frequency Range (GHz)	● 2.4 GHz: 2.400–2.4835 ● 5 GHz: 5.150–5.850 ● 6 GHz: 5.925–7.125
Cable Insertion Loss (dB)	< 1
VSWR	≤ 2 (Typ.)
Gain (dBi)	1 (Typ.)
Max. Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Vertical

Note: The antenna connector will be fixed in the actual use of the finished product and cannot be replaced.

3.8.5. 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.

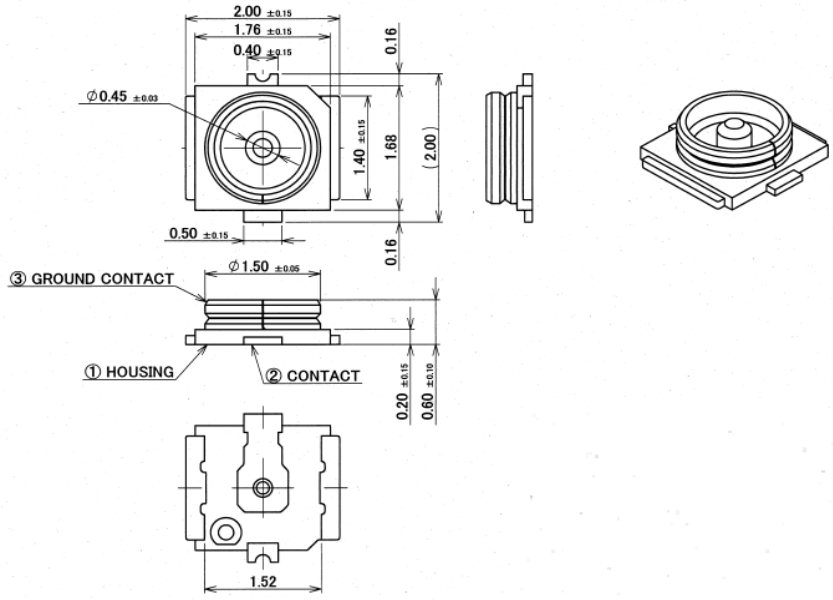


Figure 14: Dimensions of the Receptacle (Unit: mm)

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

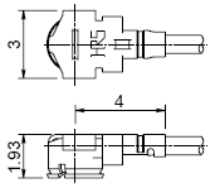
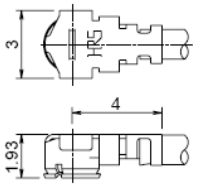
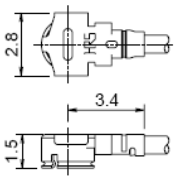
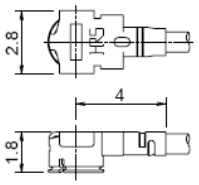
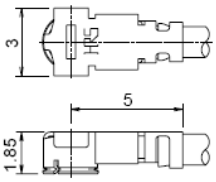
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia.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

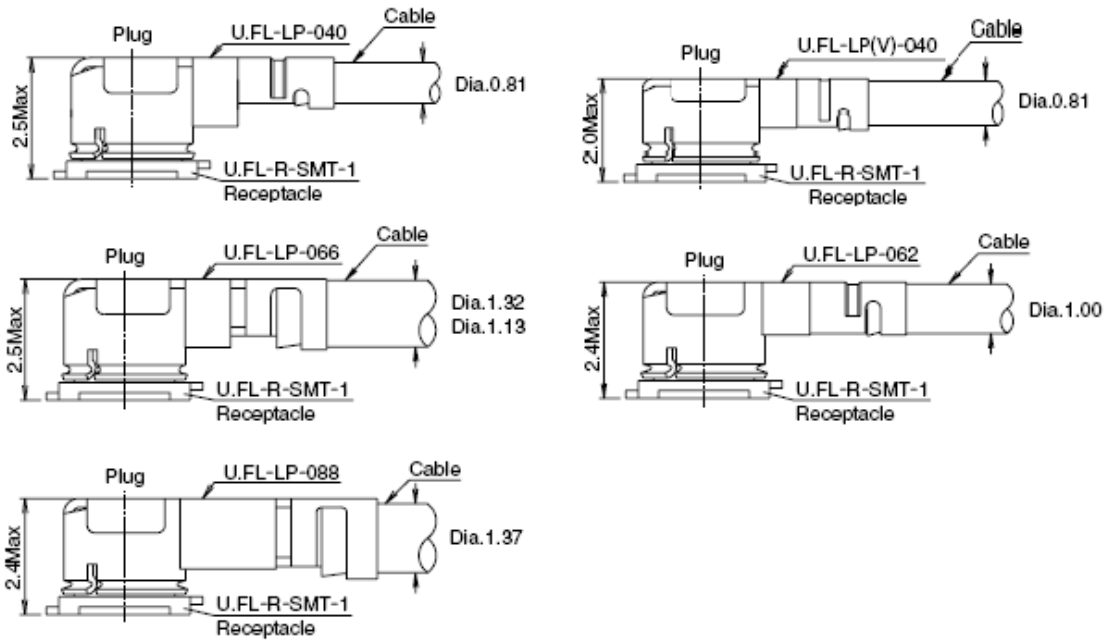


Figure 16: Space Factor of Mated Connectors (Unit: mm)

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

4 Electrical Characteristics & Reliability

4.1. Absolute Maximum Ratings

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

Table 18: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VDD_CORE_VL	-0.3	V_{DDX} + 0.2
VDD_CORE_VM	-0.3	V_{DDX} + 0.2
VDD_CORE_VH	-0.3	V_{DDX} + 0.2
VDD_IO	-0.3	V_{DDX} + 0.2
VDD_RF	-0.3	V_{DDX} + 0.2
Voltage at Digital Pins	-0.3	VDD_IO + 0.2

NOTE

V_{DDX} is the external supply voltage for the corresponding power input pins.

4.2. Power Supply Ratings

Table 19: Module Power Supply Ratings (Unit: V)

Parameter	Min.	Typ.	Max.
VDD_CORE_VL	0.9	1.0	1.05
VDD_CORE_VM	1.3	1.8	2.1
VDD_CORE_VH	1.85	2.0	2.1
VDD_IO	1.71	1.8	1.89
VDD_RF	1.9	2.0	2.4

4.3. Digital I/O Characteristics

Table 20: VDD_IO I/O Requirements (Unit: V)

Parameter	Description	Min.	Max.
V_{IH}	High-level input voltage	0.65 × VDD_IO	VDD_IO + 0.3
V_{IL}	Low-level input voltage	-0.3	0.35 × VDD_IO
V_{OH}	High-level output voltage	VDD_IO - 0.45	VDD_IO
V_{OL}	Low-level output voltage	0	0.45

4.4. Operating and Storage Temperatures

Table 21: Operating and Storage Temperatures (Unit: ºC)

Parameter	Min.	Typ.	Max.
Operating Temperature Range [4]	-30	25	+75
Storage Temperature Range	-40	-	+85

[4] 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. Thermal dissipation is necessary for the module in soft-AP mode. Within this range, the module's indicators comply with IEEE and Bluetooth specification requirements.

4.5. Power Consumption

Table 22: Power Consumption in Non-signaling Mode (Unit: mA)

Mode	Condition	VDD_CORE_VL (1.0 V)	VDD_CORE_VM (1.8 V)	VDD_CORE_VH (2.0 V)	VDD_IO (1.8 V)	VDD_RF (2.0 V)
1 × 1	2.4 GHz 802.11b @ 1 Mbps	300.42	136.38	93.6	2.93	366.89
	2.4 GHz 802.11g @ 6 Mbps	299.17	136.37	93.61	2.92	352.65
	2.4 GHz 802.11n HT20 @ MCS 0	300.62	136.09	93.35	2.7	345.94
	2.4 GHz 802.11ax HE40 @ MCS 11	322.96	143.7	92.72	2.83	304.95
	5 GHz 802.11a @ 6 Mbps	316.01	162.62	107.6	2.64	312.3
	5 GHz 802.11n HT20 @ MCS 0	309.07	163.07	104.23	2.83	316.67
	5 GHz 802.11ac VHT40 @ MCS 9	326.02	165.52	103.38	2.9	370.09
	5 GHz 802.11ax HE80 @ MCS 11	409.37	168.34	99.36	2.56	455.29
2 × 2	2.4 GHz 802.11n HT20 @ MCS 0	386.73	173.39	123.84	2.92	717.42
	2.4 GHz 802.11n HT40 @ MCS 7	394.78	179.08	118.99	2.83	606.19
	2.4 GHz 802.11ax HE40 @ MCS 11	390.55	185.37	117.55	2.9	554.28

	5 GHz 802.11n HT20 @ MCS 0	402.2	260.99	143.97	2.84	663.39
	5 GHz 802.11ac VHT40 @ MCS 9	439.5	264.94	141.83	2.91	552.6
	5 GHz 802.11ax HE80 @ MCS 11	583.84	268.09	151.57	2.95	540.68
	5 GHz 802.11ax HE80 @ MCS 0	563.83	273.32	153.62	2.91	630.2
2 × 2 + 2 × 2 (For FC66E only)	802.11n HT20 @ MCS 0	417.56	303.69	222.21	2.92	1336
	802.11n HT40 @ MCS 7	526.4	316.91	218.83	2.91	1087
	802.11n HT20 @ MCS 0 + 802.11ac VHT20 @ MCS 0	424.04	306.3	223.24	2.91	1342
	802.11n HT40 @ MCS 7+ 802.11ac VHT80 @ MCS 9	672.59	319.42	218.2	2.9	1127
	802.11ax HE20 @ MCS 0	429.49	311.57	232.78	2.91	1355
	802.11ax 2.4 GHz HE40 @ MCS 11 + 5 G Hz HE80 @ MCS 11	674.75	324.69	228.4	2.92	1111

4.6. RF Performances

4.6.1. Wi-Fi RF Performances

Table 23: Wi-Fi Tx Power & Rx Sensitivity (Unit: dBm; Tolerance: ±2 dB)

Condition		Tx Power (Typ.)	Rx Sensitivity (Typ.)
2.4 GHz	802.11b @ 1 Mbps	17	-97
	802.11b @ 11 Mbps	17	-89
	802.11g @ 6 Mbps	16	-93
	802.11g @ 54 Mbps	14.5	-75
	802.11n, HT20 @ MCS 0	16	-93
	802.11n, HT20 @ MCS 7	13.5	-75
	802.11n, HT40 @ MCS 0	15.5	-91
	802.11n, HT40 @ MCS 7	13	-72
	802.11ax, HE20 @ MCS 0	16	-94
	802.11ax, HE20 @ MCS 11	11	-63
	802.11ax, HE40 @ MCS 0	15.5	-91
	802.11ax, HE40 @ MCS 11	10	-61
5 GHz	802.11a @ 6 Mbps	15	-91
	802.11a @ 54 Mbps	13	-73
	802.11n, HT20 @ MCS 0	15	-91
	802.11n, HT20 @ MCS 7	12	-73
	802.11n, HT40 @ MCS 0	14.5	-88
	802.11n, HT40 @ MCS 7	11.5	-71
	802.11ac, VHT20 @ MCS 0	15	-91

	802.11ac, VHT20 @ MCS 8	11.5	-68
	802.11ac, VHT40 @ MCS 0	14.5	-88
	802.11ac, VHT40 @ MCS 9	10.5	-65
	802.11ac, VHT80 @ MCS 0	14	-85
	802.11ac, VHT80 @ MCS 9	10	-62
	802.11ac, VHT160 @ MCS 0	13.5	-83
	802.11ac, VHT160 @ MCS 9	9.5	-59
	802.11ax, HE20 @ MCS 0	15	-91
	802.11ax, HE20 @ MCS 11	9.5	-62
	802.11ax, HE40 @ MCS 0	14	-88
	802.11ax, HE40 @ MCS 11	9.5	-60
	802.11ax, HE80 @ MCS 0	14	-85
	802.11ax, HE80 @ MCS 11	8.5	-57
	802.11ax, HE160 @ MCS 0	13.5	-82
	802.11ax, HE160 @ MCS 11	8	-53
6 GHz	802.11a @ 6 Mbps	14	-90
	802.11a @ 54 Mbps	12	-72
	802.11ax, HE20 @ MCS 0	14	-90
	802.11ax, HE20 @ MCS 11	8.5	-60
	802.11ax, HE40 @ MCS 0	13.5	-88
	802.11ax, HE40 @ MCS 11	8.5	-58
	802.11ax, HE80 @ MCS 0	13	-84
	802.11ax, HE80 @ MCS 11	7.5	-56
	802.11ax, HE160 @ MCS 0	12.5	-82
	802.11ax, HE160 @ MCS 11	7	-52

4.6.2. Bluetooth RF Performances

The following tables summarize the transmitting and receiving performances of the module.

Table 24: Bluetooth Tx Power & Rx Sensitivity (Unit: dBm; Tolerance: ±2 dB)

Condition	Transmitting Power (Typ.)	Receiving Sensitivity (Typ.)
GFSK	7	-91
π/4-DQPSK	4	-90
8-DQPSK	4	-84
BLE (1 Mbps)	7	-94
BLE (2 Mbps)	7	-92

4.7. 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 25: Electrostatic Discharge Characteristics (Unit: kV)

Model	Test Result	Standard
Human Body Model (HBM)	±1.5	*ESDA/JEDEC JS-001-2017*
Charged Device Model (CDM)	±0.25	*ESDA/JEDEC JS-002-2018*

4.8. Thermal Dissipation [5]

[5] Thermal dissipation is necessary for module in sof-AP mode.

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 functions (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.

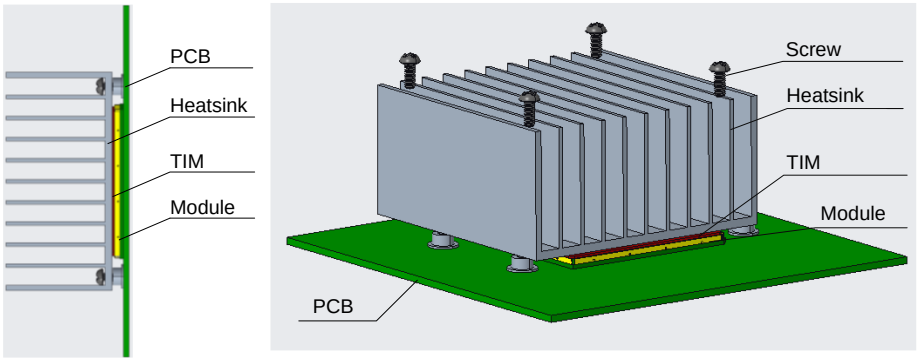


Figure 17: Placement and Fixing of the Heatsink

5 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.

5.1. Mechanical Dimensions

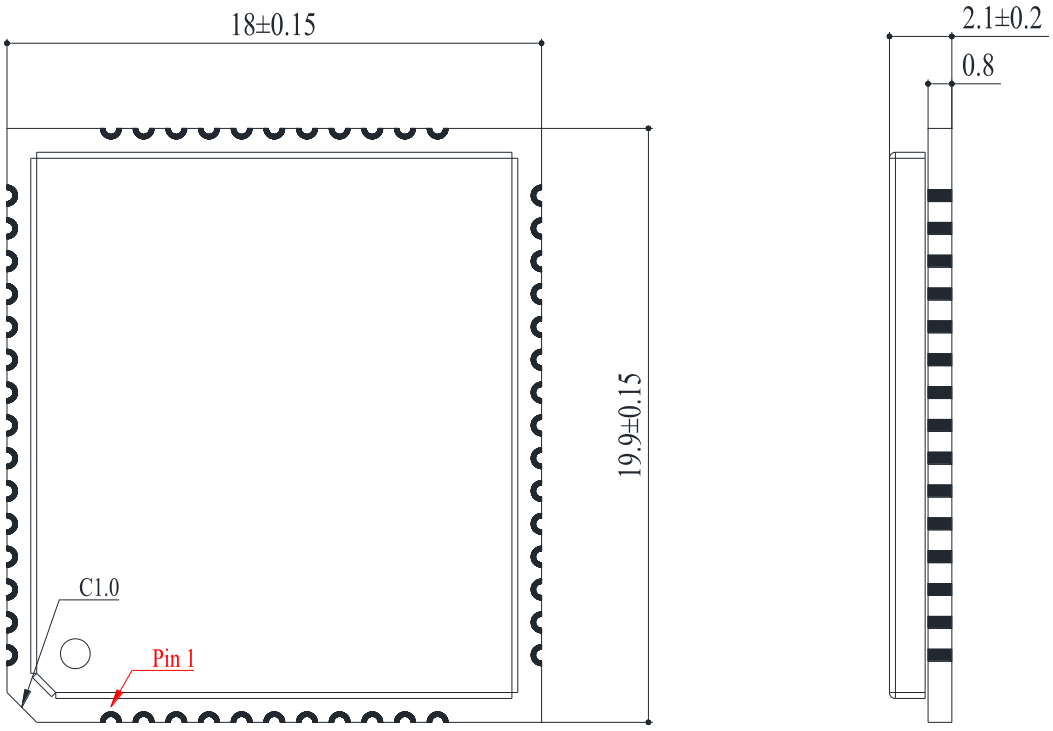


Figure 18: Top and Side Dimensions

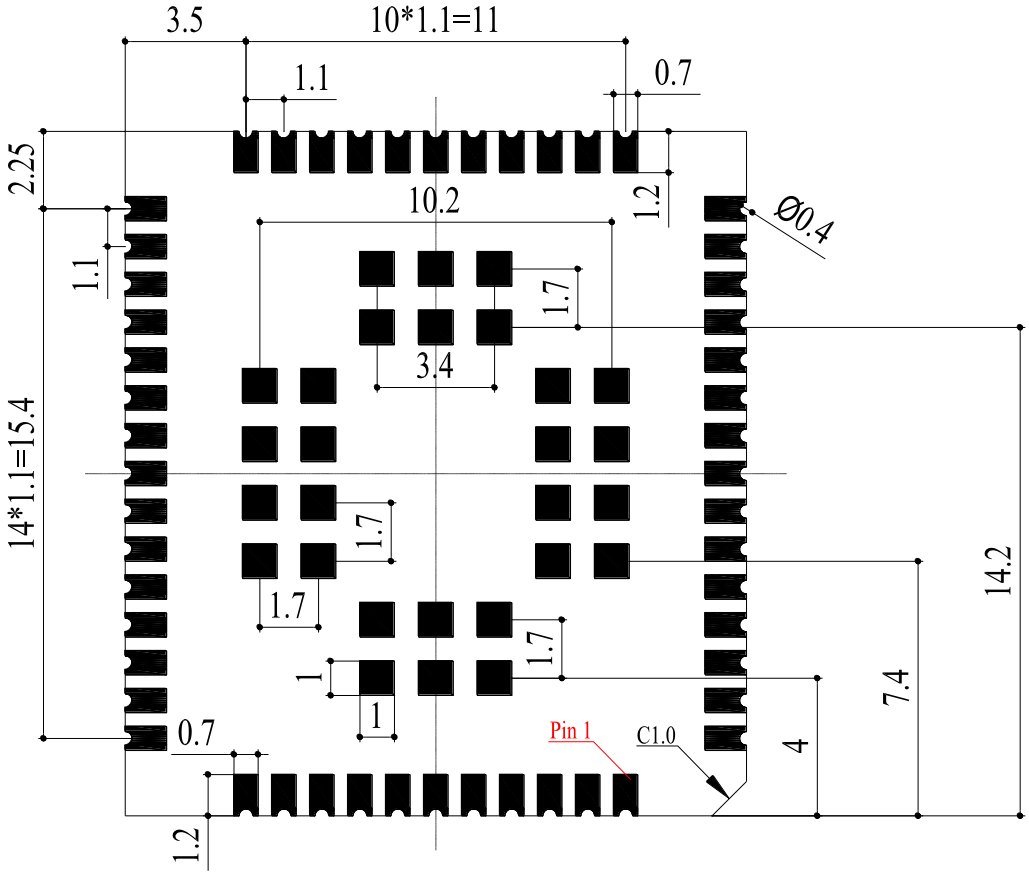


Figure 19: Bottom Dimensions (Bottom View)

NOTE

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

5.2. Recommended Footprint

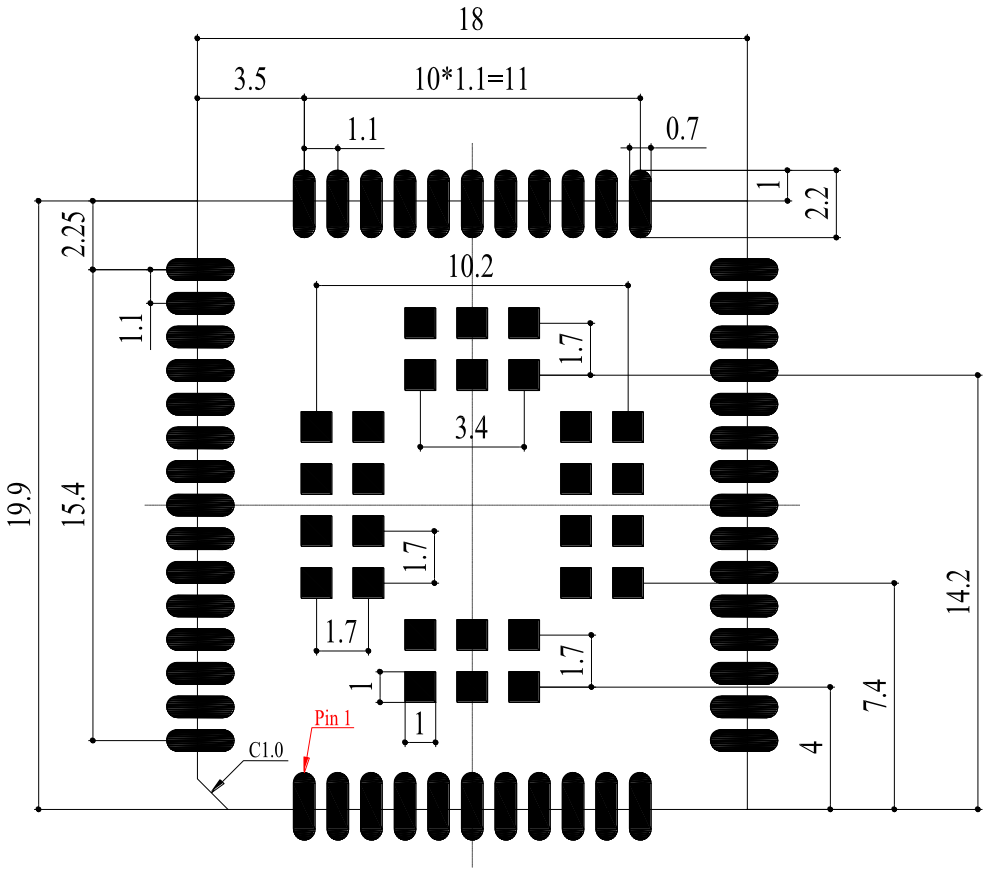


Figure 20: Recommended Footprint

NOTE

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

5.3. Top and Bottom Views

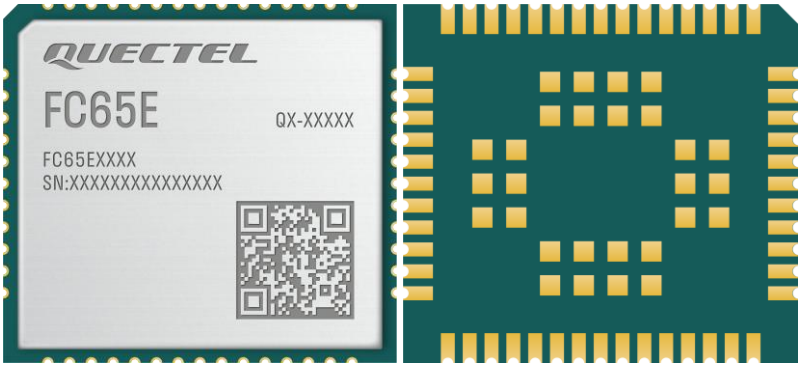


Figure 21: FC65E Top and Bottom Views

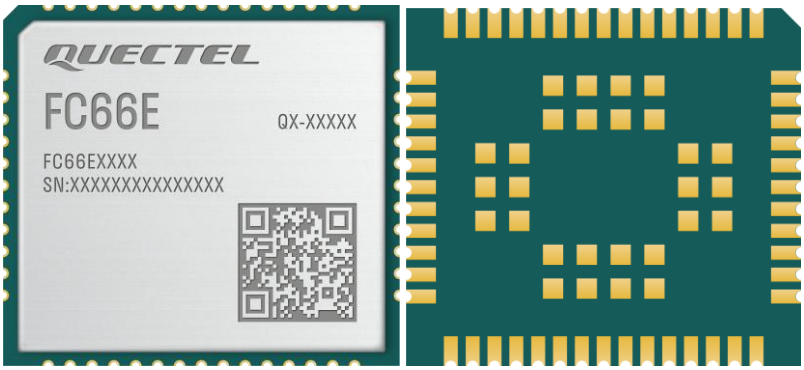


Figure 22: FC66E Top and Bottom Views

NOTE

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

6 Storage, Manufacturing and Packaging

6.1. 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 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.

NOTE

[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.

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.

6.2. 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 [4]***

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.

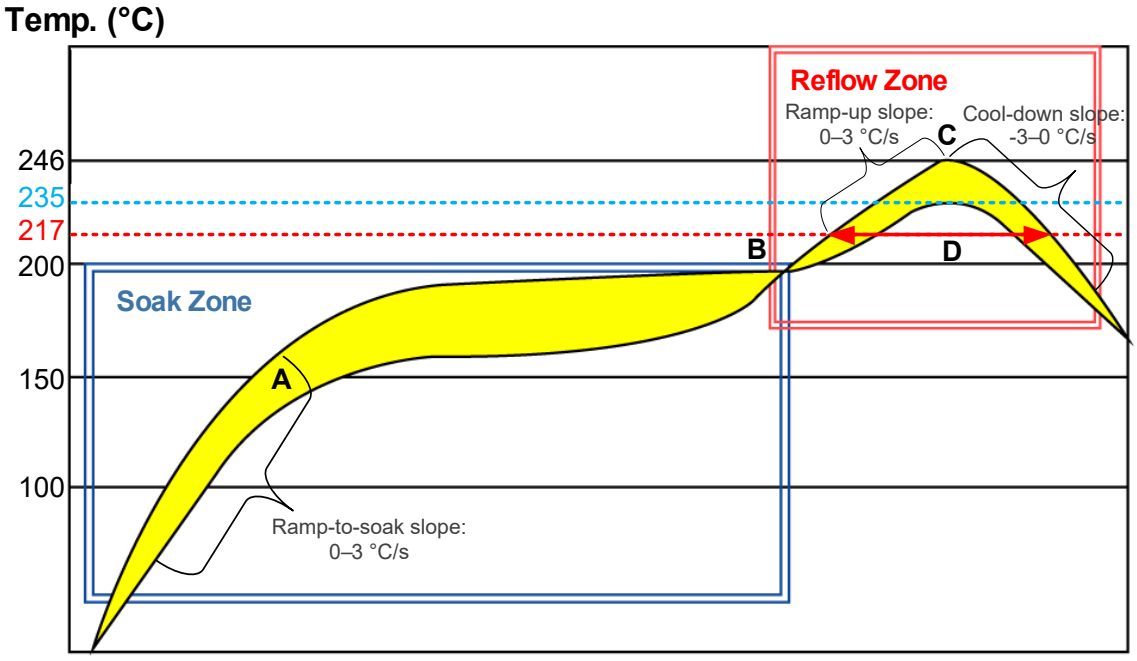


Figure 23: Recommended Reflow Soldering Thermal Profile

Table 26: Recommended Thermal Profile Parameters

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

NOTE

1. The above profile parameter requirements are for the measured temperature of 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 [4]***.

6.3. 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:

6.3.1. Carrier Tape

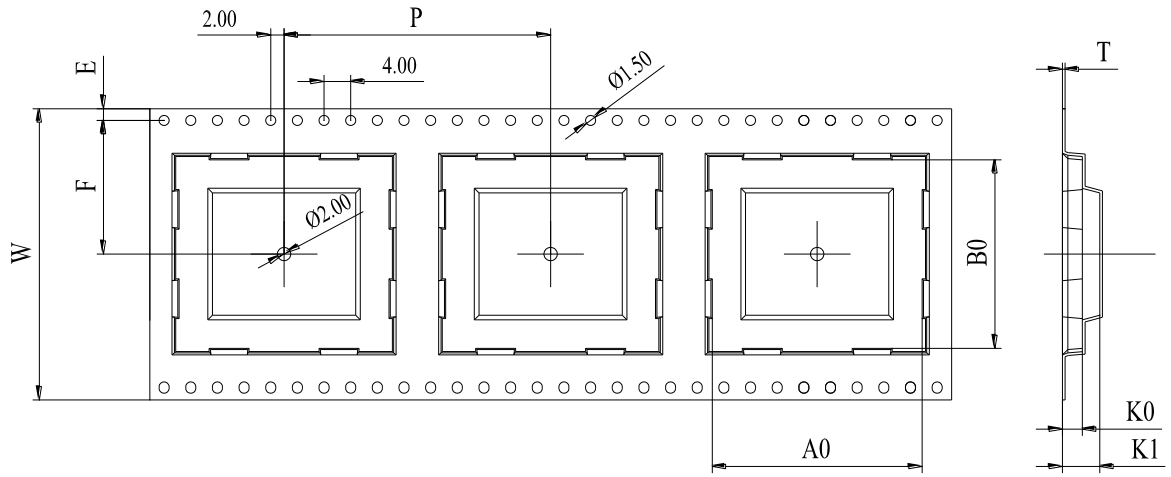


Figure 24: Carrier Tape Dimension Drawing

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

W	P	T	A0	B0	K0	K1	F	E
44	32	0.4	20.4	18.5	2.6	6.8	20.2	1.75

6.3.2. Plastic Reel

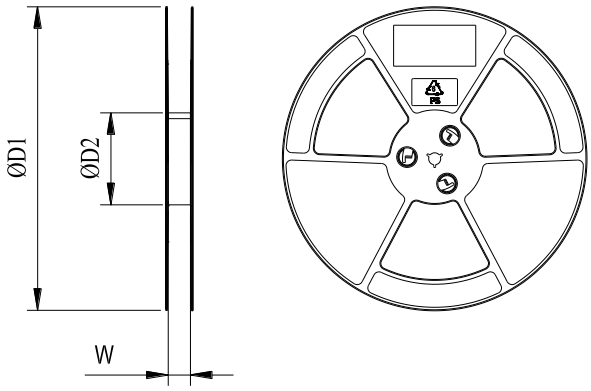


Figure 25: Plastic Reel Dimension Drawing

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

øD1	øD2	W
330	100	44.5

6.3.3. Mounting Direction

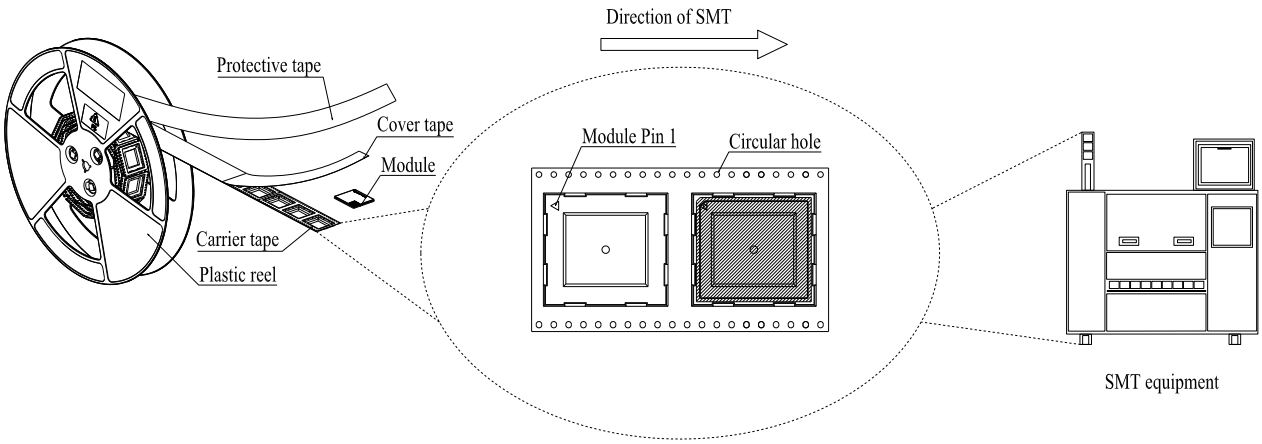
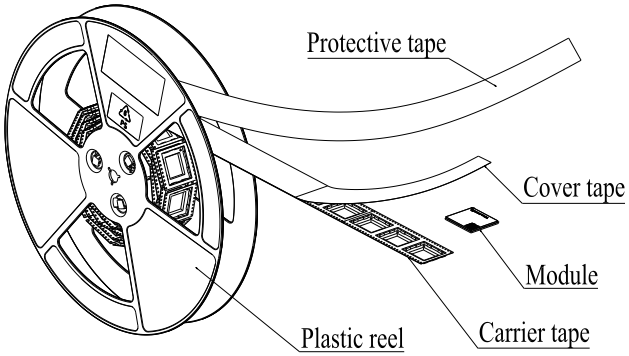


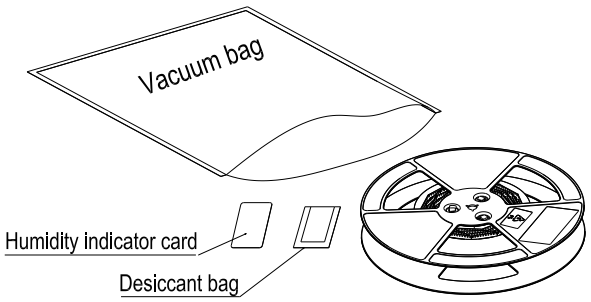
Figure 26: Mounting Direction

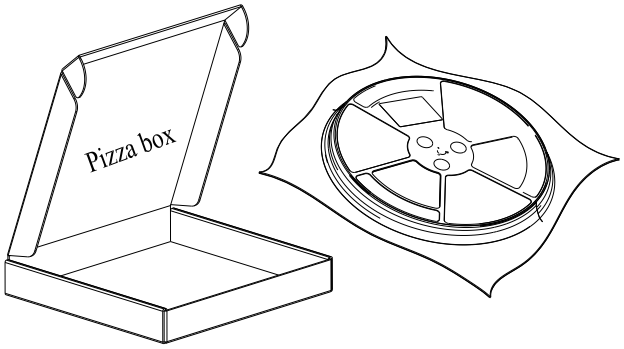
6.3.4. Packaging Process



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

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





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

Put 4 packaged pizza boxes into 1 carton box and seal it. 1 carton box can pack 1000 modules.

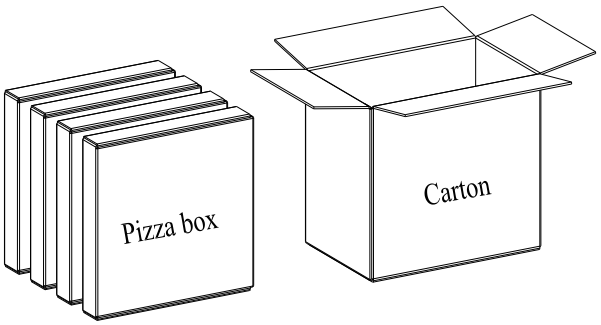


Figure 27: Packaging Process

7 Appendix References

Table 29: Related Documents

Document Name
[1] Quectel_FC6xE_M.2_User_Guides
[2] Quectel_FC6xE_Reference_Design
[3] Quectel_RF_Layout_Application_Note
[4] Quectel_Module_SMT_Application_Note

Table 30: Terms and Abbreviations

Abbreviation	Description
AFH	Adaptive Frequency Hopping
AP	Access Point
BPSK	Binary Phase Shift Keying
BLE	Bluetooth Low Energy
BR	Basic Rate
CCK	Complementary Code Keying
CDM	Charged Device Model
CTS	Clear To Send
DBPSK	Differential Binary Phase Shift Keying
DBS	Dual Band Simultaneous
DPSK	Differential Phase Shift Keying

DQPSK	Differential Quadrature Phase Shift Keying
EDR	Enhanced Data Rate
ESD	Electrostatic Discharge
EVB	Evaluation Board
GFSK	Gauss frequency Shift Keying
GND	Ground
HBM	Human Body Model
HCI	Host Controller Interface
HE	High Efficiency
HT	High Throughput
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
LAA	License Assisted Access
LCC	Leadless chip carrier
LTE	Long Term Evolution
MAC	Medium Access Control
Mbps	Megabits per second
MCS	Modulation and Coding Scheme
MSL	Moisture Sensitivity Levels
MU-MIMO	Multi-User Multiple-Input Multiple-Output
PA	Power Amplifier
PCB	Printed Circuit Board
PCIe	Peripheral Component Interconnect Express
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
SMT	Surface Mount Technology
STA	Station
TVS	Transient Voltage Suppressor
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
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
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access

FCC Declaration:

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

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

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

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

Host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification.

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

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.

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

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

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

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and the Max allowed antenna gain is as following table showed:

Antenna type	2.4GHz band Peak Gain (dBi)	5.2GHz band Peak Gain (dBi)	5.3GHz band Peak Gain (dBi)	5.5GHz band Peak Gain (dBi)	5.8GHz band Peak Gain (dBi)	6GHz band Peak Gain (dBi)
Dipole	0.73	1.14	1.00	0.60	0.95	-0.24

- The product is provided with an approved antenna. Use only supplied or approved antenna by Quectel. Any changes or modifications to the Antenna may void the regulatory approvals obtained for the product.
- Host device must comply with FCC Part 15 antenna requirements
- The OEM must design the host so that the antenna will be installed as an integrated antenna for the host containing the FC65E and the end user shall not be able to access, remove or replace the antenna.

2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 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

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not 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

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 FCC ID: XMR2023FC65E".The grantee's FCC ID can be used only when all FCC compliance requirements are met.

Manual Information To the End User

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

5.925-7.125 GHz Radio Transmitters

General

Refer to KDB publication 987594 D01, Operation of these devices in the 5.925-7.125 GHz band is prohibited on oil platforms, cars, trains, boats, and aircraft, except that operation of this device is permitted in large aircraft while flying above 10,000 feet.

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

2. That the device will only associate and connect with a low-power indoor access point or subordinate device and never directly connect to other client devices.

3. That this device will always initiate transmission under the control of a low-power indoor AP or subordinate except for brief transmissions before joining a network. These short messages will only occur if the client has detected an indoor AP or subordinate operating on a channel. These brief messages will have a time-out mechanism such that if it does not receive a response from an AP it will not continually repeat the request.

4. Prohibited for control of or communications with unmanned aircraft systems, including drones.

This device complies with Part 15.247 and Part 15.407 of the FCC Rules. The FCC ID for this device is XMR2023FC65E.

Antenna change notice

If you desire to increase antenna gain and either change antenna type or use same antenna type certified , a Class Il permissive change application is required to be filed by us , or you (host manufacturer) can take responsibility through the change in FCC ID (new application) procedurefollowed by a Class Il permissive change application

Information on test modes and additional testing requirements

The OEM integrator is responsible for ensuring that the end-user has no manual instruction to remove or install the module .The module is limited to installation in mobile applications , a separate approval is required for all other operating configurations , including portable configurations with respect to Part 2.1093 and different antenna configurations

Test software to access different test modes : QRCT4 tool

Testing item , frequencies , transmit power can be selected following the test script instructions

IC Declaration:

This device complies with ISED's licence-exempt RSSs. 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.

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) le dispositif ne doit pas produire de brouillage pré judiciable, et (2) ce dispositif doit accepter tout brouillage reçu, y compris un brouillage susceptible de provoquer un fonctionnement indésirable.

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.

This device is intended only for OEM integrators under the following conditions: (For module device use)

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 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.

Cet appareil est conçu uniquement pour les intégrateurs OEM dans les conditions suivantes: (Pour utilisation de dispositif module)

1) L'antenne doit être installée de telle sorte qu'une distance de 20 cm est respectée entre l'antenne et les utilisateurs, et

2) Le module émetteur peut ne pas être coïmplanté avec un autre émetteur ou antenne.

Tant que les 2 conditions ci-dessus sont remplies, des essais supplémentaires sur l'émetteur ne seront pas nécessaires. Toutefois, l'intégrateur OEM est toujours responsable des essais sur son produit final pour toutes exigences de conformité supplémentaires requis pour ce module installé.

IMPORTANT NOTE:

In the event that these conditions can not be met (for example certain laptop configurations or co- location with another transmitter), then the Canada authorization is no longer considered valid and the IC ID can not 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 Canada authorization.

NOTE IMPORTANTE:

Dans le cas où ces conditions ne peuvent être satisfaites (par exemple pour certaines configurations d'ordinateur portable ou de certaines co-localisation avec un autre émetteur), l'autorisation du Canada n'est plus considéré comme valide et l'ID IC ne peut pas être utilisé sur le produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'une autorisation distincte au Canada.

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-2023FC65E".

Plaque signalétique du produit final

Ce module émetteur est autorisé uniquement pour une utilisation dans un dispositif où l'antenne peut être installée de telle sorte qu'une distance de 20cm peut être maintenue entre l'antenne et les utilisateurs. Le produit final doit être étiqueté dans un endroit visible avec l'inscription suivante: "Contient des IC: 10224A-2023FC65E".

Manual Information To the End User

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

Manuel d'information à l'utilisateur final

L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF dans le manuel de l'utilisateur du produit final qui intègre ce module.

Le manuel de l'utilisateur final doit inclure toutes les informations réglementaires requises et avertissements comme indiqué dans ce manuel.

RSS-247 Section 6.4 (5) (6) (for local area network devices, 5GHz)

The device could automatically discontinue transmission in case of absence of information to transmit, or operational failure. Note that this is not intended to prohibit transmission of control or signaling information or the use of repetitive codes where required by the technology.

Caution:

i) The device for operation in the band 5150–5250 MHz is only for indoor use to reduce the potential for harmful interference to co-channel mobile satellite systems;

ii) where applicable, antenna type(s), antenna models(s), and worst-case tilt angle(s) necessary to remain compliant with the e.i.r.p. elevation mask requirement set forth in section 6.2.2.3 shall be clearly indicated.

L'appareil peut interrompre automatiquement la transmission en cas d'absence d'informations à transmettre ou de panne opérationnelle. Notez que ceci n'est pas destiné à interdire la transmission d'informations de contrôle ou de signalisation ou l'utilisation de codes répétitifs lorsque cela est requis par la technologie.

Avertissement:

i) Le dispositif utilisé dans la bande 5150-5250 MHz est réservé à une utilisation en intérieur afin de réduire le risque de brouillage préjudiciable aux systèmes mobiles par satellite dans le même canal;

ii) lorsqu'il y a lieu, les types d'antennes (s'il y en a plusieurs), les numéros de modèle de l'antenne et les pires angles d'inclinaison nécessaires pour rester conforme à l'exigence de la

p.i.r.e. applicable au masque d'élévation, énoncée à la section 6.2.2.3, doivent être clairement indiqués.

Caution:

Operation shall be limited to indoor use only;

Operation on oil platforms, cars, trains, boats and aircraft shall be prohibited except for on large aircraft flying above 10,000 ft.

Avertissement:

Utilisation limitée à l'intérieur seulement;

Utilisation interdite à bord de plateformes de forage pétrolier, de voitures, de trains, de bateaux et d'aéronefs, sauf à bord d'un gros aéronef volant à plus de 10 000 pieds d'altitude 5.925-7.125 GHz Radio Transmitters

General

Refer to KDB publication 987594 D01, Operation of these devices in the 5.925-7.125 GHz band is prohibited on oil platforms, cars, trains, boats, and aircraft, except that operation of this device is permitted in large aircraft while flying above 10,000 feet.

1. Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
2. That the device will only associate and connect with a low-power indoor access point or subordinate device and never directly connect to other client devices.
3. That this device will always initiate transmission under the control of a low-power indoor AP or subordinate except for brief transmissions before joining a network. These short messages will only occur if the client has detected an indoor AP or subordinate operating on a channel. These brief messages will have a time-out mechanism such that if it does not receive a response from an AP it will not continually repeat the request.
4. Prohibited for control of or communications with unmanned aircraft systems, including drones.