QUECTEL

AF55C Hardware Design

Automotive Wi-Fi&Bluetooth Module Series

Version: 1.0.0

Date: 2023-03-29

Status: Preliminary

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.

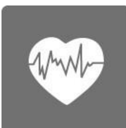
Disclaimer

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.

Copyright © Quectel Wireless Solutions Co., Ltd. 2023. All rights reserved.

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
-	2023-01-04	Oir HUANG/ Ashley HUANG	Creation of the document
1.0.0	2023-03-29	Oir HUANG/ Ashley HUANG	Preliminary

Contents

Safety Information 3
About the Document 4
Contents 5
Table Index 7
Figure Index 8

1 Introduction 9
1.1. Special Marks 9

2 Product Overview 10
2.1. General Description 10
2.2. Key Features 10
2.3. Functional Diagram 12
2.4. EVB Kit 12

3 Application Interfaces 13
3.1. General Description 13
3.2. Pin Assignment 14
3.3. Pin Description 15
3.4. Power Supply 19
3.5. Wi-Fi Application Interfaces 19
3.5.1. WLAN_EN 20
3.5.2. PCIe Interfaces 20
3.5.3. SDIO Interfaces* 22
3.6. Bluetooth Application Interfaces 23
3.6.1. BT_EN 24
3.6.2. PCM Interfaces 24
3.6.3. Bluetooth UART 25
3.7. Control Signals* 26
3.7.1. HOST_WAKE_BT & BT_WAKE_HOST 26
3.7.2. HOST_WAKE_WLAN & WLAN_WAKE_HOST 26
3.8. Coexistence UART Interfaces 26
3.9. WLAN_SLP_CLK 27
3.10. RF Antenna Interfaces 27
3.10.1. Operating Frequencies 28
3.10.2. RF Antenna Reference Design 28
3.10.3. RF Routing Guidelines 29
3.10.4. Antenna Design Requirements 30
3.10.5. RF Connector Recommendation 31

4 Electrical Characteristics & Reliability 33
4.1. Absolute Maximum Ratings 33
4.2. Power Supply Ratings 33

4.3. Digital I/O Characteristics 34
4.4. Power Consumption 34
4.5. RF Performances 38
4.5.1. Wi-Fi Performances 38
4.5.2. Bluetooth Performances 41
4.6. ESD Protection 41
4.7. Operating and Storage Temperatures 42
4.8. Thermal Dissipation 42

5 Mechanical Information 44
5.1. Mechanical Dimensions of the Module 44
5.2. Recommended Footprint 46
5.3. Top and Bottom Views 47

6 Storage, Manufacturing & Packaging 48
6.1. Storage Conditions 48
6.2. Manufacturing and Soldering 49
6.3. Packaging Specifications 51
6.3.1. Carrier Tape 51
6.3.2. Plastic Reel 52
6.3.3. Mounting Direction 52
6.3.4. Packaging Process 53

7 Appendix References 54

Table Index

Table 1: Special Marks 9
Table 2: Key Features 10
Table 3: I/O Parameter Definition 15
Table 4: Pin Description 15
Table 5: Definition of Power Supply and GND Pins 19
Table 6: Pin Definition of WLAN_EN 20
Table 7: Pin Definition of PCIe Interfaces 20
Table 8: Pin Definition of SDIO Interfaces 22
Table 9: Pin Definition of BT_EN 24
Table 10: Pin Definition of PCM Interfaces 24
Table 11: Pin Definition of Bluetooth UART 25
Table 12: Pin Definition of HOST_WAKE_BT & BT_WAKE_HOST 26
Table 13: Pin Definition of HOST_WAKE_WLAN & WLAN_WAKE_HOST 26
Table 14: Pin Definition of Coexistence UART Interfaces 26
Table 15: Pin Definition of WLAN_SLP_CLK 27
Table 16: Pin Definition of RF Antenna Interfaces 27
Table 17: Operating Frequencies (Unit: GHz) 28
Table 18: Antenna Design Requirements 30
Table 19: Absolute Maximum Ratings (Unit: V) 33
Table 20: Module Power Supply Ratings (Unit: V) 33
Table 21: VDD_IO I/O Requirements (Unit: V) 34
Table 22: Power Consumption (Normal Operation) 34
Table 23: Tx Power at 2.4 GHz 38
Table 24: Tx Power at 5 GHz 38
Table 25: Rx Sensitivity at 2.4 GHz (Unit: dBm) 39
Table 26: Rx Sensitivity at 5 GHz (Unit: dBm) 40
Table 27: RF Performance of Bluetooth (Unit: dBm) 41
Table 28: Electrostatic Discharge Characteristics (Temperature: 25–30 ºC, Humidity: 40 ±5 %) 41
Table 29: Operating and Storage Temperatures (Unit: °C) 42
Table 30: Recommended Thermal Profile Parameters 50
Table 31: Carrier Tape Dimension Table (Unit: mm) 51
Table 32: Plastic Reel Dimension Table (Unit: mm) 52
Table 33: Related Documents 54
Table 34: Terms and Abbreviations 54

Figure Index

Figure 1: Functional Diagram ... 12
Figure 2: Pin Assignment (Top View) ... 14
Figure 3: Power-up Timing ... 19
Figure 4: Wi-Fi Application Interface Connection ... 20
Figure 5: PCIe Interface Connection ... 21
Figure 6: Bluetooth Interface Connection ... 24
Figure 7: PCM Interface Connection ... 25
Figure 8: Bluetooth UART Interface Connection ... 25
Figure 9: Coexistence UART Interface Connection ... 27
Figure 10: RF Antenna Reference Design ... 28
Figure 11: Microstrip Design on a 2-layer PCB ... 29
Figure 12: Coplanar Waveguide Design on a 2-layer PCB ... 29
Figure 13: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground) ... 29
Figure 14: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground) ... 30
Figure 15: Dimensions of the Receptacle (Unit: mm) ... 31
Figure 16: Specifications of Mated Plugs ... 32
Figure 17: Space Factor of Mated Connectors (Unit: mm) ... 32
Figure 18: Placement and Fixing of the Heatsink ... 43
Figure 19: Top and Side Dimensions ... 44
Figure 20: Bottom Dimension (Perspective View) ... 45
Figure 21: Recommended Footprint ... 46
Figure 22: Top and Bottom Views ... 47
Figure 23: Recommended Reflow Soldering Thermal Profile ... 49
Figure 24: Carrier Tape Dimension Drawing ... 51
Figure 25: Plastic Reel Dimension Drawing ... 52
Figure 26: Mounting Direction ... 52
Figure 27: Packaging Process ... 53

1 Introduction

This document defines the AF55C 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 automotive industry mobile applications with the module.

1.1. Special Marks

Table 1: Special Marks

Mark	Definition
*	Unless otherwise specified, when an asterisk (*) is used after a function, feature, interface, pin name, AT command, or argument, it indicates that the function, feature, interface, pin, AT command, or argument is under development and currently not supported; and the asterisk (*) after a model indicates that the sample of the model is currently unavailable.
[…]	Brackets ([…]) used after a pin enclosing a range of numbers indicate all pins of the same type. For example, SDIO_DATA[0:3] refers to all four SDIO pins: SDIO_DATA0, SDIO_DATA1, SDIO_DATA2, and SDIO_DATA3.

2 Product Overview

2.1. General Description

AF55C is an automotive-grade Wi-Fi and Bluetooth module with low power consumption. It is a single-die Wi-Fi and Bluetooth combo solution supporting IEEE 802.11a/b/g/n/ac/ax 2.4 GHz and 5 GHz Wi-Fi standards and Bluetooth 5.2 standard, which enables seamless integration of WLAN and Bluetooth Low Energy (BLE) technologies.

AF55C is recommended to be used in conjunction with Quectel AG56xN series to provide Wi-Fi function with a low-power PCIe Gen 2 interface and Bluetooth function with a UART and a PCM interfaces. It also supports LTE & Wi-Fi/Bluetooth coexistence interface

2.2. Key Features

Table 2: Key Features

Feature	Details
Power Supply	● **VBAT Power Supply** Voltage range: 3.0–4.8 V Typical voltage: 3.3 V ● **VDD_IO Power Supply** Voltage range: 1.71–1.89 V Typical voltage: 1.8 V
Operating Frequencies	● 2.4 GHz Wi-Fi: 2.400–2.4835 GHz ● 5 GHz Wi-Fi: 5.150–5.850 GHz ● Bluetooth: 2.402–2.480 GHz
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) ● 802.11ax: HE20 (MCS 0–11), HE40 (MCS 0–11), HE80 (MCS 0–11)

Wi-Fi Protocol	● IEEE 802.11a/b/g/n/ac/ax
Wi-Fi Operation Modes	● AP ● STA
Wi-Fi Modulations	CCK, BPSK, QPSK, 16QAM, 64QAM, 256QAM, 1024QAM
Wi-Fi Application Interfaces	● PCIe ● SDIO*
Bluetooth Protocol	Bluetooth 5.2
Bluetooth Modulations	GFSK, 8-DPSK, π/4-DQPSK
Bluetooth Operating Modes	● Bluetooth Classic (BR + EDR) ● Bluetooth Low Energy (BLE)
Bluetooth Application Interfaces	● PCM ● UART
Antenna Interfaces	● Wi-Fi and Bluetooth antenna interface (ANT_WIFI/BT) ● Wi-Fi antenna interface (ANT_WIFI) ● Reserved dedicated Bluetooth antenna interface (ANT_BT) ● 50 Ω impedance
Physical Characteristics	● Size: (21.5 ±0.2) mm × (19.5 ±0.2) mm × (2.85 ±0.2) mm ● Package: LGA ● Weight: 2.7g
Temperature Ranges	● Operating temperature range: -40 °C to +85 °C [1] ● Storage temperature range: -40 °C to +95 °C
RoHS	All hardware components are fully compliant with EU RoHS directive

[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 performance complies with IEEE and Bluetooth specifications requirements.

2.3. Functional Diagram

The following figure shows a block diagram of the module:

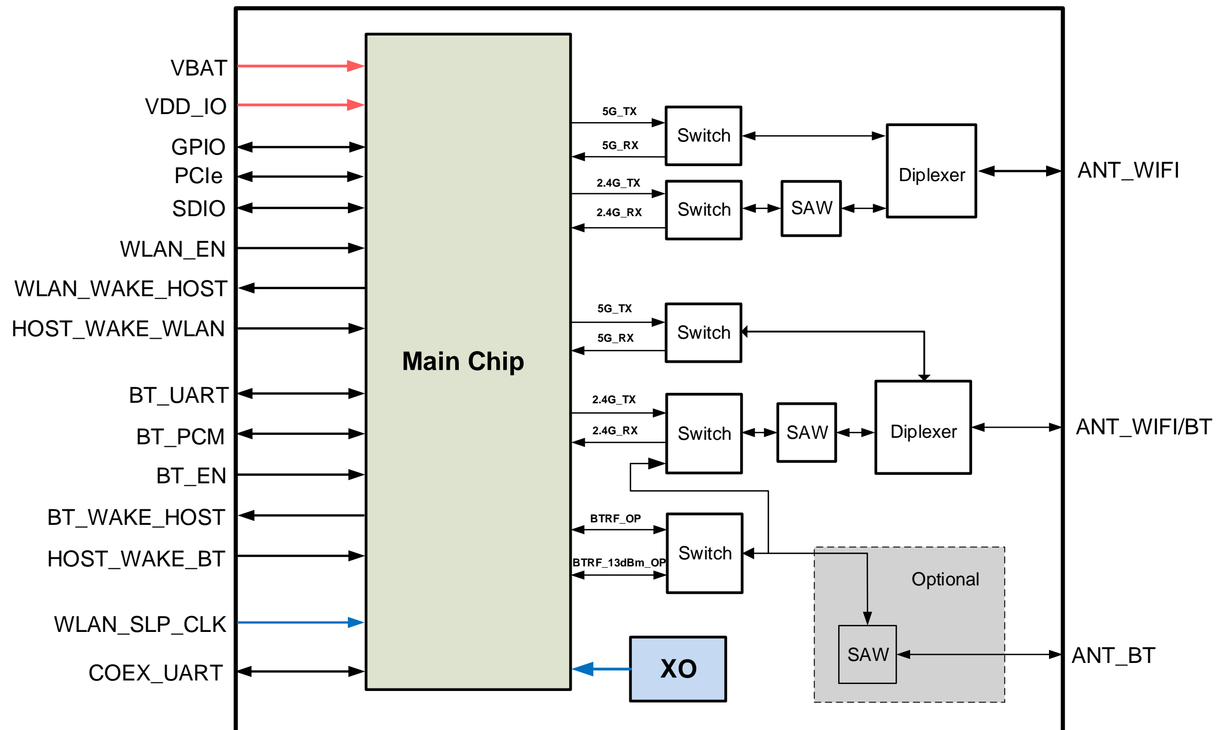


Figure 1: Functional Diagram

2.4. EVB Kit

To help you develop applications with the module, Quectel supplies an evaluation board (V2X&5G EVB) with accessories to control or test the module. For more details, see ***document [1]***.

3 Application Interfaces

3.1. General Description

The module is equipped with 108 LGA pins that can be connected to the cellular application platform. The subsequent chapters will provide a detailed introduction to the following interfaces and pins of the module:

- Power supply
- Wi-Fi application interfaces
  - WLAN_EN
  - PCIe interfaces
  - SDIO interfaces*
- Bluetooth application interfaces
  - BT_EN
  - PCM interfaces
  - Bluetooth UART
- Control signals*
  - HOST_WAKE_BT
  - BT_WAKE_HOST
  - HOST_WAKE_WLAN
  - WLAN_WAKE_HOST
- Coexistence UART interfaces*
- WLAN_SLP_CLK
- RF antenna interfaces

3.2. Pin Assignment

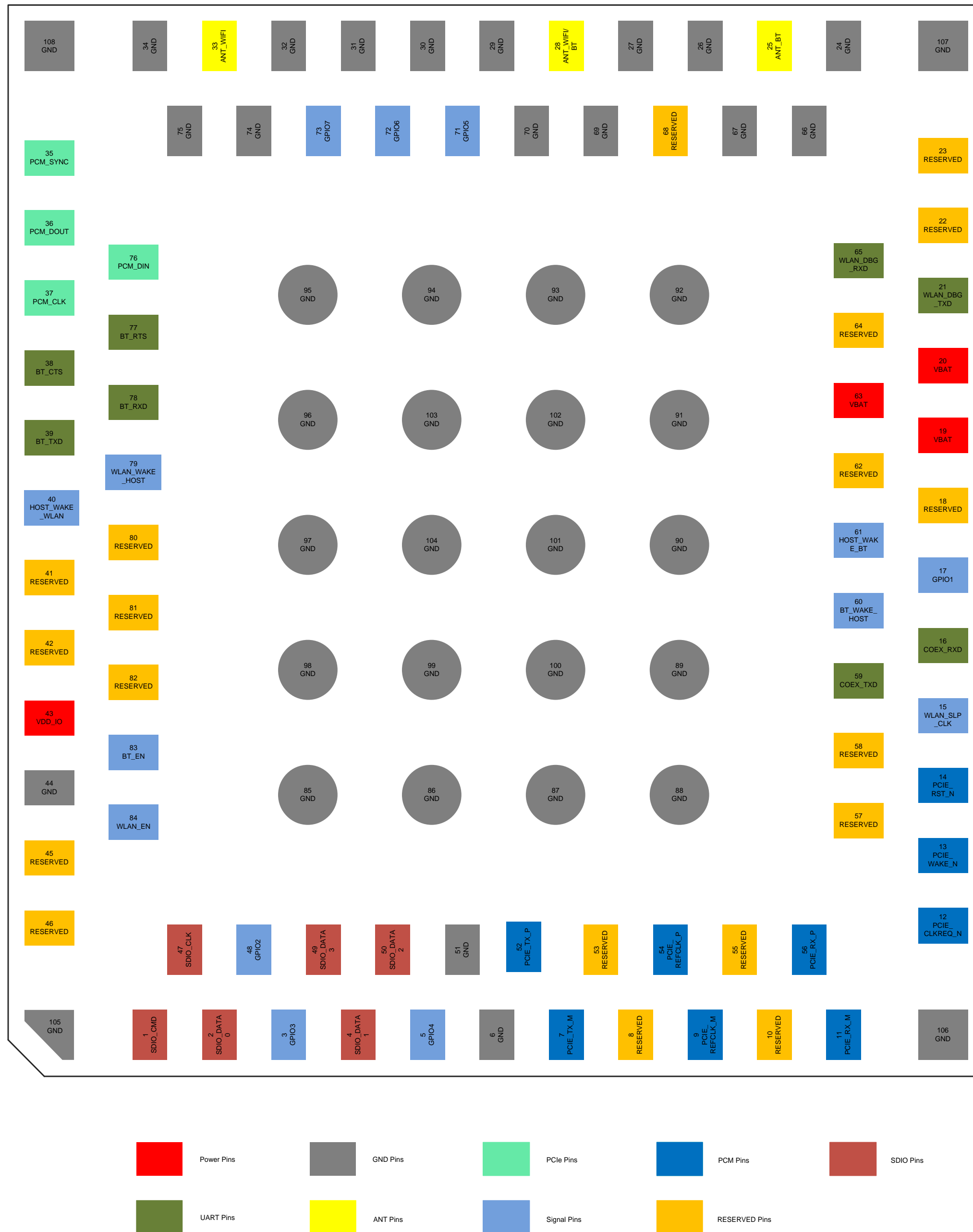


Figure 2: Pin Assignment (Top View)

NOTE

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

3.3. Pin Description

Table 3: I/O Parameter Definition

Type	Description
AI	Analog Input
AO	Analog Output
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, etc.

Table 4: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	19, 20, 63	PI	Power supply for the module	Vmin = 3.0 V Vnom = 3.3 V Vmax = 4.8 V	RF performance is only tested under 3.13–3.5 V (typ. 3.3 V) currently. It must be provided with sufficient current up to 1.5A.
VDD_IO	43	PI	Power supply 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 100 mA.
GND	6, 24, 26, 27, 29–32, 34, 44, 51, 66, 67, 69, 70, 74, 75, 85–108				
Wi-Fi Application Interfaces					

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
WLAN_EN	84	DI	Wi-Fi function enable control	VDD_IO	Active high.
PCIE_REFCLK_P	54	AI	PCIe reference clock (+)	VDD_IO	Requires differential impedance of 100 Ω.
PCIE_REFCLK_M	9	AI	PCIe reference clock (-)		
PCIE_TX_P	52	AO	PCIe transmit (+)		
PCIE_TX_M	7	AO	PCIe transmit (-)		
PCIE_RX_P	56	AI	PCIe receive (+)		
PCIE_RX_M	11	AI	PCIe receive (-)		
PCIE_CLKREQ_N	12	DO	PCIe clock request		Active low.
PCIE_RST_N	14	DI	PCIe reset		
PCIE_WAKE_N	13	DO	PCIe wake up		
SDIO_CMD*	1	DIO	SDIO command		SDIO is optional and is not supported by default. Requires impedance of 50 Ω. If unused, keep them open.
SDIO_CLK*	47	DI	SDIO clock		
SDIO_DATA0*	2	DIO	SDIO data bit 0		
SDIO_DATA1*	4	DIO	SDIO data bit 1		
SDIO_DATA2*	50	DIO	SDIO data bit 2		
SDIO_DATA3*	49	DIO	SDIO data bit 3		
Bluetooth Application Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
BT_EN	83	DI	Bluetooth enable control	VDD_IO	Active high.
PCM_DIN	76	DI	PCM data input		If unused, keep them open.
PCM_SYNC	35	DI	PCM data frame sync		
PCM_CLK	37	DI	PCM clock		
PCM_DOUT	36	DO	PCM data output		

BT_RTS	77	DO	DCE request to send signal to DTE		
BT_CTS	38	DI	DCE clear to send signal from DTE		
BT_TXD	39	DO	Bluetooth UART transmit		
BT_RXD	78	DI	Bluetooth UART receive		
Control Signals*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
HOST_WAKE_BT	61	DI	Host wakes up Bluetooth	VDD_IO	If unused, keep them open.
BT_WAKE_HOST	60	DO	Bluetooth wakes up the host		
HOST_WAKE_ WLAN	40	DI	Host wakes up WLAN		
WLAN_WAKE_ HOST	79	DO	WLAN wakes up the host		
Coexistence Interfaces*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
COEX_TXD	59	DO	LTE & Wi-Fi/Bluetooth coexistence transmit	VDD_IO	If unused, keep them open.
COEX_RXD	16	DI	LTE & Wi-Fi/Bluetooth coexistence receive		
Debug Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WLAN_DBG_ TXD	21	DO	Wi-Fi/Bluetooth debug UART transmit	VDD_IO	Test points must be reserved. These pins can be used as GPIOs. If unused, keep them open.
WLAN_DBG_ RXD	65	DI	Wi-Fi/Bluetooth debug UART receive		
RF Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
ANT_WIFI/BT	28	AIO	Wi-Fi and Bluetooth antenna interface		50 Ω impedance
ANT_WIFI	33	AIO	Wi-Fi antenna interface		
ANT_BT	25	AIO	Reserved dedicated Bluetooth antenna interface		
GPIO Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GPIO1	17	DIO	General-purpose input/output	VDD_IO	If unused, keep them open.
GPIO2	48	DIO	General-purpose input/output		
GPIO3	3	DIO	General-purpose input/output		
GPIO4	5	DIO	General-purpose input/output		
GPIO5	71	DIO	General-purpose input/output		
GPIO6	72	DIO	General-purpose input/output		
GPIO7	73	DIO	General-purpose input/output		
Other Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WLAN_SLP_CLK	15	DI	External 32.768 kHz WLAN sleep clock input	VDD_IO	
RESERVED					
Pin Name	**Pin No.**				**Comment**
RESERVED	8, 10, 18, 22, 23, 41, 42, 45, 46, 53, 55, 57, 58, 62, 64, 68, 80–82				Keep them open.

3.4. Power Supply

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

Table 5: Definition of Power Supply and GND Pins

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT	19, 20, 63	Power supply for the module	3.0	3.3	4.8	V
VDD_IO	43	Power supply for the module's I/O pins	1.71	1.8	1.89	V
GND	6, 24, 26, 27, 29–32, 34, 44, 51, 66, 67, 69, 70, 74, 75, 85–108					

The power-up timing is illustrated in the flowing figure.

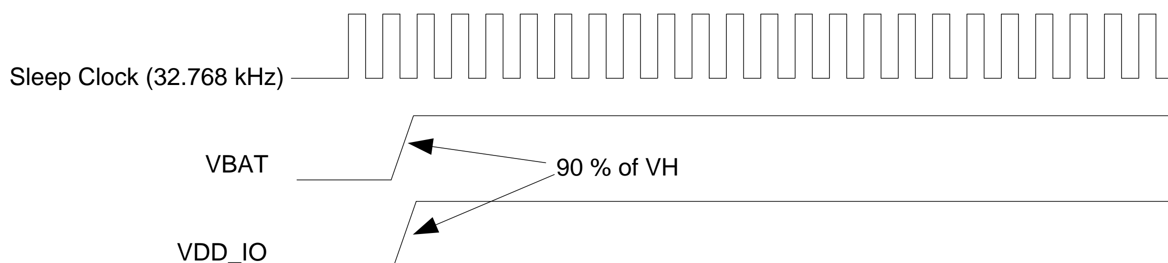


Figure 3: Power-up Timing

NOTE

1. VBAT and VDD_IO should not rise 10 %–90 % faster than 40 μs.
2. VBAT should be up before or at the same time as VDD_IO. VDD_IO should not be present first or be held high before VBAT is high.

3.5. Wi-Fi Application Interfaces

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

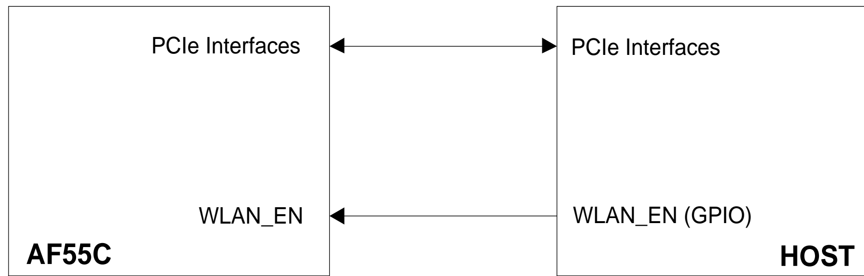


Figure 4: Wi-Fi Application Interface Connection

3.5.1. 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. This pin has an internal 50 KΩ pull-down resistor by default.

Table 6: Pin Definition of WLAN_EN

Pin Name	Pin No.	I/O	Description	Comment
WLAN_EN	84	DI	Wi-Fi function enable control	Active high.

NOTE

WLAN_EN is a sensitive signal, and it should be ground shielded and be routed as close to AF55C as possible.

3.5.2. PCIe Interfaces

The following table shows the pin definition of the PCIe interfaces.

Table 7: Pin Definition of PCIe Interfaces

Pin Name	Pin No.	I/O	Description	Comment
PCIE_REFCLK_P	54	AI	PCIe reference clock (+)	Requires differential impedance of 100 Ω.
PCIE_REFCLK_M	9	AI	PCIe reference clock (-)	
PCIE_TX_P	52	AO	PCIe transmit (+)	

PCIE_TX_M	7	AO	PCIe transmit (-)	
PCIE_RX_P	56	AI	PCIe receive (+)	
PCIE_RX_M	11	AI	PCIe receive (-)	
PCIE_CLKREQ_N	12	DO	PCIe clock request	
PCIE_RST_N	14	DI	PCIe reset	Active low.
PCIE_WAKE_N	13	DO	PCIe wake up	

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

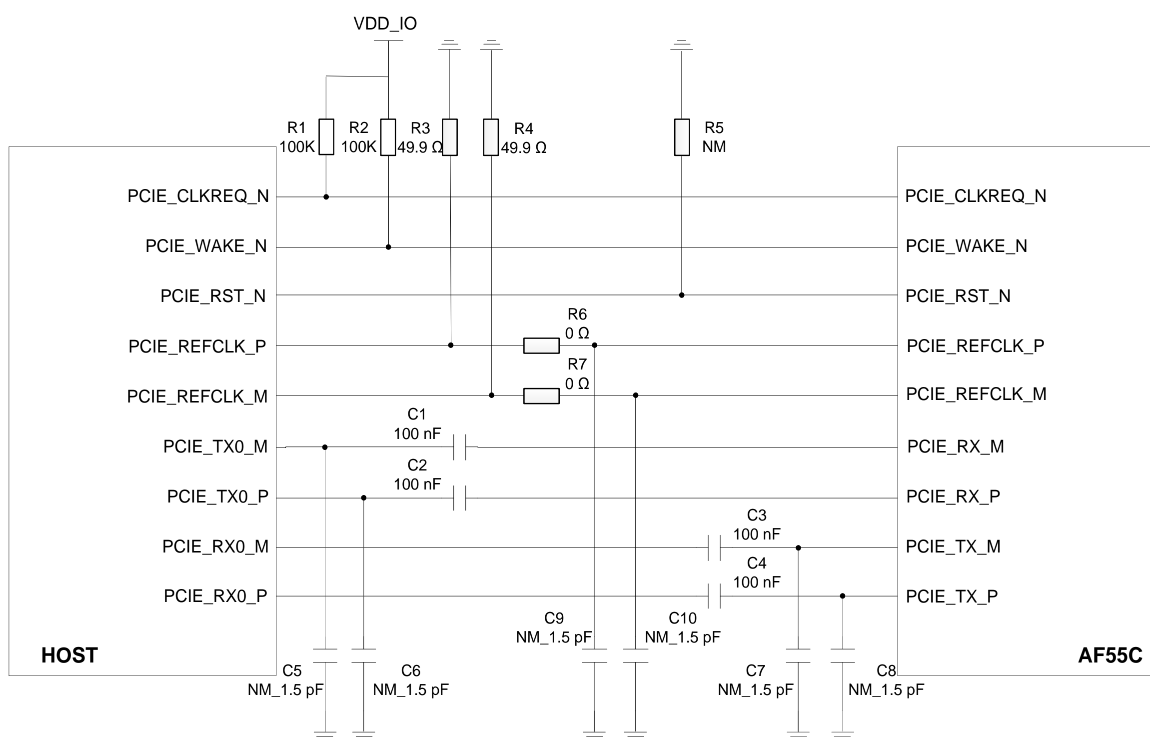


Figure 5: PCIe Interface Connection

To ensure the signal integrity of PCIe interfaces, C1 and C2 should be placed close to the HOST, and C3 and C4 should be placed close to the module. The extra stubs of traces must be as short as possible. Reserve R6, R7 and C5 to C10 for impedance matching.

The following principles of PCIe interface design should be complied with to meet PCIe Gen 2 specifications.

- It is important to route the PCIe signal traces as differential pairs with ground surrounded. And the differential impedance is 100 Ω ±10 %.

- For PCIe signal traces, the maximum length of each differential data pair (Tx/Rx/REFCLK) is recommended to be less than 300 mm, and each differential data pair matching should be less than 0.7 mm.
- Spacing to all other signals is 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.

3.5.3. SDIO Interfaces*

The following table shows the pin definition of SDIO interfaces. SDIO is optional and is not supported by default.

Table 8: Pin Definition of SDIO Interfaces

Pin Name	Pin No.	I/O	Description	Comment
SDIO_CMD	1	DIO	SDIO command	SDIO is optional and is not supported by default. Requires impedance of 50 Ω. If unused, keep them open.
SDIO_CLK	47	DI	SDIO clock	
SDIO_DATA0	2	DIO	SDIO data bit 0	
SDIO_DATA1	4	DIO	SDIO data bit 1	
SDIO_DATA2	50	DIO	SDIO data bit 2	
SDIO_DATA3	49	DIO	SDIO data bit 3	

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

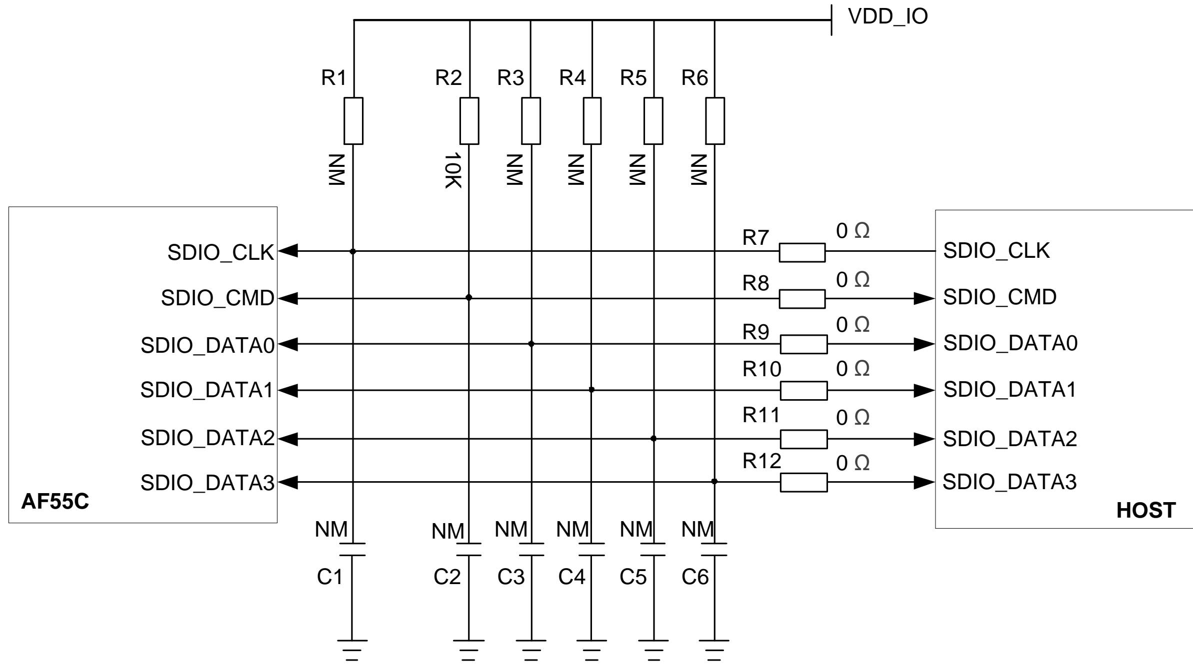


Figure 5: SDIO Interface Connection

Follow the principles below in the SDIO circuit design:

- To avoid jitter of bus, it is recommended to reserve resistors R1–R6 (10–100 kΩ) to pull up SDIO traces to VDD_1V8. R1–R6 are not mounted by default.
- Bypass capacitors C1–C6 are reserved and not mounted by default.
- SDIO signal traces should comply with the following principles:
  a) It is important to route the SDIO signal end traces with surrounded ground. The impedance of SDIO data trace should be 50 Ω.
  b) Keep the spacing between adjacent SDIO_DATA traces and spacing between SDIO_DATA and SDIO_CLK traces twice the trace width.
  c) Keep SDIO signals far away from other sensitive circuits/signals such as RF circuits, analog signals, etc., as well as noise signals such as clock signals, DC-DC signals, etc.
  d) It is recommended to keep the trace length difference between SDIO_CLK and SDIO_DATA[0:3]/SDIO_CMD less than 1 mm.

3.6. Bluetooth Application Interfaces

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

If Bluetooth function of the module is used, the UART and PCM interfaces of the module must be connected to that of the host.

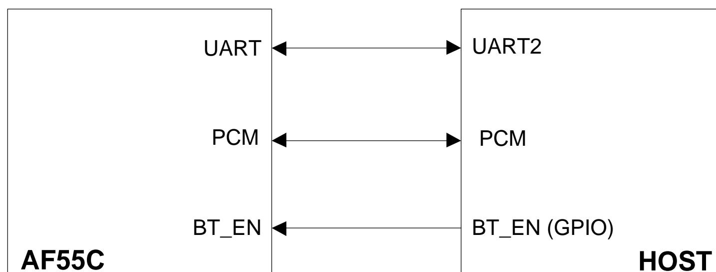


Figure 6: Bluetooth Interface Connection

3.6.1. 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. This pin has an internal 50 KΩ pull-down resistor by default.

Table 9: Pin Definition of BT_EN

Pin Name	Pin No.	I/O	Description	Comment
BT_EN	83	DI	Bluetooth enable control	Active high.

3.6.2. PCM Interfaces

The following table shows the pin definition of PCM interfaces.

Table 10: Pin Definition of PCM Interfaces

Pin Name	Pin No.	I/O	Description	Comment
PCM_DIN	76	DI	PCM data input	If unused, keep them open.
PCM_SYNC	35	DI	PCM data frame sync	
PCM_CLK	37	DI	PCM clock	
PCM_DOUT	36	DO	PCM data output	

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

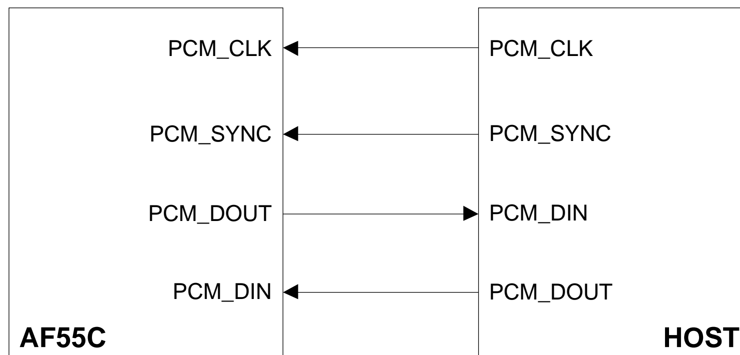


Figure 7: PCM Interface Connection

3.6.3. Bluetooth UART

The module serves as DCE (Data Communication Equipment), which is connected in the traditional DCE-DTE (Data Terminal Equipment) mode.

The following table shows the pin definition of Bluetooth UART.

Table 11: Pin Definition of Bluetooth UART

Pin Name	Pin No.	I/O	Description	Comment
BT_RTS	77	DO	DCE request to send signal to DTE	If unused, keep them open.
BT_CTS	38	DI	DCE clear to send signal from DTE	
BT_TXD	39	DO	Bluetooth UART transmit	
BT_RXD	78	DI	Bluetooth UART receive	

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

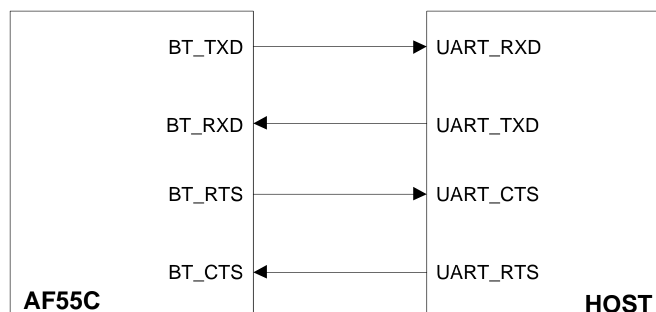


Figure 8: Bluetooth UART Interface Connection

3.7. Control Signals*

3.7.1. HOST_WAKE_BT & BT_WAKE_HOST

Table 12: Pin Definition of HOST_WAKE_BT & BT_WAKE_HOST

Pin Name	Pin No.	I/O	Description	Comment
HOST_WAKE_BT	61	DI	Host wakes up Bluetooth	If unused, keep them open.
BT_WAKE_HOST	60	DO	Bluetooth wakes up the host	

3.7.2. HOST_WAKE_WLAN & WLAN_WAKE_HOST

Table 13: Pin Definition of HOST_WAKE_WLAN & WLAN_WAKE_HOST

Pin Name	Pin No.	I/O	Description	Comment
HOST_WAKE_WLAN	40	DI	Host wakes up WLAN	If unused, keep them open.
WLAN_WAKE_HOST	79	DO	WLAN wakes up the host	

3.8. Coexistence UART Interfaces*

The following table shows the pin definition of coexistence UART interfaces.

Table 14: Pin Definition of Coexistence UART Interfaces

Pin Name	Pin No.	I/O	Description	Comment
COEX_TXD	59	DO	LTE & Wi-Fi/Bluetooth coexistence transmit	If unused, keep them open.
COEX_RXD	16	DI	LTE & Wi-Fi/Bluetooth coexistence receive	

The module supports LTE & Wi-Fi coexistence and LTE & Bluetooth coexistence. The following figure shows the coexistence UART interface connection between the module and the host.

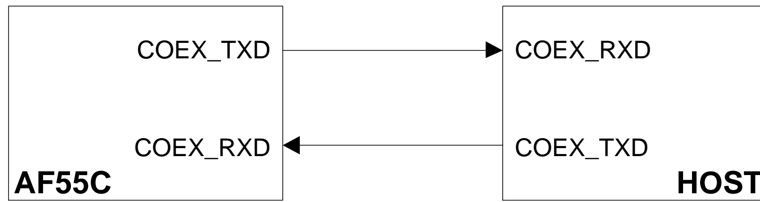


Figure 9: Coexistence UART Interface Connection

3.9. WLAN_SLP_CLK

The module will fail to turn on and work without sleep clock, so an external 32.768 kHz sleep clock connecting to WLAN_SLP_CLK is necessary.

Table 15: Pin Definition of WLAN_SLP_CLK

Pin Name	Pin No.	I/O	Description
WLAN_SLP_CLK	15	DI	External 32.768 kHz WLAN sleep clock input

Parameter	LPO Clock	Unit
Nominal input frequency	32.768	KHz
Frequency accuracy	±250	ppm
Duty cycle	30-70	%
Input signal amplitude	200-1800	mV,p-p
Signal type	Square-wave or sine-wave	-
Input impedance	>100K	Ω
	<5	pF
Clock jitter(during initial startup)	< 10000	ppm

3.10. RF Antenna Interfaces

The following table shows the pin definition of RF antenna interfaces.

Table 16: Pin Definition of RF Antenna Interfaces

Pin Name	Pin No.	I/O	Description	Comment

ANT_WIFI/BT	28	AIO	Wi-Fi and Bluetooth antenna interface	50 Ω impedance
ANT_WIFI	33	AIO	Wi-Fi antenna interface	
ANT_BT	25	AIO	Reserved dedicated Bluetooth antenna interface	

3.10.1. Operating Frequencies

The operating frequencies of the module is shown in the table below:

Table 17: Operating Frequencies (Unit: GHz)

Feature	Frequency
2.4 GHz Wi-Fi	2.400–2.4835
5 GHz Wi-Fi	5.150–5.850
Bluetooth	2.402–2.480

3.10.2. RF Antenna Reference Design

The module provides three RF antenna interfaces for antenna connection. An example reference design with ANT_WIFI, which applies to other RF antenna interfaces as well, is illustrated in the following figure.

It is recommended to reserve two notch filter circuits and a π-type matching circuit for better RF performance. L1, L2, C1 and C2 comprise two notch filter circuits for filtering out interference caused by a particular frequency. When L1, L2, C1 and C2 are not mounted, C3, R1 and C4 comprise a π-type matching circuit. Capacitors (C1, C2, C3 and C4) and inductors (L1 and L2) are not mounted by default, and R1 is only mounted with 0 Ω resistor.

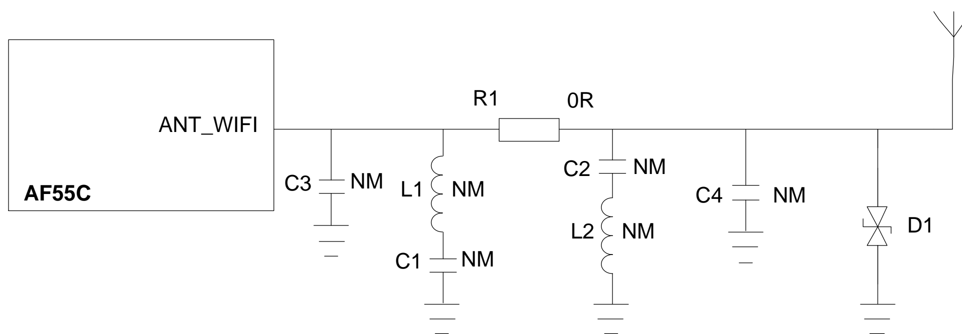


Figure 10: RF Antenna Reference Design

3.10.3. 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.

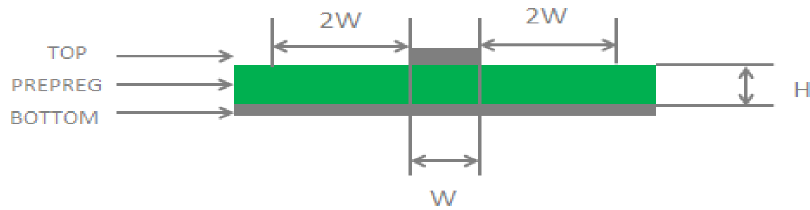


Figure 11: Microstrip Design on a 2-layer PCB

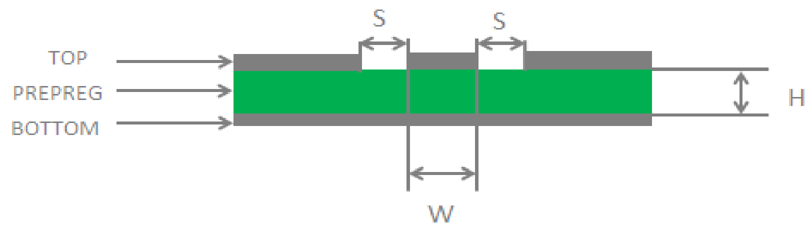


Figure 12: Coplanar Waveguide Design on a 2-layer PCB

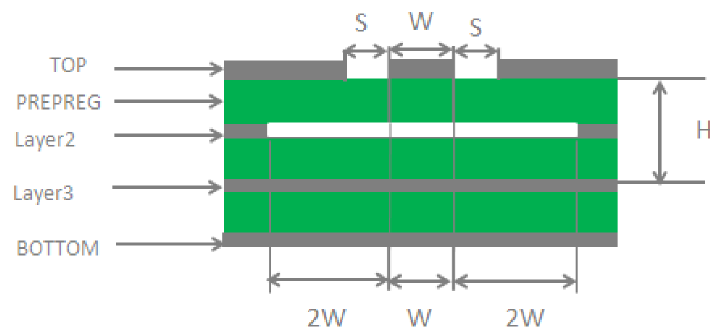


Figure 13: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

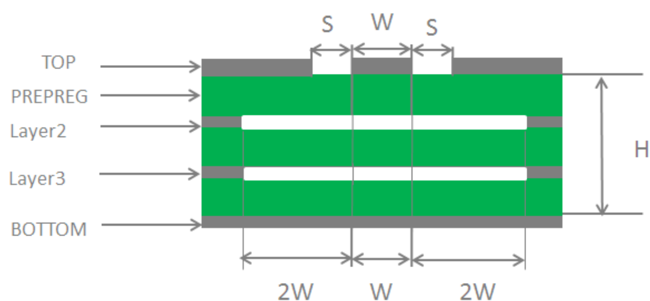


Figure 14: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

To ensure RF performance and reliability, the following principles should be complied with RF layout design:

- Use impedance simulation tool to control the characteristic impedance of RF traces to 50 Ω.
- The GND pins adjacent to RF pins should not be designed as thermal relief pins, 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 [2]***.

3.10.4. Antenna Design Requirements

Table 18: Antenna Design Requirements

Parameter	Requirements
Frequency Ranges (GHz)	● 2.4 GHz Wi-Fi: 2.400–2.4835 ● 5 GHz Wi-Fi: 5.150–5.850 ● Bluetooth: 2.402–2.480
Cable Insertion Loss (dB)	< 1
VSWR	≤ 2
Gain (dBi)	1 (Typ.)
Max Input Power (W)	50

Input Impedance (Ω)	50
Polarization Type	Vertical

3.10.5. 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.

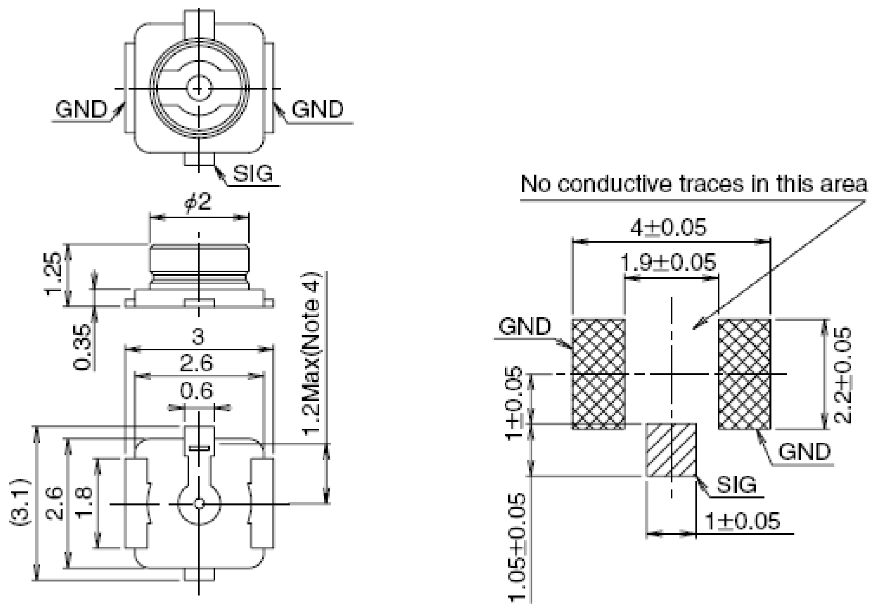


Figure 15: Dimensions of the Receptacle (Unit: mm)

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.

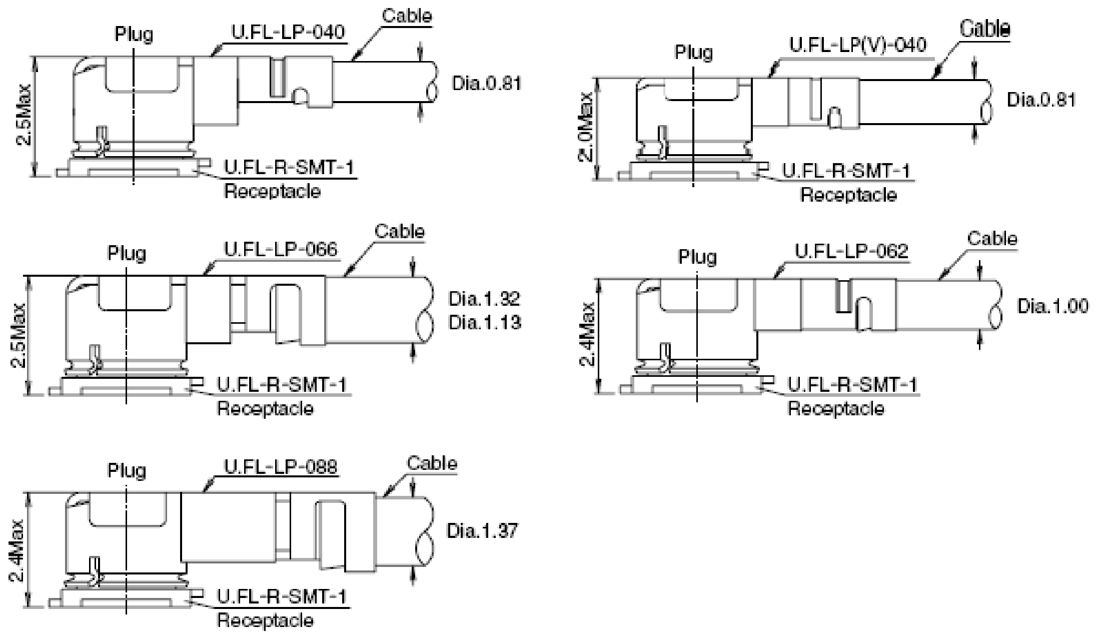


Figure 17: Space Factor of Mated Connectors (Unit: mm)

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

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 19: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VBAT	-0.5	6.0
VDD_IO	-0.5	2.2
Voltage at Digital Pins	-0.5	2.2

4.2. Power Supply Ratings

Table 20: Module Power Supply Ratings (Unit: V)

Parameter	Min.	Typ.	Max.
VBAT	3.0	3.3	4.8
VDD_IO	1.71	1.8	1.89

4.3. Digital I/O Characteristics

Table 21: VDD_IO I/O Requirements (Unit: V)

Parameter	Description	Min.	Max.
V_{IH}	High-level input voltage	0.65 × VDD_IO	-
V_{IL}	Low-level input voltage	-	0.35 × VDD_IO
V_{OH}	High-level output voltage	VDD_IO - 0.40	-
V_{OL}	Low-level output voltage	-	0.45

4.4. Power Consumption

The values of power consumption are shown as below.

Table 22: Power Consumption (Normal Operation)

Condition	Data Rate	I_{VBAT}	I_{VDD_IO}	Unit
802.11b (2.4 GHz)	Tx @ 1 Mbps	255	6	mA
	Tx @ 11 Mbps	250	6	mA
802.11g (2.4 GHz)	Tx @ 6 Mbps	255	6	mA
	Tx @ 54 Mbps	200	5	mA
802.11n (2.4 GHz)	Tx HT20 @ MCS 0	255	6	mA
	Tx HT20 @ MCS 7	180	5	mA
802.11ax (2.4 GHz)	Tx HE20 @ MCS 0	255	6	mA
	Tx HE20 @ MCS 11	190	5	mA
802.11a (5 GHz)	Tx @ 6 Mbps	352	6	mA
	Tx @ 54 Mbps	282	5	mA

802.11n (5 GHz)	Tx HT20 @ MCS 0	368	6	mA
	Tx HT20 @ MCS 7	312	5	mA
	Tx HT40 @ MCS 0	350	6	mA
	Tx HT40 @ MCS 7	230	4	mA
802.11ac (5 GHz)	Tx VHT20 @ MCS 0	385	6	mA
	Tx VHT20 @ MCS 8	306	5	mA
	Tx VHT40 @ MCS 0	392	6	mA
	Tx VHT40 @ MCS 9	276	5	mA
	Tx VHT80 @ MCS 0	412	6	mA
	Tx VHT80 @ MCS 9	300	5	mA
802.11ax (5 GHz)	Tx HE20 @ MCS 0	370	6	mA
	Tx HE20 @ MCS 11	260	5	mA
	Tx HE40 @ MCS 0	372	6	mA
	Tx HE40 @ MCS 11	242	5	mA
	Tx HE80 @ MCS 0	380	6	mA
	Tx HE80 @ MCS 11	240	4	mA

Condition	Data Rate	I_{VBAT}	I_{VDD_IO}	Unit
802.11b (2.4 GHz)	Rx @ 1 Mbps	76	1.6	mA
	Rx @ 11 Mbps	78	1.6	mA
802.11g (2.4 GHz)	Rx @ 6 Mbps	78	1.6	mA
	Rx @ 54 Mbps	80	1.6	mA
802.11n (2.4 GHz)	Rx HT20 @ MCS 0	78	1.6	mA
	Rx HT20 @ MCS 7	80	1.6	mA
802.11ax (2.4 GHz)	Rx HE20 @ MCS 0	78	1.6	mA
	Rx HE20 @ MCS 11	80	1.6	mA

802.11a (5 GHz)	Rx @ 6 Mbps	86	1.6	mA
	Rx @ 54 Mbps	90	1.6	mA
802.11n (5 GHz)	Rx HT20 @ MCS 0	86	1.6	mA
	Rx HT20 @ MCS 7	90	1.6	mA
	Rx HT40 @ MCS 0	93	1.6	mA
	Rx HT40 @ MCS 7	96	1.6	mA
802.11ac (5 GHz)	Rx VHT20 @ MCS 0	86	1.6	mA
	Rx VHT20 @ MCS 8	90	1.6	mA
	Rx VHT40 @ MCS 0	93	1.6	mA
	Rx VHT40 @ MCS 9	97	1.6	mA
	Rx VHT80 @ MCS 0	103	1.6	mA
	Rx VHT80 @ MCS 9	108	1.6	mA
802.11ax (5 GHz)	Rx HE20 @ MCS 0	86	1.6	mA
	Rx HE20 @ MCS 11	88	1.6	mA
	Rx HE40 @ MCS 0	93	1.6	mA
	Rx HE40 @ MCS 11	95	1.6	mA
	Rx HE80 @ MCS 0	104	1.6	mA
	Rx HE80 @ MCS 11	104	1.6	mA

Condition	Data Rate	I_{VBAT}	I_{VDD_IO}	Unit
802.11n (2.4 GHz)	Tx MIMO HT20 @ MCS 0	396	9	mA
	Tx MIMO HT20 @ MCS 7	240	6	mA
802.11ax (2.4 GHz)	Tx MIMO HE20 @ MCS 0	412	9.5	mA
	Tx MIMO HE20 @ MCS 11	265	7	mA
802.11n (5 GHz)	Tx MIMO HT20 @ MCS 0	647	9.5	mA
	Tx MIMO HT20 @ MCS 7	488	8	mA

	Tx MIMO HT40 @ MCS 0	556	8	mA
	Tx MIMO HT40 @ MCS 7	322	5.5	mA
802.11ac (5 GHz)	Tx MIMO VHT20 @ MCS 0	677	8.5	mA
	Tx MIMO VHT20 @ MCS 8	479	7.5	mA
	Tx MIMO VHT40 @ MCS 0	684	9.5	mA
	Tx MIMO VHT40 @ MCS 9	399	6.5	mA
	Tx MIMO VHT80 @ MCS 0	712	9.5	mA
	Tx MIMO VHT80 @ MCS 9	438	7	mA
802.11ax (5 GHz)	Tx MIMO HE20 @ MCS 0	630	9.5	mA
	Tx MIMO HE20 @ MCS 11	388	7	mA
	Tx MIMO HE40 @ MCS 0	642	9	mA
	Tx MIMO HE40 @ MCS 11	350	6.5	mA
	Tx MIMO HE80 @ MCS 0	620	8.5	mA
	Tx MIMO HE80 @ MCS 11	340	6	mA

Condition	Data Rate	I_{VBAT}	I_{VDD_IO}	Unit
BlueTooth BR	DH5	20	17	mA
BlueTooth EDR	2-DH5	19	17	mA
	3-DH5	19	17	mA
BlueTooth LE5.0	1 Mbps	24	11	mA
	2 Mbps	15	11	mA
	S = 2	21	11	mA
	S = 8	28	11	mA

NOTE

1. The power consumption data above is for reference only, which may vary among different modules. For detailed information, please contact Quectel Technical Support for the power consumption test report of the module.
2. Wi-Fi power consumption default test antenna and channel:
   - 2.4 GHz test ANT0 and channel CH6;
   - 5 GHz test ANT0 and channel CH100 (20 MHz)/CH102(40 MHz)/CH106 (80 MHz).
3. The Bluetooth power consumption test uses the max. transmitting power by default, the BR & EDR test channel uses CH39, and the LE test channel uses CH19.

4.5. RF Performances

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

4.5.1. Wi-Fi Performances

Table 23: Tx Power at 2.4 GHz

Standard	Typ. (dBm)	Tolerance (dB)
802.11b @ 1 Mbps	16	± 2.5
802.11b @ 11 Mbps	16	± 2.5
802.11g @ 6 Mbps	16	± 2.5
802.11g @ 54 Mbps	15	± 2.5
802.11n, HT20 @ MCS 0	16	± 2.5
802.11n, HT20 @ MCS 7	13	± 2.5
802.11ax, HE20 @ MCS 0	15	± 2.5
802.11ax, HE20 @ MCS 11	11	± 2.5

Table 24: Tx Power at 5 GHz

Standard	Typ. (dBm)	Tolerance (dB)

802.11a @ 6 Mbps	15	± 2.5
802.11a @ 54 Mbps	15	± 2.5
802.11n, HT20 @ MCS 0	15	± 2.5
802.11n, HT20 @ MCS 7	13	± 2.5
802.11n, HT40 @ MCS 0	15	± 2.5
802.11n, HT40 @ MCS 7	12	± 2.5
802.11ac, VHT20 @ MCS 0	16	± 2.5
802.11ac, VHT20 @ MCS 8	13	± 2.5
802.11ac, VHT40 @ MCS 0	16	± 2.5
802.11ac, VHT40 @ MCS 9	12	± 2.5
802.11ac, VHT80 @ MCS 0	16	± 2.5
802.11ac, VHT80 @ MCS 9	12	± 2.5
802.11ax, HE20 @ MCS 0	15	± 2.5
802.11ax, HE20 @ MCS 11	10	± 2.5
802.11ax, HE40 @ MCS 0	15	± 2.5
802.11ax, HE40 @ MCS 11	9	± 2.5
802.11ax, HE80 @ MCS 0	15	± 2.5
802.11ax, HE80 @ MCS 11	9	± 2.5

Table 25: Rx Sensitivity at 2.4 GHz (Unit: dBm)

Standard	802.11 (Max.)	Receiving Sensitivity (Typ.)
802.11b @ 1 Mbps	-82	-97
802.11b @ 11 Mbps	-76	-88
802.11g @ 6 Mbps	-82	-91
802.11g @ 54 Mbps	-65	-75

802.11n, HT20 @ MCS 0	-82	-93
802.11n, HT20 @ MCS 7	-64	-74
802.11ax, HE20 @ MCS 0	-82	-90
802.11ax, HE20 @ MCS 11	-52	-62

Table 26: Rx Sensitivity at 5 GHz (Unit: dBm)

Standard	802.11 (Max.)	Receiving Sensitivity (Typ.)
802.11a @ 6 Mbps	-82	-92
802.11a @ 54 Mbps	-65	-74
802.11n, HT20 @ MCS 0	-82	-92
802.11n, HT20 @ MCS 7	-64	-72
802.11n, HT40 @ MCS 0	-79	-89
802.11n, HT40 @ MCS 7	-61	-70
802.11ac, VHT20 @ MCS 0	-82	-92
802.11ac, VHT20 @ MCS 8	-59	-68
802.11ac, VHT40 @ MCS 0	-79	-89
802.11ac, VHT40 @ MCS 9	-54	-63
802.11ac, VHT80 @ MCS 0	-76	-86
802.11ac, VHT80 @ MCS 9	-51	-61
802.11ax, HE20 @ MCS 0	-82	-93
802.11ax, HE20 @ MCS 11	-52	-60
802.11ax, HE40 @ MCS 0	-79	-91
802.11ax, HE40 @ MCS 11	-49	-57
802.11ax, HE80 @ MCS 0	-76	-88
802.11ax, HE80 @ MCS 11	-46	-54

NOTE

1. The sensitivity data above is for reference only, which may vary among different modules. For detailed information, please contact Quectel Technical Support for the Rx sensitivity test report of the module.
2. Rx sensitivity default test antenna and channel:
- 2.4 GHz test ANT0 and channel CH6;
- 5 GHz test ANT0 and channel CH100 (20 MHz)/CH102(40 MHz)/CH106 (80 MHz).

4.5.2. Bluetooth Performances

Table 27: RF Performance of Bluetooth (Unit: dBm)

Operating Mode	Transmitting Power (Typ.)	Receiving Sensitivity (Typ.)
BR	9 ± 2.5	-90
EDR (2-DH5)	0 ± 2.5	-94
EDR (3-DH5)	0 ± 2.5	-88
BLE (1 Mbps)	0 ± 2.5	-93
BLE (2 Mbps)	0 ± 2.5	-91
BLE (S = 2)	0 ± 2.5	-93
BLE (S = 8)	0 ± 2.5	-98

4.6. 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 28: Electrostatic Discharge Characteristics (Temperature: 25–30 ºC, Humidity: 40 ±5 %)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VBAT, VDD_IO, GND	±6	±10	kV

Antenna interfaces	±6	±10	kV
Other interfaces	±0.5	±1	kV

4.7. Operating and Storage Temperatures

Table 29: Operating and Storage Temperatures (Unit: °C)

Parameter	Min.	Typ.	Max.
Operating temperature range [2]	-40	+25	+85
Storage temperature range	-40	-	+95

4.8. 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

[2] 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 performance complies with IEEE and Bluetooth specifications requirements.

prevent the heatsink from falling off during the drop, vibration test, or transportation.

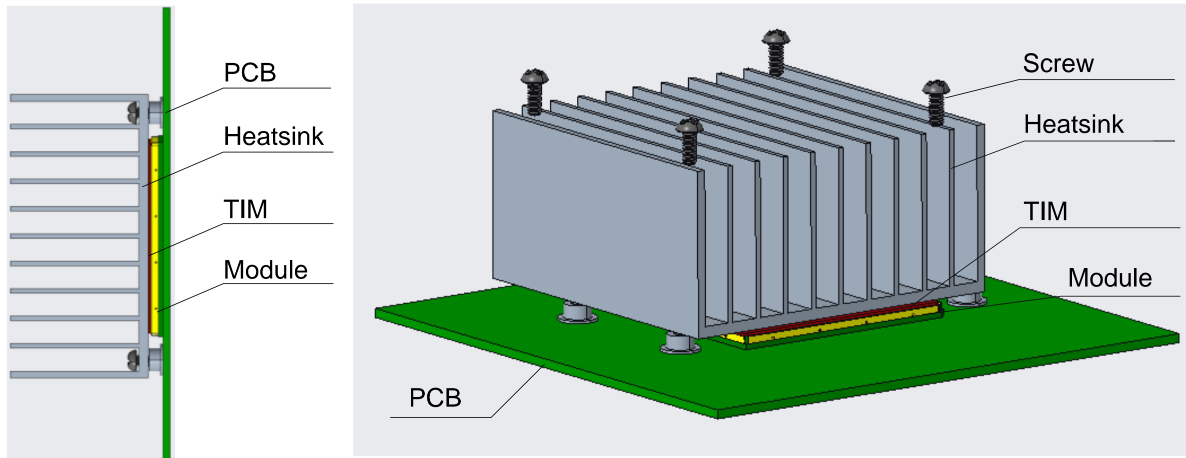


Figure 18: Placement and Fixing of the Heatsink

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 of the Module

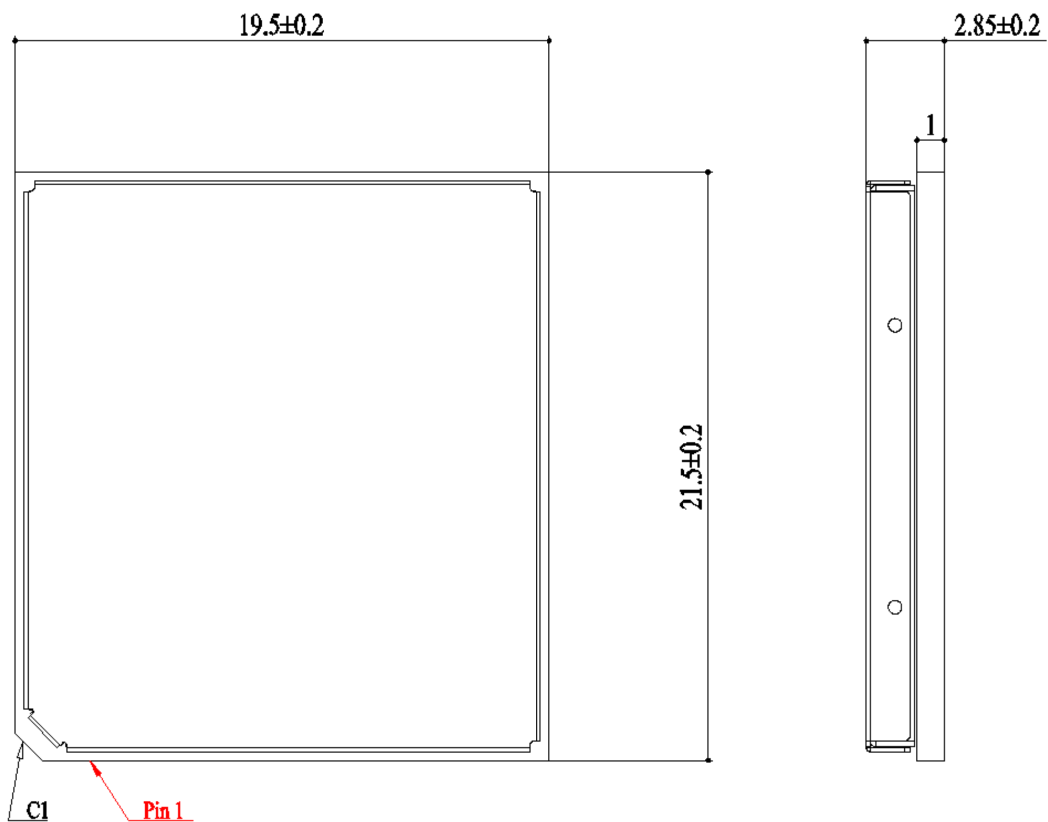


Figure 19: Top and Side Dimensions

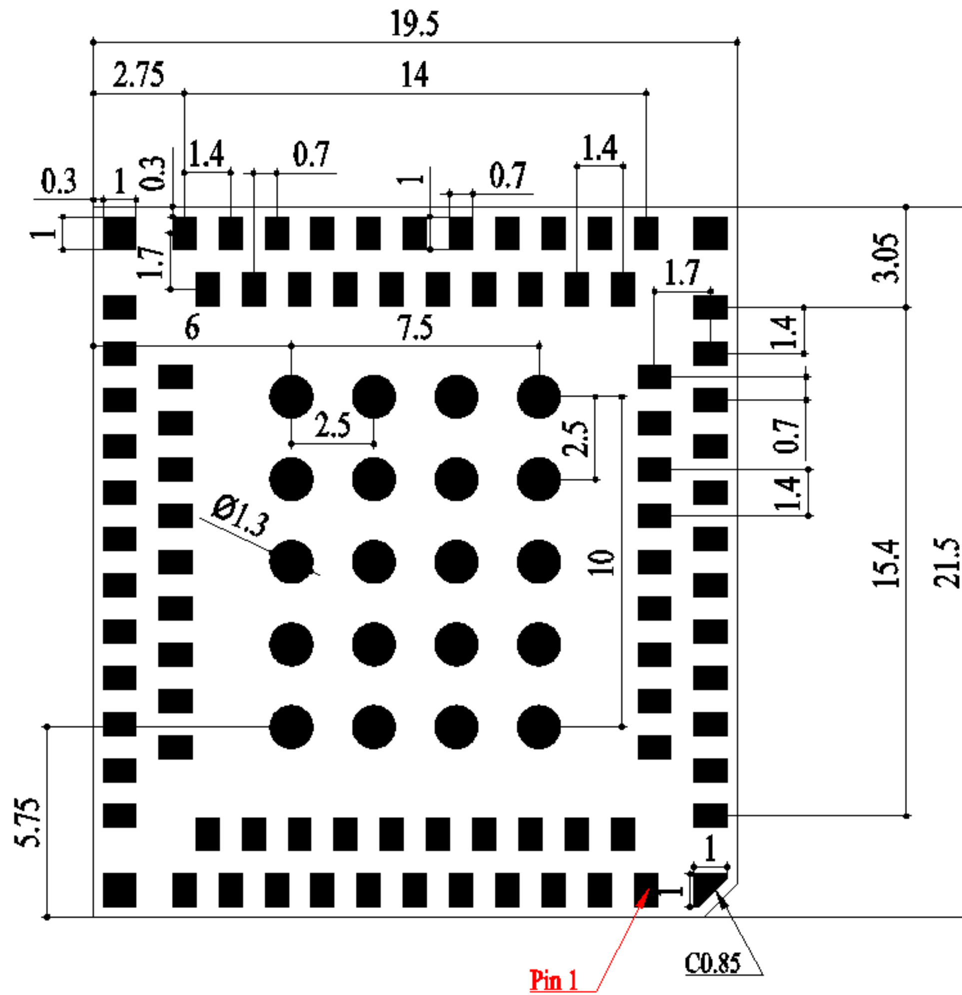


Figure 20: Bottom Dimension (Perspective View)

NOTE

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

5.2. Recommended Footprint

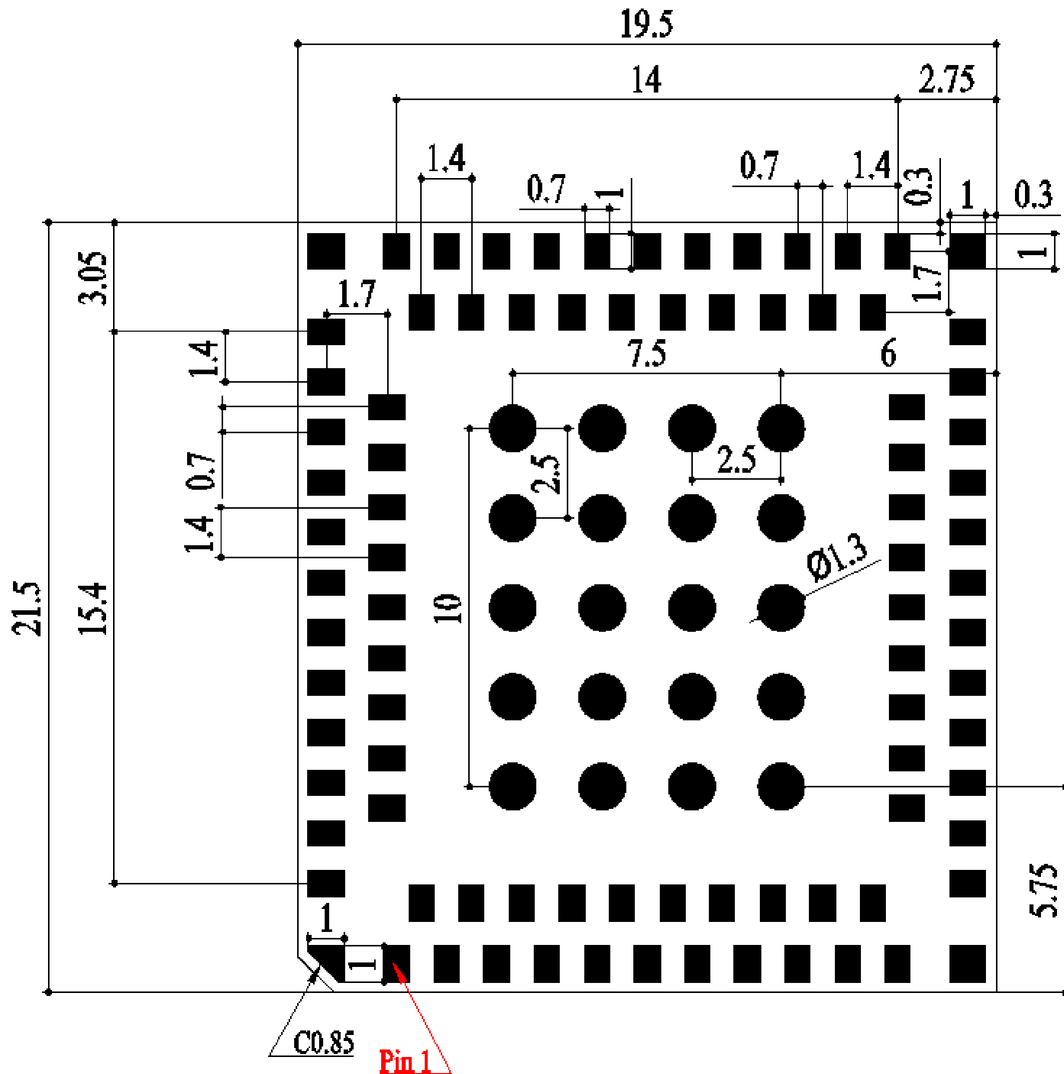


Figure 21: Recommended Footprint

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

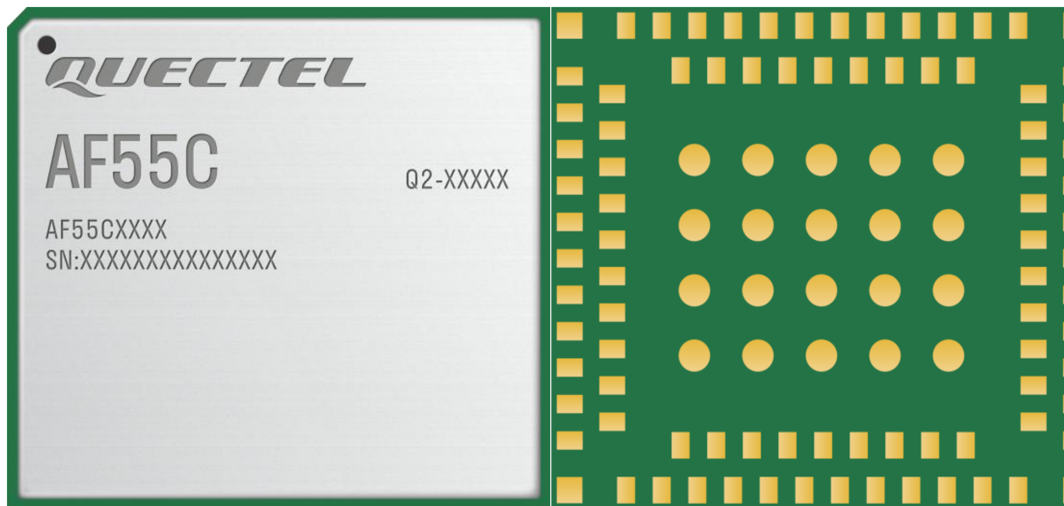


Figure 22: Top and Bottom Views

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 & 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 [3] 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.

[3] This floor life is only applicable when the environment conforms to *IPC/JEDEC J-STD-033*. It is recommended to start the solder reflow process within 24 hours after the package is removed if the temperature and moisture do not conform to, or are not sure to conform to *IPC/JEDEC J-STD-033*. Do not unpack the modules in large quantities until they are ready for soldering.

NOTE

1. To avoid blistering, layer separation and other soldering issues, extended exposure of the module to the air is forbidden.
2. Take out the module from the package and put it on high-temperature-resistant fixtures before baking. If shorter baking time is desired, see *IPC/JEDEC J-STD-033* for the baking procedure.
3. Pay attention to ESD protection, such as wearing anti-static gloves, when touching the modules.

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 [3]***.

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.

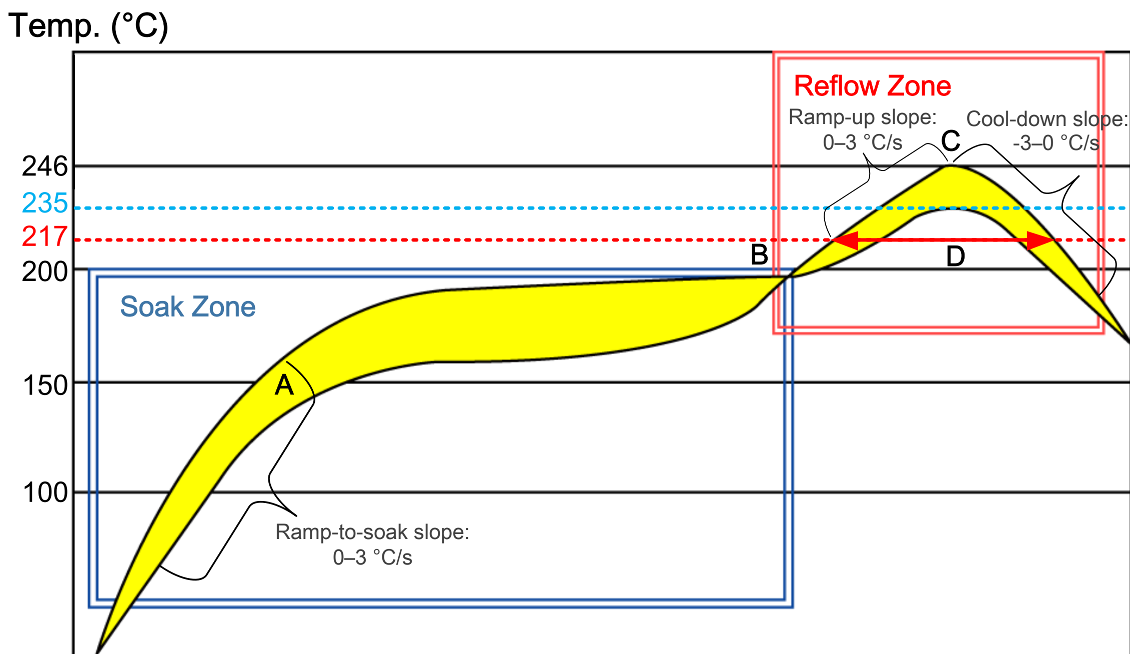


Figure 23: Recommended Reflow Soldering Thermal Profile

Table 30: 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 [3]***.

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

Dimension details are as follow:

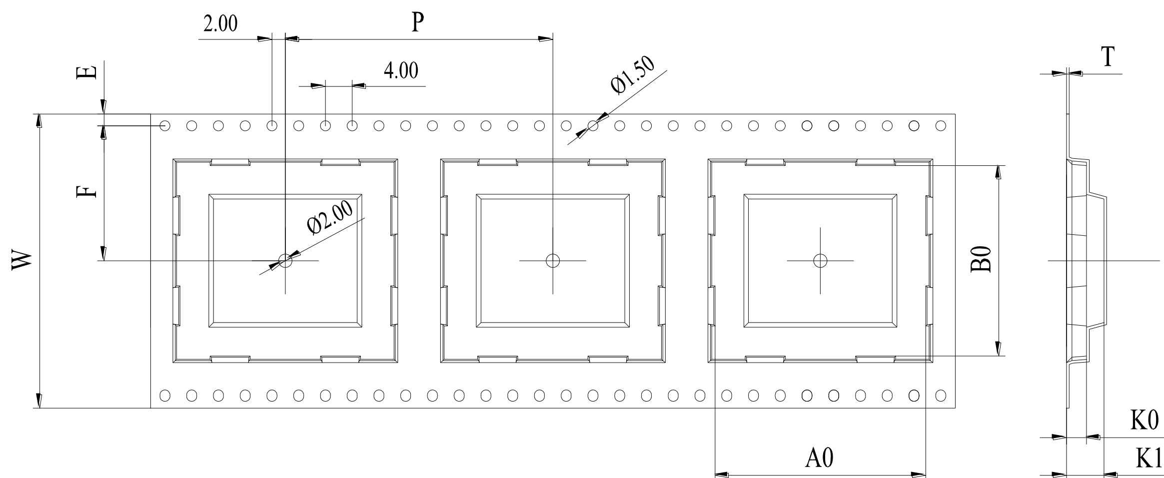


Figure 24: Carrier Tape Dimension Drawing

Table 31: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
44	32	0.4	22	20	3.15	7.1	20.2	1.75

6.3.2. Plastic Reel

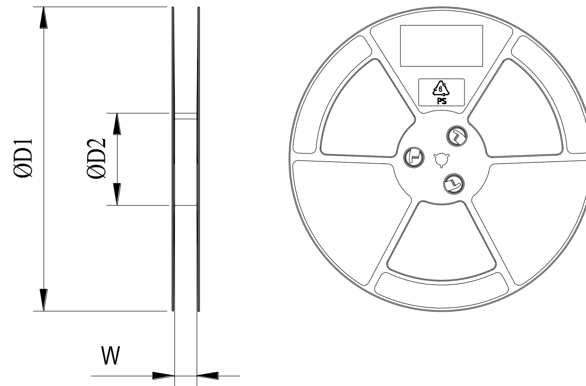


Figure 25: Plastic Reel Dimension Drawing

Table 32: Plastic Reel Dimension Table (Unit: mm)

øD1	øD2	W
330	100	44.5

6.3.3. Mounting Direction

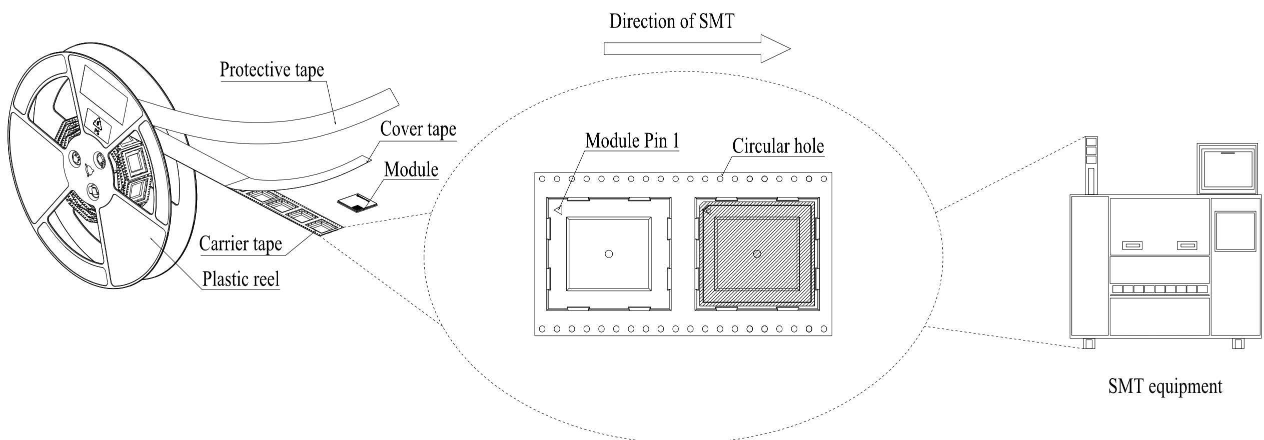
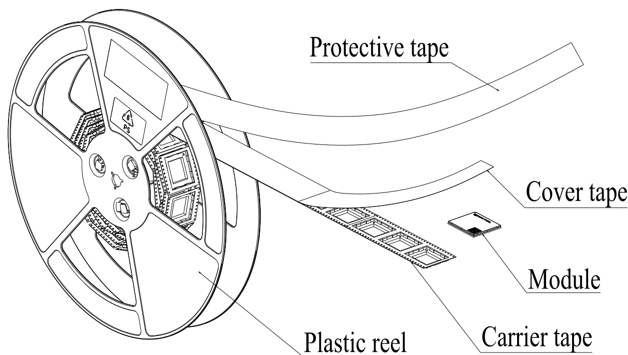


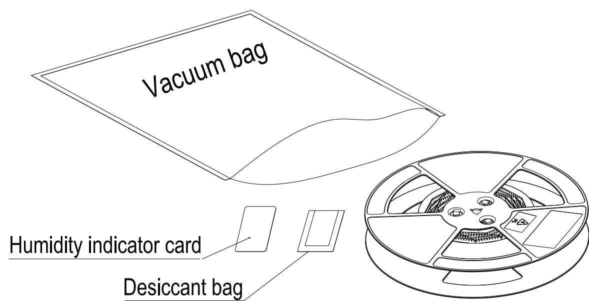
Figure 26: Mounting Direction

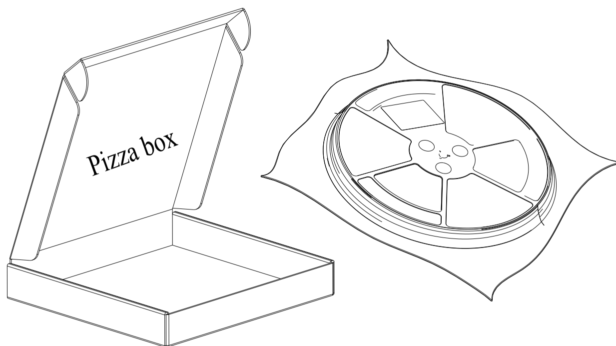
6.3.4. Packaging Process



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.

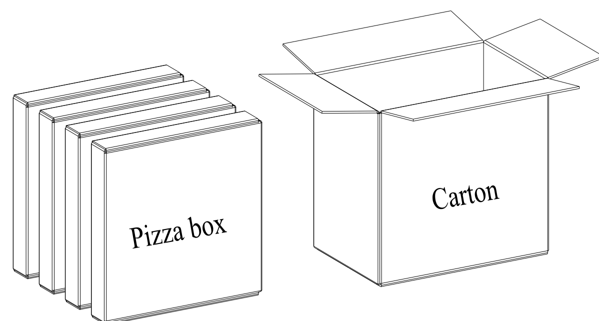


Figure 27: Packaging Process

7 Appendix References

Table 33: Related Documents

Document Name
[1] Quectel_V2X&5G_EVB_User_Guide
[2] Quectel_RF_Layout_Application_Note
[3] Quectel_Module_SMT_Application_Note

Table 34: Terms and Abbreviations

Abbreviation	Description
AP	Access Point
BLE	Bluetooth Low Energy
BPSK	Binary Phase Shift Keying
BR	Basic Rate
CCK	Complementary Code Keying
DPSK	Differential Phase Shift Keying
DQPSK	Differential Quadrature Phase Shift Keying
EDR	Enhanced Data Rate
ESD	Electrostatic Discharge
EVB	Evaluation Board
GND	Ground
HE	High Efficiency
HT	High Throughput

IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers
I/O	Input/Output
LGA	Land Grid Array
LTE	Long Term Evolution
Mbps	Megabits per second
MCS	Modulation and Coding Scheme
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
Rx	Receive
SAW	Surface Acoustic Wave
SDIO	Secure Digital Input/Output
SPDT	Single-Pole Double-Throw
STA	Station
TBD	To Be Determined
TIM	Thermal Interface Material
TVS	Transient Voltage Suppressor
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
VHT	Very High Throughput

Vmax	Maximum Voltage
Vmin	Minimum Voltage
Vnom	Nominal Voltage
VSWR	Voltage Standing Wave Ratio
Wi-Fi	Wireless-Fidelity
WLAN	Wireless Local Area Network

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: XMR202309AF55C.
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:≤-0.10 dBi
❒ U-NII-1:≤ -0.9dBi
U-NII-2A:≤-1.4dBi
U-NII-2C:≤-0.3dBi
U-NII-3:≤0.4dBi

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: XMR202309AF55C.” or “Contains FCC ID: XMR202309AF55C.” 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:≤-0.10 dBi
- U-NII-1:≤ -0.9dBi
  U-NII-2A:≤-1.4dBi
  U-NII-2C:≤-0.3dBi
  U-NII-3:≤0.4dBi

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-202309AF55C" or "where: 10224A-202309AF55C is the module's certification number".