FGS060N

Hardware Design

Wi-Fi, Bluetooth & 802.15.4 Module Series

Version: 0.1

Date: 2023-03-06

Status: Draft

At Quectel, our aim is to provide timely and comprehensive services to our customers. If you require any assistance, please contact our headquarters:

Quectel Wireless Solutions Co., Ltd.
Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai 200233, China
Tel: +86 21 5108 6236
Email: info@quectel.com

Or our local offices. For more information, please visit:
http://www.quectel.com/support/sales.htm.

For technical support, or to report documentation errors, please visit:
http://www.quectel.com/support/technical.htm.
Or email us at: support@quectel.com.

Legal Notices

We offer information as a service to you. The provided information is based on your requirements and we make every effort to ensure its quality. You agree that you are responsible for using independent analysis and evaluation in designing intended products, and we provide reference designs for illustrative purposes only. Before using any hardware, software or service guided by this document, please read this notice carefully. Even though we employ commercially reasonable efforts to provide the best possible experience, you hereby acknowledge and agree that this document and related services hereunder are provided to you on an “as available” basis. We may revise or restate this document from time to time at our sole discretion without any prior notice to you.

Use and Disclosure Restrictions

License Agreements

Documents and information provided by us shall be kept confidential, unless specific permission is granted. They shall not be accessed or used for any purpose except as expressly provided herein.

Copyright

Our and third-party products hereunder may contain copyrighted material. Such copyrighted material shall not be copied, reproduced, distributed, merged, published, translated, or modified without prior written consent. We and the third party have exclusive rights over copyrighted material. No license shall be granted or conveyed under any patents, copyrights, trademarks, or service mark rights. To avoid ambiguities, purchasing in any form cannot be deemed as granting a license other than the normal non-exclusive, royalty-free license to use the material. We reserve the right to take legal action for noncompliance with abovementioned requirements, unauthorized use, or other illegal or malicious use of the material.

Trademarks

Except as otherwise set forth herein, nothing in this document shall be construed as conferring any rights to use any trademark, trade name or name, abbreviation, or counterfeit product thereof owned by Quectel or any third party in advertising, publicity, or other aspects.

Third-Party Rights

This document may refer to hardware, software and/or documentation owned by one or more third parties ("third-party materials"). Use of such third-party materials shall be governed by all restrictions and obligations applicable thereto.

We make no warranty or representation, either express or implied, regarding the third-party materials, including but not limited to any implied or statutory, warranties of merchantability or fitness for a particular purpose, quiet enjoyment, system integration, information accuracy, and non-infringement of any third-party intellectual property rights with regard to the licensed technology or use thereof. Nothing herein constitutes a representation or warranty by us to either develop, enhance, modify, distribute, market, sell, offer for sale, or otherwise maintain production of any our products or any other hardware, software, device, tool, information, or product. We moreover disclaim any and all warranties arising from the course of dealing or usage of trade.

Privacy Policy

To implement module functionality, certain device data are uploaded to Quectel's or third-party's servers, including carriers, chipset suppliers or customer-designated servers. Quectel, strictly abiding by the relevant laws and regulations, shall retain, use, disclose or otherwise process relevant data for the purpose of performing the service only or as permitted by applicable laws. Before data interaction with third parties, please be informed of their privacy and data security policy.

Disclaimer

a) We acknowledge no liability for any injury or damage arising from the reliance upon the information.
b) We shall bear no liability resulting from any inaccuracies or omissions, or from the use of the information contained herein.
c) While we have made every effort to ensure that the functions and features under development are free from errors, it is possible that they could contain errors, inaccuracies, and omissions. Unless otherwise provided by valid agreement, we make no warranties of any kind, either implied or express, and exclude all liability for any loss or damage suffered in connection with the use of features and functions under development, to the maximum extent permitted by law, regardless of whether such loss or damage may have been foreseeable.
d) We are not responsible for the accessibility, safety, accuracy, availability, legality, or completeness of information, advertising, commercial offers, products, services, and materials on third-party websites and third-party resources.

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
-	2023-03-05	Bourne Qian	Creation of the document
0.1	2023-03-06	Bourne Qian	Draft

Contents

Table Index

Figure Index

1 Introduction

This document defines the FGS060N and describes its air interfaces and hardware interfaces which are connected with your applications.

With this document, you can quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. The document, coupled with application notes and user guides, makes it easy to design and set up mobile applications with the module.

1.1. Special Mark

Table 1: Special Mark

Mark	Definition
[…]	Brackets ([…]) used after a pin enclosing a range of numbers indicate all pins of the same type. For example, SDIO_DATA[0:3] refers to all four SDIO pins: SDIO_DATA0, SDIO_DATA1, SDIO_DATA2, and SDIO_DATA3.

Hereby, Quectel Wireless Solutions Co., Ltd. declares that the radio equipment type FGS060N 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

FGS060N is a high-performance IEEE 802.11 a/b/g/n/ac/ax Wi-Fi, Bluetooth 5.2 and 802.15.4 module. It supports 2.4/5 GHz dual-band 1T1R Wi-Fi 6. Peak data rates up to 480 Mbps. It provides SDIO 3.0 interface for Wi-Fi, UART for Bluetooth and SPI for 802.15.4.
It is an LGA module with compact packaging. Related information is listed in the table below:

Table 2: Basic Information

FGS060N	
Packaging type	LGA
Pin counts	84
Dimensions	(13±0.1) mm × (14±0.1) mm × (2±0.08) mm
Weight	TBD

2.1. Key Features

Table 3: Key Features

Basic Information	
Protocol and Standard	● Wi-Fi protocols: IEEE 802.11 a/b/g/n/ac/ax ● Bluetooth protocol: Bluetooth 5.2 ● 802.15.4 ● All hardware components are fully compliant with EU RoHS directive
Power Supply	**VBAT_3V3 Power Supply:** ● 3.14–3.46 V，Typ.:3.3V **VBAT_1V8 Power Supply:** ● 1.71–1.89 V，Typ.:1.8V **VDDIO Power Supply:** ● 3.14–3.46 V，Typ.:3.3V ● 1.71–1.89 V，Typ.:1.8V

	VDDIO_RF Power Supply: ● 3.14–3.46 V，Typ.:3.3V ● 1.71–1.89 V，Typ.:1.8V **SDIO_VDD Power Supply:** ● 3.14–3.46 V，Typ.:3.3V ● 1.71–1.89 V，Typ.:1.8V
Temperature Ranges	● Operating temperature [1]: -40 to +85 °C ● Storage temperature: -45 to +95°C
EVB Kit	TBD
RF Antenna Interface	
Wi-Fi Antenna Interface	● ANT_WIFI/BT ● 50 Ω impedance
Hardware Interface	
Wi-Fi Application Interface	SDIO 3.0
Bluetooth Application Interface	UART
802.15.4 Application Interface	SPI

[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.

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:** 4.900–5.895 GHz				
Modulation				
DSSS, OFDM, DBPSK, DQPSK, CCK, BPSK, QPSK, 16QAM, 64QAM, 256QAM,1024QAM				
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), VHT80(MCS 0~9) ● 802.11ax：HE20 (MCS 0~11), HE40 (MCS 0~11), HE80 (MCS 0~11)				
Condition		**EVM**	**Unit: dBm, Tolerance: ±2 dB**	
			Transmitting Power @ Typ.	**Receiving Sensitivity @ Typ.**
2.4 GHz	802.11b @ 1 Mbps	≤ -9 dB	TBD	TBD
	802.11b @ 11 Mbps		TBD	TBD
	802.11g @ 6 Mbps	≤ -5 dB	TBD	TBD
	802.11g @ 54 Mbps	≤ -25 dB	TBD	TBD
	802.11n, HT20 @ MCS 0	≤ -5 dB	TBD	TBD

	802.11n, HT20 @ MCS 7	≤ -27 dB	TBD	TBD
	802.11n, HT40 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11n, HT40 @ MCS 7	≤ -27 dB	TBD	TBD
	802.11ax, HE20 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11ax, HE20 @ MCS 11	≤ -35dB	TBD	TBD
	802.11ax, HE40 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11ax, HE40 @ MCS 11	≤ -35dB	TBD	TBD
5 GHz	802.11a @ 6 Mbps	≤ -5 dB	TBD	TBD
	802.11a @ 54 Mbps	≤ -25 dB	TBD	TBD
	802.11n, HT20 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11n, HT20 @ MCS 7	≤ -27 dB	TBD	TBD
	802.11n, HT40 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11n, HT40 @ MCS 7	≤ -27 dB	TBD	TBD
	802.11ac, VHT20@MCS 0	≤ -5 dB	TBD	TBD
	802.11ac, VHT20@MCS 8	≤ -30 dB	TBD	TBD
	802.11ac, VHT40@MCS 0	≤ -5 dB	TBD	TBD
	802.11ac, VHT40@MCS 9	≤ -32 dB	TBD	TBD
	802.11ac, VHT80@MCS 0	≤ -5 dB	TBD	TBD
	802.11ac, VHT80@MCS 9	≤ -32 dB	TBD	TBD
	802.11ax, HE20 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11ax, HE20 @ MCS 11	≤ -35dB	TBD	TBD
	802.11ax, HE40 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11ax, HE40 @ MCS 11	≤ -35dB	TBD	TBD
	802.11ax, HE80 @ MCS 0	≤ -5 dB	TBD	TBD
	802.11ax, HE80 @ MCS 11	≤ -35dB	TBD	TBD

Table 5: Wi-Fi Power Consumption

Protocol	Condition	I_{VDDIO}	I_{VBAT}	Unit
802.11b	Tx @ 1 Mbps	TBD	TBD	mA
	Tx @ 11 Mbps	TBD	TBD	mA
	Rx @ 1 Mbps	TBD	TBD	mA
	Rx @ 11 Mbps	TBD	TBD	mA
802.11g	Tx @ 6 Mbps	TBD	TBD	mA
	Tx @ 54 Mbps	TBD	TBD	mA
	Rx @ 6 Mbps	TBD	TBD	mA
	Rx @ 54 Mbps	TBD	TBD	mA
802.11a	Tx @ 6 Mbps	TBD	TBD	mA
	Tx @ 54 Mbps	TBD	TBD	mA
	Rx @ 6 Mbps	TBD	TBD	mA
	Rx @ 54 Mbps	TBD	TBD	mA
802.11n, HT20	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 7	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 7	TBD	TBD	mA
802.11n, HT40	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 7	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 7	TBD	TBD	mA
802.11ac, VHT20	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 8	TBD	TBD	mA

	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 8	TBD	TBD	mA
802.11ac, VHT40	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 9	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 9	TBD	TBD	mA
802.11ac, VHT80	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 9	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 9	TBD	TBD	mA
802.11ax, HE20	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 11	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 11	TBD	TBD	mA
802.11ax, HE40	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 11	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 11	TBD	TBD	mA
802.11ax, HE80	Tx @ MCS 0	TBD	TBD	mA
	Tx @ MCS 11	TBD	TBD	mA
	Rx @ MCS 0	TBD	TBD	mA
	Rx @ MCS 11	TBD	TBD	mA

3.2. Bluetooth Performances

Table 6: Bluetooth Performances

Operating Frequency		
2.400–2.4835 GHz		
Modulation		
GFSK, π/4-DQPSK, 8DPSK		
Operating Mode		
BR，EDR，BLE		
Condition	**Unit: dBm, Tolerance: ±2 dB**	
	Transmitting Power @ Typ.	**Receiving Sensitivity @ Typ.**
BR	TBD	TBD
EDR	TBD	TBD
BLE	TBD	TBD

Table 7: BLE Power Consumption in Non-signaling Modes

Mode	**Transmitting Power**	**I_{VBAT}**	**I_{VDDIO}**
BR	TBD	TBD	TBD
EDR	TBD	TBD	TBD
BLE	TBD	TBD	TBD

4 Application Interfaces

4.1. Pin Assignment

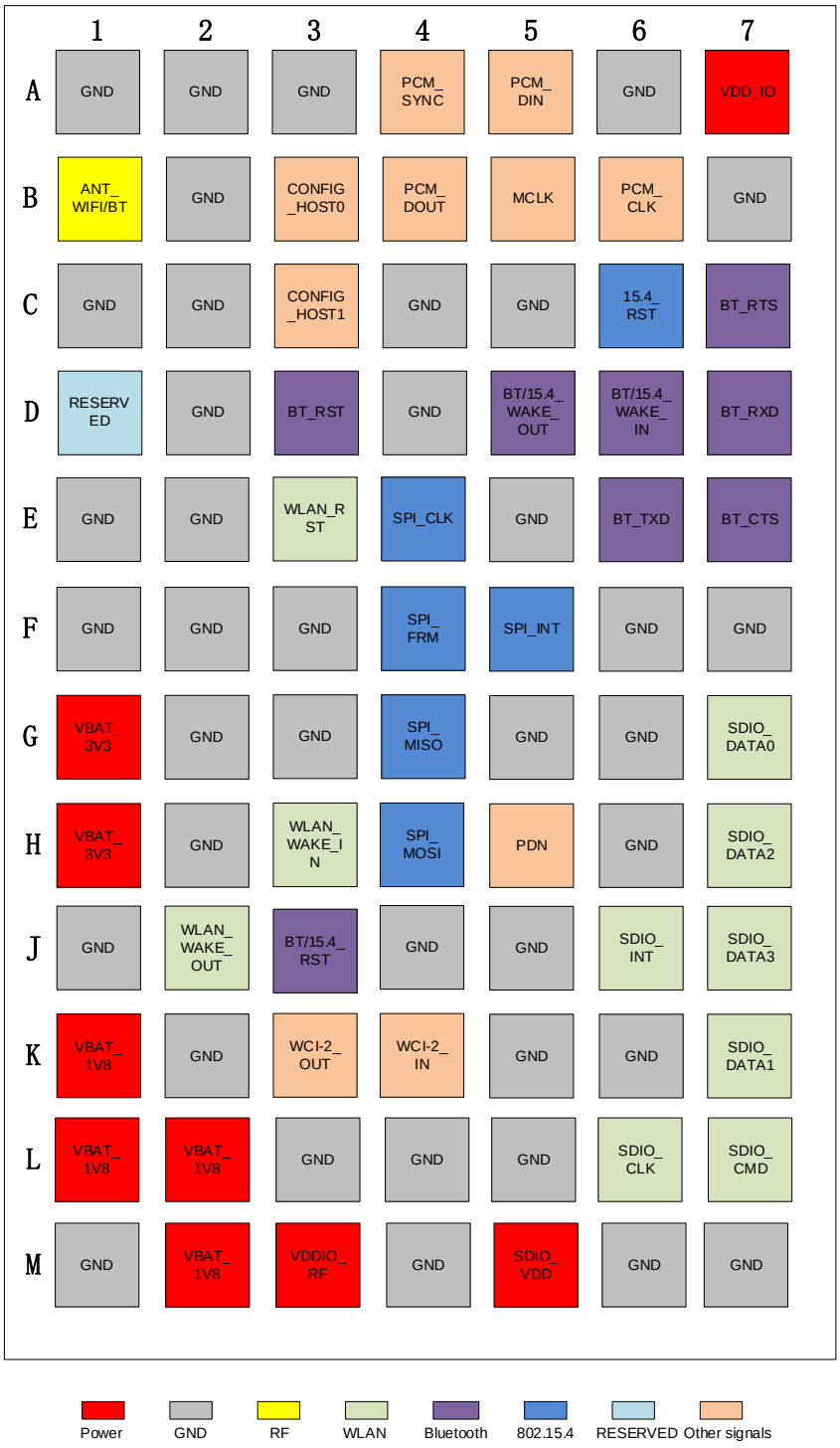


Figure 1: Pin Assignment (Top View)

NOTE

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

4.2. Pin Description

Table 8: 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 9: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_3V3	G1, H1	PI	Power supply for the module	Vmin = 3.14 V Vnom = 3.3 V Vmax = 3.46 V	-
VBAT_1V8	K1, L1, L2, M2	PI	Power supply for the module	Vmin = 1.71 V Vnom = 1.8 V Vmax = 1.89 V	-

VDD_IO	A7	PI	Power supply for the module ‘s digital I/O power supply	Vmin = 3.14 V Vnom = 3.3 V Vmax = 3.46 V Or Vmin = 1.71 V Vnom = 1.8 V Vmax = 1.89 V	-
VDDIO_RF	M3	PI	Power supply for the module ‘s digital I/O RF power supply	Vmin = 3.14 V Vnom = 3.3 V Vmax = 3.46 V or Vmin = 1.71 V Vnom = 1.8 V Vmax = 1.89 V	-
SDIO_VDD	M5	PI	Power supply for the module ‘s digital I/O SDIO power supply	Vmin = 3.14 V Vnom = 3.3 V Vmax = 3.46 V or Vmin = 1.71 V Vnom = 1.8 V Vmax = 1.89 V	-
GND	A1, A2, A3, A6, B2, B7, C1, C2, C4, C5, D2, D4, E1, E2, E5, F1, F2, F3, F6, F7, G2, G3, G5, G6, H2, H6, J1, J4, J5, K2, K5, K6, L3, L4, L5, M1, M4, M6, M7				

Wi-Fi Application Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
WLAN_RST	E3	DI	Independent software reset for Wi-Fi	VDDIO	-
WLAN_ WAKE_IN	H3	DI	Wi-Fi radio wake-up input signal		-
WLAN_ WAKE_OUT	J2	DO	Wi-Fi radio wake-up output signal		-
SDIO_INT	J6	DO	SDIO interrupt output signal		-
SDIO_CMD	L7	DIO	SDIO command	SDIO_VDD	Requires impedance of 50 Ω. SDIO 3.0 compliant.
SDIO_CLK	L6	DI	SDIO clock		
SDIO_DATA3	J7	DIO	SDIO data bit 3		
SDIO_DATA2	H7	DIO	SDIO data bit 2		
SDIO_DATA0	G7	DIO	SDIO data bit 0		

SDIO_DATA1	K7	DIO	SDIO data bit 1		
Bluetooth Application Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
BT_RST	D3	DI	Reset for Bluetooth	VDDIO	-
BT/15.4_RST	J3	DO	Bluetooth/802.15.4 independent software reset		
BT/15.4_WAKE_OUT	D5	DO	Bluetooth/802.15.4 radio wake-up output signal		-
BT/15.4_WAKE_IN	D6	DI	Bluetooth/802.15.4 radio wake-up input signal		-
BT_TXD	E6	DO	Bluetooth UART transmit		-
BT_RXD	D7	DI	Bluetooth UART receive		-
BT_CTS	E7	DI	UART clear-to-send input signal		-
BT_RTS	C7	DO	UART request-to-send output signal		-
802.15.4 Application Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
15.4_RST	C6	DI	Reset for 802.15.4	VDDIO	-
SPI_CLK	E4	DI	SPI clock input signal		-
SPI_MOSI	H4	DI	SPI receive input signal		-
SPI_MISO	G4	DO	SPI transmit output signal		-
SPI_FRM	F4	DI	SPI frame input signal		-
SPI_INT	F5	DO	SPI interrupt output signal		-
RF Antenna Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

ANT_WIFI/BT	B1	AIO	Wi-Fi /Bluetooth/ 802.15.4 antenna interface	-	-
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
CONFIG_HOST 0	B3	DI	Host configuration	VBAT_1V8	-
CONFIG_HOST 1	C3	DI			
PCM_SYNC	A4	DIO	Multi-Functional Pins	VDDIO	-
PCM_DIN	A5	DIO			-
PCM_DOUT	B4	DO			-
MCLK	B5	DIO			-
PCM_CLK	B6	DI			-
WCI-2_OUT	K3	DO	WCI-2 coexistence interface	VDDIO	-
WCI-2_IN	K4	DI			-
PDN	H5			VBAT_1V8	-
RESERVED Pins					
Pin Name	**Pin No.**				**Comment**
RESERVED	D1				Do not connect

4.3. Power Supply

The module uses multiple power supplies. There are 5 power supplies, VBAT_ 3V3,VBAT_1V8,VDDIO, VDDIO_RF，SDIO_VDD. VBAT_ 3V3 is powered by 3.3V, the current is at least 0.5A, VBAT_ 1V8 current at least 1A, VDDIO，VDDIO_RF，SDIO_VDD These three VDDs can be powered by 1.8V or 3.3V, mainly for digital IO interface. In order to obtain better power performance, it is recommended to connect 47 μ F in parallel near the VBAT pin and 1 μ F and 100 nF filter capacitors close to the Module. In addition, it is recommended to add TVS near VBAT to improve the surge voltage withstand capacity of the module.

In principle, the design wiring width of each VBAT power supply is as wide as possible and the length is as short as possible.

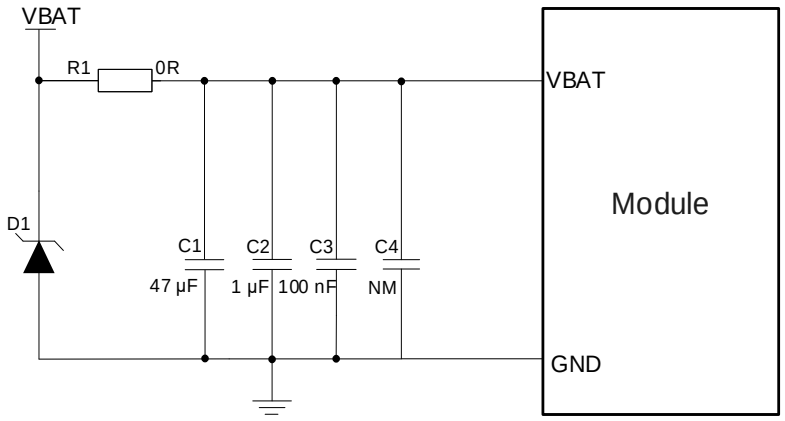


Figure 2: Reference Circuit of Power Supply

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

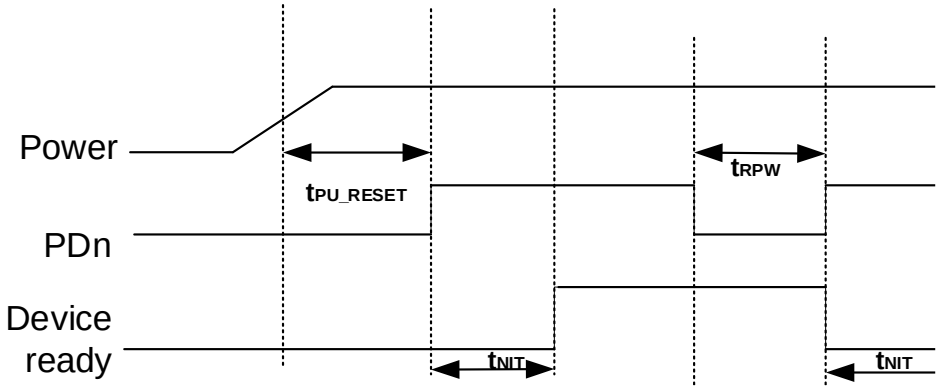


Figure 3: Power-up Timing

NOTE

t_{PU_RESET} : Valid power to PDn de-asserted.
t_{RPW}: PDn pulse width
t_{INIT}: From PDn de-assertion to device ready (SDIO bus enumeration)

4.4. Wi-Fi Application Interface

Wi-Fi application interface connection between the module and the host is illustrated in the figure below.

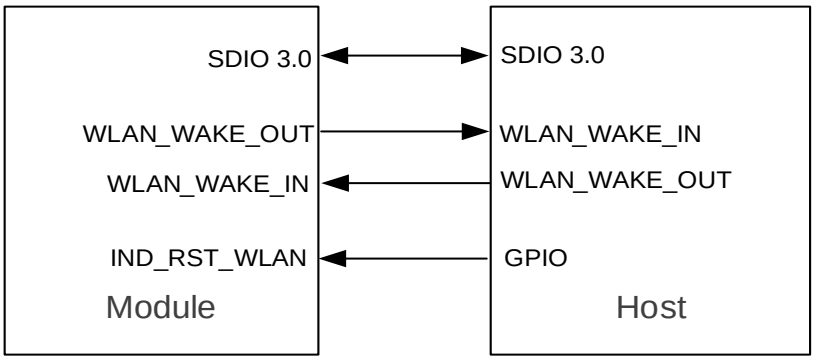


Figure 4: Wi-Fi Application Interface Connection

4.4.1. SDIO Interface

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

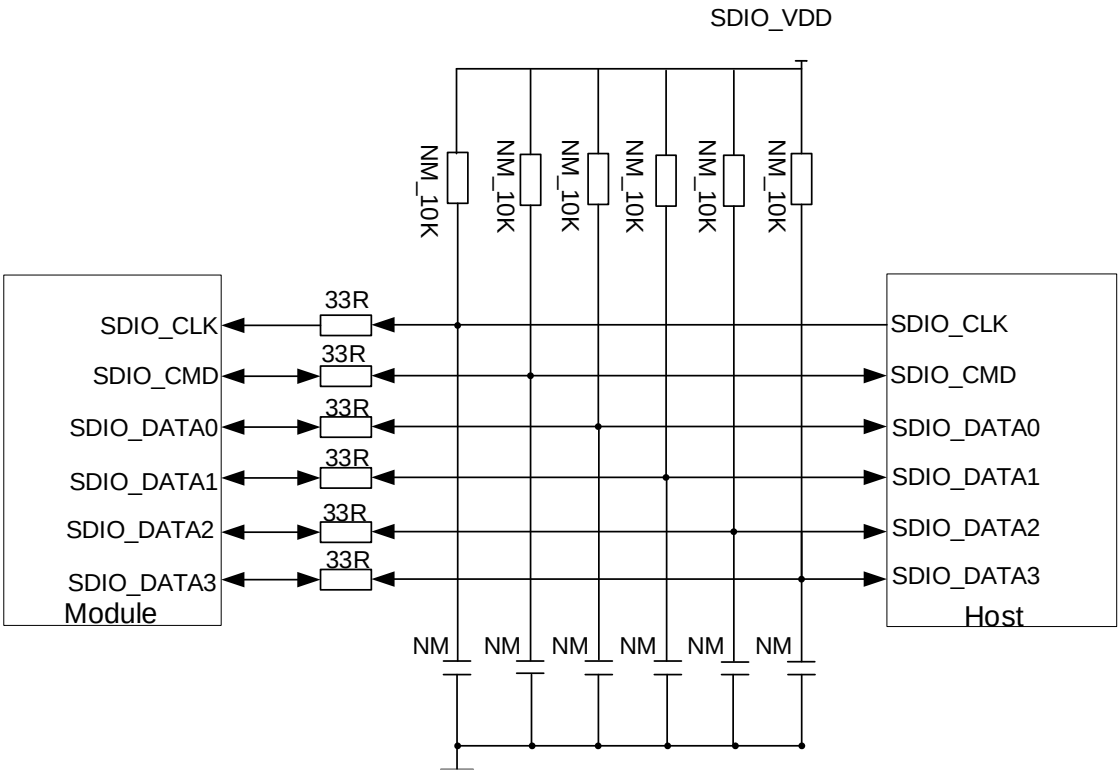


Figure 5: SDIO Interface Connection

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

- 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. The impedance of SDIO signal trace is 50 Ω ±10 %.

- 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.
- SDIO signal traces (SDIO_CLK and SDIO_DATA[0:3]/SDIO_CMD) need to be equal in length (less than 1 mm distance between the traces).
- 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.

4.5. Bluetooth Application Interface

Bluetooth application interface connection between the module and the host is illustrated in the figure below.

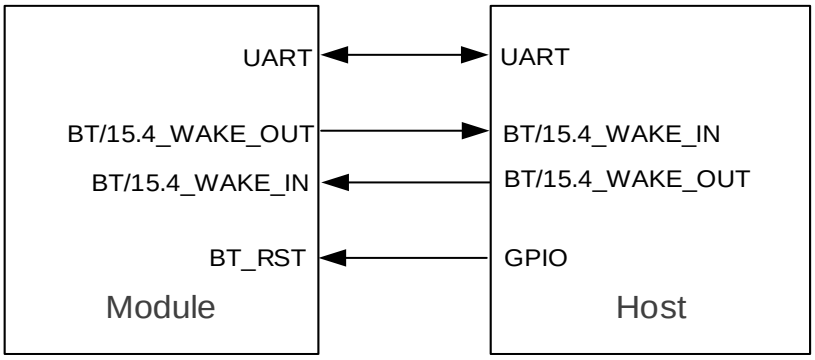


Figure 6: Bluetooth Application Connection

4.5.1. UART Interface

The module supports an HCI (Host Controller Interface) UART. The UART is used for data transmission with the host.

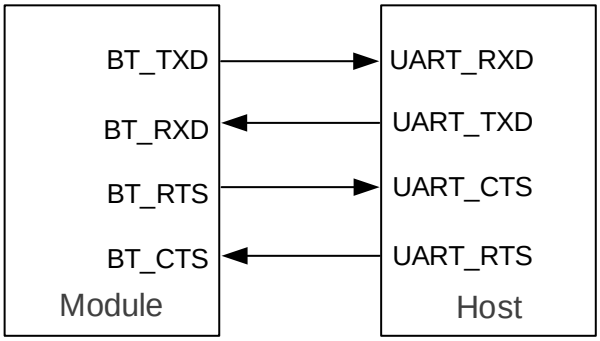


Figure 7: UART Connection

4.6. 802.15.4 Application Interface

802.15.4 application interface connection between the module and the host is illustrated in the figure below.

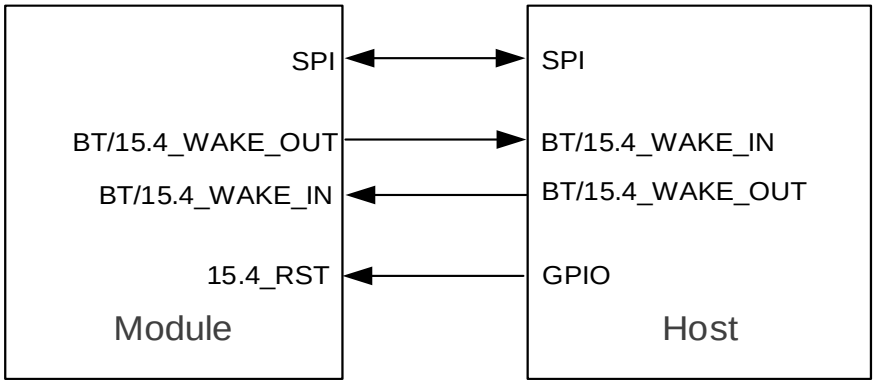


Figure 8: 802.15.4 Application Connection

4.6.1. SPI Interface

The module supports an HCI (Host Controller Interface) SPI. The SPI is used for data transmission with the host.

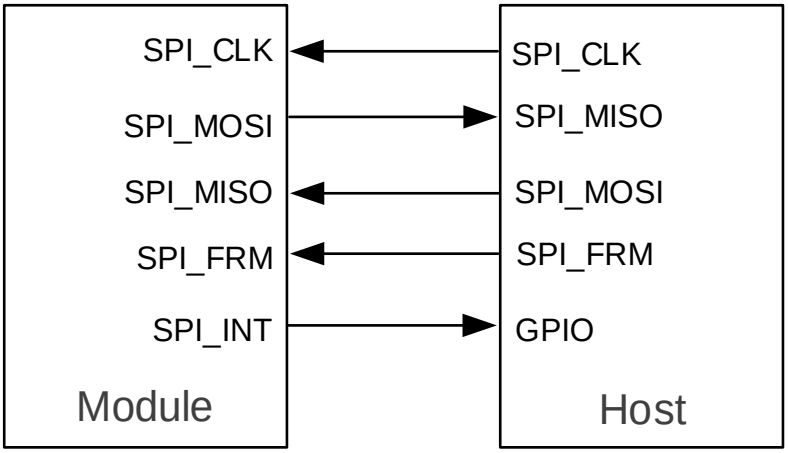


Figure 9: SPI Connection

4.7. RF Antenna Interface

The module supports pin antenna interface (ANT_WIFI/BT). The impedance of antenna port is 50 Ω.

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 10: Antenna Design Requirements

Parameter	Requirement [2]
Frequency Ranges (GHz)	2.400–2.4835,4.900–5.895
Cable Insertion Loss (dB)	TBD
VSWR	TBD
Gain (dBi)	TBD
Max Input Power (W)	TBD
Input Impedance (Ω)	50
Polarization Type	TBD

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

4.7.1. 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.

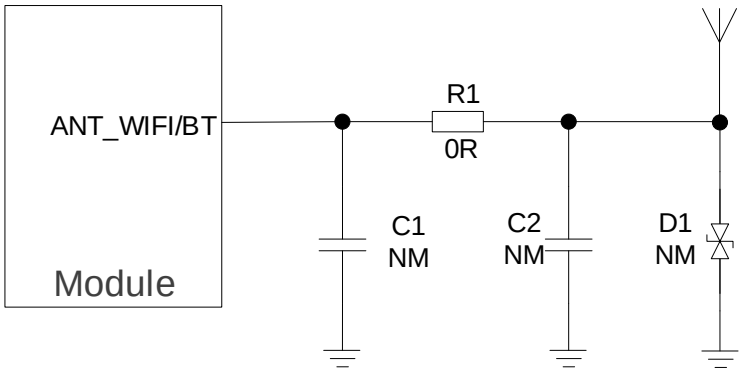


Figure 10: Reference Circuit for RF Antenna Interface

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

4.7.2. 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.

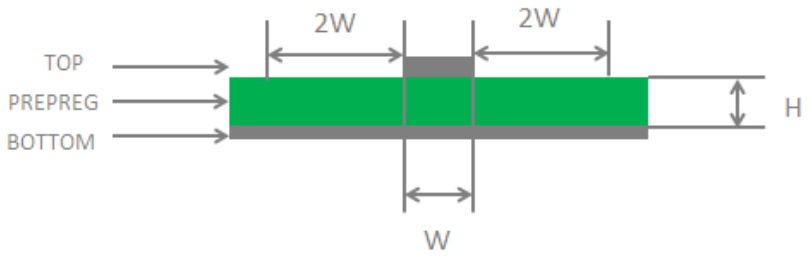


Figure 11: Microstrip Design on a 2-layer PCB

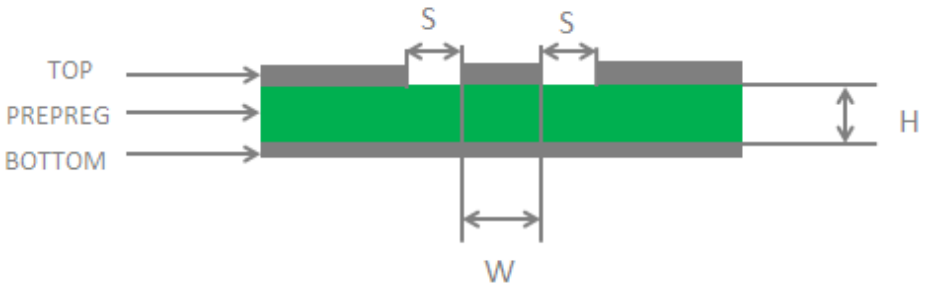


Figure 12: Coplanar Waveguide Design on a 2-layer PCB

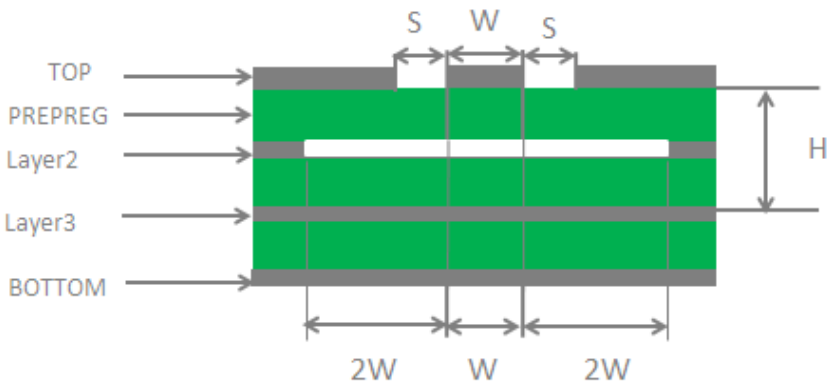


Figure 13: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

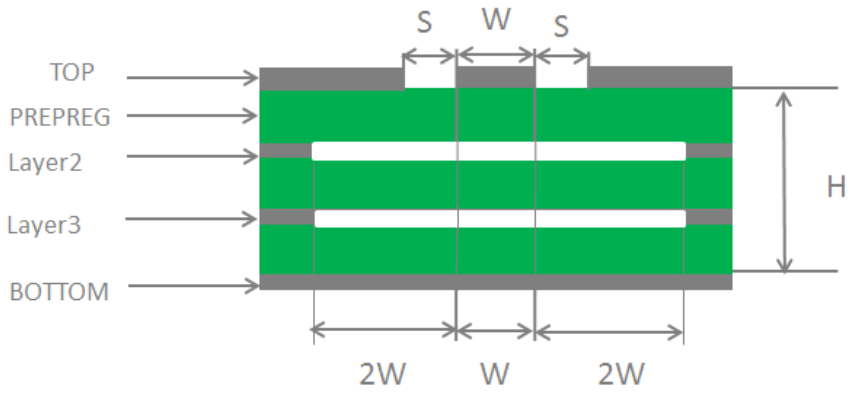


Figure 14: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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]***.

4.7.3. 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.

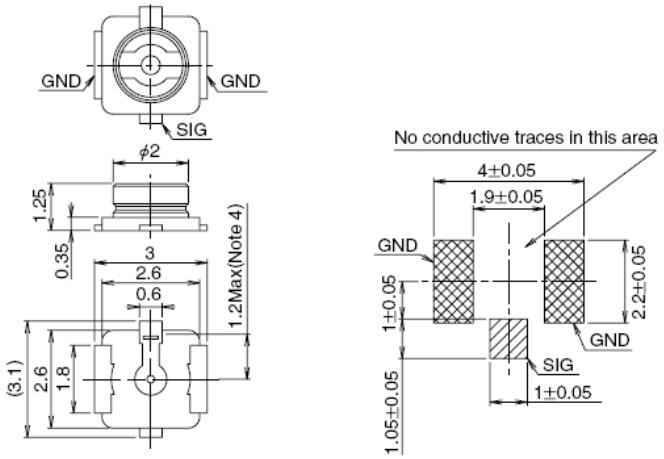


Figure 15: Dimensions of the Receptacle (Unit: mm)

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

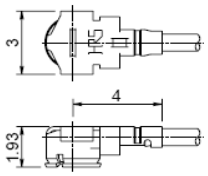
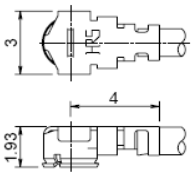
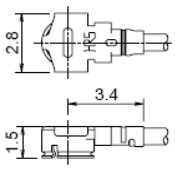
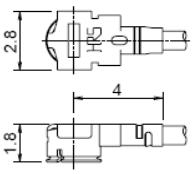
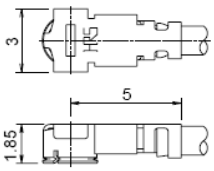
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 16: Specifications of Mated Plugs

The following figure describes the space factor of mated connectors.

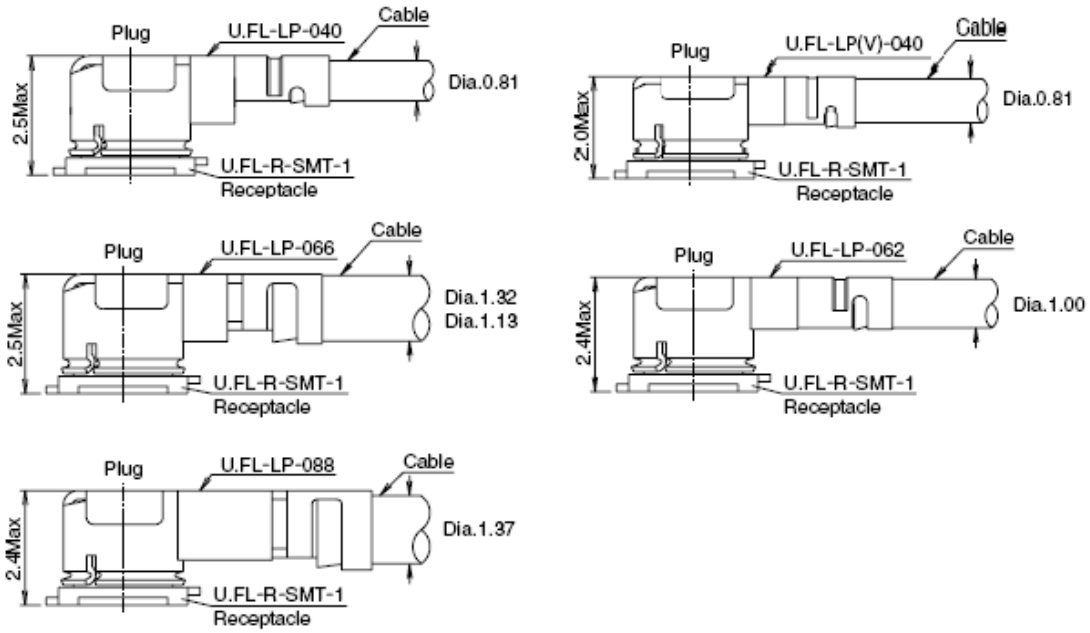


Figure 17: Space Factor of Mated Connectors (Unit: mm)

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

5 Electrical Characteristics & Reliability

5.1. Absolute Maximum Ratings

Table 11: Absolute Maximum Ratings (Unit: V)

Parameter		Min.	Max.
VBAT_3V3	3.3	-	3.96
VBAT_1V8	1.8	-	2.16
VDDIO	3.3	-	3.96
	1.8	-	2.16
VDDIO_RF	3.3	-	3.96
	1.8	-	2.16
SDIO_VDD	3.3	-	3.96
	1.8	-	2.16

5.2. Power Supply Ratings

Table 12: Module Power Supply Ratings (Unit: V)

Parameter	Voltage	Min.	Typ.	Max.
VBAT_3V3	3.3	3.14	3.3	3.46
VBAT_1V8	1.8	1.71	1.8	1.89
VDDIO	3.3	3.14	3.3	3.46
	1.8	1.71	1.8	1.89
VDDIO_RF	3.3	3.14	3.3	3.46
	1.8	1.71	1.8	1.89
SDIO_VDD	3.3	3.14	3.3	3.46
	1.8	1.71	1.8	1.89

5.3. 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 13: Electrostatics Discharge Characteristics (Unit: kV)

Model	Test Result	Standard
Human Body Model (HBM)	TBD	JEDEC EIA/JESD22-A114

5.4. Digital I/O Characteristics

Table 14: VDDIO 1V8 I/O Characteristics (Unit: V)

When I/O supply voltage VDDIO=1.8V

Parameter	Description	Min.	Max.
VIO	I/O pad supply voltage	1.71	1.89
V_{IH}	High-level Input Voltage	0.7*VIO	VIO+0.4
V_{IL}	Low-level Input Voltage	-0.4	0.3*VIO
V_{OH}	High-level Output Voltage	VIO-0.4	-
V_{OL}	Low-level Output Voltage	-	0.4

Table 15: VDDIO 3V3 I/O Characteristics (Unit: V)

When I/O supply voltage VDDIO=3.3V

Parameter	Description	Min.	Max.
VIO	I/O pad supply voltage	3.14	3.46
V_{IH}	High-level Input Voltage	0.7*VIO	VIO+0.4

V_{IL}	Low-level Input Voltage	-0.4	0.3*VIO
V_{OH}	High-level Output Voltage	VIO-0.4	-
V_{OL}	Low-level Output Voltage	-	0.4

Table 16: VDDIO_RF 1V8 I/O Characteristics (Unit: V)

When I/O supply voltage VDDIO_RF=1.8V

Parameter	Description	Min.	Max.
VDDIO_RF	I/O pad supply voltage	1.71	1.89
V_{IH}	High-level Input Voltage	0.7*VIO	VIO+0.4
V_{IL}	Low-level Input Voltage	-0.4	0.3*VIO
V_{OH}	High-level Output Voltage	VIO-0.4	-
V_{OL}	Low-level Output Voltage	-	0.4

Table 17: VDDIO_RF 3V3 I/O Characteristics (Unit: V)

When I/O supply voltage VDDIO_RF=3.3V

Parameter	Description	Min.	Max.
VDDIO_RF	I/O pad supply voltage	3.14	3.46
V_{IH}	High-level Input Voltage	0.7*VIO	VIO+0.4
V_{IL}	Low-level Input Voltage	-0.4	0.3*VIO
V_{OH}	High-level Output Voltage	VIO-0.4	-
V_{OL}	Low-level Output Voltage	-	0.4

Table 18: SDIO_VDD 1V8 I/O Characteristics (Unit: V)

When I/O supply voltage SDIO_VDD=1.8V

Parameter	Description	Min.	Max.
VDDIO_RF	I/O pad supply voltage	1.71	1.89
V_{IH}	High-level Input Voltage	0.7*VIO	VIO+0.4
V_{IL}	Low-level Input Voltage	-0.4	0.3*VIO
V_{OH}	High-level Output Voltage	VIO-0.4	-
V_{OL}	Low-level Output Voltage	-	0.4

Table 19: SDIO_VDD 3V3 I/O Characteristics (Unit: V)

When I/O supply voltage SDIO_VDD=3.3V

Parameter	Description	Min.	Max.
VDDIO_RF	I/O pad supply voltage	3.14	3.46
V_{IH}	High-level Input Voltage	0.7*VIO	VIO+0.4
V_{IL}	Low-level Input Voltage	-0.4	0.3*VIO
V_{OH}	High-level Output Voltage	VIO-0.4	-
V_{OL}	Low-level Output Voltage	-	0.4

5.5. 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.

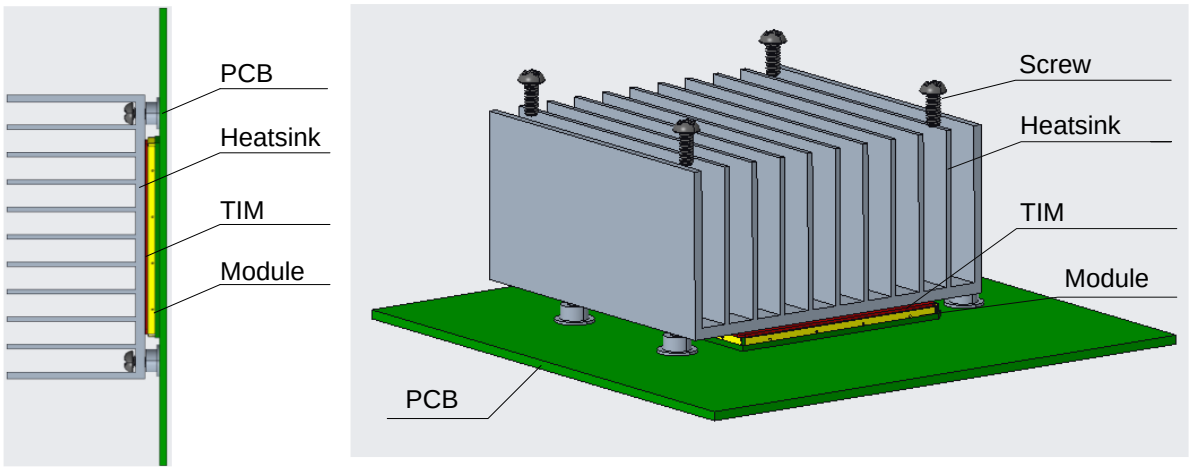


Figure 18: Placement and Fixing of the Heatsink

6 Mechanical Information

TBD

7 Storage, Manufacturing & Packaging

TBD

8 Appendix References

Table 20: Related Documents

Document Name
[1] Quectel_RF_Layout_Application_Note
[2] Quectel_Module_SMT_Application_Note

Table 21: Terms and Abbreviations

Abbreviation	Description
1T1R	One Transmit One Receive
AP	Access Point
BLE	Bluetooth Low Energy
BPSK	Binary Phase Shift Keying
CCK	Complementary Code Keying
DBPSK	Differential Binary Phase Shift Keying
π/4-DQPSK	π/4-Differential Quadrature Phase Shift Keying
8DPSK	8-Differential phase shift keying
DSSS	Direct Sequence Spread Spectrum
ESD	Electrostatic Discharge
EVM	Error Vector Magnitude
GFSK	Gauss Frequency Shift Keying
GND	Ground

HCI	Host Controller Interface
HBM	Human Body Model
HE	High Efficiency
HT	High Throughput
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
MISO	Host input/slave output
MOSI	Host output/slave input
Mbps	Million Bits Per Second
MCS	Modulation and Coding Scheme
PCB	Printed Circuit Board
OFDM	Orthogonal Frequency-Division Multiplexing
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
Rx	Receive
SDIO	Secure Digital Input/Output
SMT	Surface Mount Technology
STA	Station
TVS	Transient Voltage Suppressor
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
V_{IH}	High-level Input Voltage
V_{IL}	Low-level Input Voltage

Vmax	Maximum Voltage
Vmin	Minimum Voltage
Vnom	Nominal Voltage
V_{OH}	High-level Output Voltage
V_{OL}	Low-level Output Voltage
VSWR	Voltage Standing Wave Ratio
Wi-Fi	Wireless Fidelity

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: XMR2023FGS060N.
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
- Wi-Fi 5G:≤1.14 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: XMR2023FGS060N.” or “Contains FCC ID: XMR2023FGS060N.” 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
❒ Wi-Fi 5G:≤1.14 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 user manual for LE-LAN devices shall contain instructions related to the restrictions mentioned in the abovesections, namely that:
i. the device for operation in the band 5150-5250 MHz is only for indoor use to reduce the potential for harmfulinterference to co-channel mobile satellite systems;

ii. for devices with detachable antenna(s), the maximum antenna gain permitted for devices in the bands 5250-5350 MHz and 5470-5725 MHz shall be such that the equipment still complies with the e.i.r.p. limit.
iii. for devices with detachable antennals), the maximum antenna gain permitted for devices in the band5725-5850 MHz shall be such that the equipment still complies with the e.i.r.p. limits as appropriate;
iv. where applicable, antenna type(s), antenna models(s), and worst-case tilt angle(s) necessary to remain compliantwith the e.iro. elevation mask reauirement set forth in section 6.2.2.3 shall be clearly indicated.

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-2023FGS060N” or “where: 10224A-2023FGS060N is the module’s certification number”.