AF66T Hardware Design

Automotive Wi-Fi&Bluetooth Module Series

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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 paid to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the 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 emergent 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
-	2022-05-20	Mona LIU	Creation of the document
1.0.0	2022-05-20	Mona LIU	Preliminary
1.0.1	2022-08-11	Mona LIU/ Isabella LI	Preliminary: 1. Updated the Functional Diagram (Figure 1); 2. Updated Pin Assignment Map (Figure 2); 3. Deleted AF66T's Tx coupling capacitor (Figure 6); 4. Deleted Turning on Sequence; 5. Modified digital I/O characteristics (Table 25).
1.0.2	2023-04-13	Isabella LI/ Mona LIU/ Kerry LIU	Preliminary: 1. Added the mounting direction in packaging (Chapter 8.3.3); 2. Added PCM Timing (Figure 10 & 11 and Table12 & 13); 3. Added the turn-on timing (Chapter 3.1.3); 4. Added WLAN_SLP_CLK signal diagram and the relevant parameter requirements. (Figure 15 and Table 18); 5. Updated the comment of WLAN_SLP_CLK (Table 5 and Table 17); 6. Updated the pins 101, 102, 105 and 106 into VDD_PA (Figure 1, Figure 2 and Table 5); 7. Updated the recommended reflow soldering thermal profile and the relevant parameters (Figure 29 and Table 34).

Contents

Table Index

Figure Index

1 Introduction

This document, describing AF66T and its air interface and hardware interfaces connected to your applications, informs you of the interface and RF specifications, electrical and mechanical details, as well as other related information of the module.

With the application notes and user guides provided separately, you can easily use the module to design and set up mobile applications.

1.1. Special Mark

Table 1: Special Mark

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.

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.

Hereby, Quectel Wireless Solutions Co., Ltd. declares that the radio equipment type AF66T 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 could be used with a separatioin distance of 20cm to the human body.

This device is restricted to indoor use only when operating in the 5150 to 5350 MHz,frequency range in the following countries:

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)

2 Product Overview

2.1. General Description

AF66T is an automotive Wi-Fi and Bluetooth module with low power consumption. It is complying with IEEE 802.11a/b/g/n/ac/ax 2.4 GHz & 5 GHz WLAN standards and Bluetooth 5.2 standard, which enables seamless integration of WLAN and Bluetooth Low Energy technologies.

It supports a low-power PCIe Gen 2 interface for Wi-Fi and a UART and a PCM interfaces for Bluetooth, and it also supports LTE & Wi-Fi/Bluetooth coexistence interface.

Table 2: Brief Introduction of the Module

AF66T	
Footprint	LGA
Pin number	112
Size	(23 ±0.2) mm × (23 ±0.2) mm × (3 ±0.2) mm
Weight	TBD
Wireless network functions	Wi-Fi and Bluetooth 5.2

2.2. Key Features

Table 3: Key Features

Parameter	Details
Power Supply	**VDD_CORE_VL:** ● 0.9–1.2 V ● Typical: 0.95 V **VDD_CORE_VM:** ● 1.28–1.42 V ● Typical: 1.35 V **VDD_CORE_VH:** ● 1.85–2.0 V ● Typical: 1.9 V **VDD_PA:** ● 3.3–4.25 V ● Typical: 3.85 V **VDD_IO:** ● 1.71–1.89 V ● Typical: 1.8 V
Frequency Range	**Wi-Fi:** ● 2.4 GHz: 2.412–2.472 GHz ● 5 GHz: 5.180–5.825 GHz **Bluetooth:** ● 2.402–2.480 GHz
Wi-Fi Transmission Data Rates	**802.11b:** ● 1 Mbps, 2 Mbps, 5.5 Mbps, 11 Mbps **802.11g:** ● 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) **802.11a:** ● 6 Mbps, 9 Mbps, 12 Mbps, 18 Mbps, 24 Mbps, 36 Mbps, 48 Mbps, 54 Mbps **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 Transmitting Power	**2.4 GHz:** ● 802.11b @ 11 Mbps: 20 dBm

	● 802.11g @ 54 Mbps: 16 dBm ● 802.11n @ HT20 MCS 7: 16 dBm ● 802.11n @ HT40 MCS 7: 16 dBm ● 802.11ax @ HE20 MCS 11: 14 dBm ● 802.11ax @ HE40 MCS 11: 14 dBm **5 GHz:** ● 802.11a @ 54 Mbps: 15 dBm ● 802.11n @ HT20 MCS 7: 15 dBm ● 802.11n @ HT40 MCS 7: 15 dBm ● 802.11ac @ VHT20 MCS 8: 14 dBm ● 802.11ac @ VHT40 MCS 9: 13 dBm ● 802.11ac @ VHT80 MCS 9: 13 dBm ● 802.11ax @ HE20 MCS 11: 12 dBm ● 802.11ax @ HE40 MCS 11: 12 dBm ● 802.11ax @ HE80 MCS 11: 12 dBm
Protocol Features	● IEEE 802.11a/b/g/n/ac/ax ● Bluetooth 5.2
Wi-Fi Modulation	BPSK, QPSK, CCK, 16QAM, 64QAM, 256QAM and 1024QAM, MU-MIMO, OFDMA
Bluetooth Modulation	GFSK, 8-DPSK, π/4-DQPSK
Wi-Fi Operating Modes	● AP ● STA
Wireless Connection Interface	● For Wi-Fi function: PCIe Gen 2 interface ● For Bluetooth function: UART and PCM interfaces
Antenna Interfaces	● Bluetooth & Wi-Fi antenna interface 0 (ANT_WIFI0) ● Wi-Fi antenna interface 1 (ANT_WIFI1) ● Reserved dedicated Bluetooth antenna interface (ANT_BT) ● 50 Ω impedance
Operating Temperature	● 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] Within this range, the module's performance complies with IEEE and 3GPP requirements.

2.3. Functional Diagram

The following figure shows a block diagram of the module and illustrates the major functional parts：

- Power management
- Baseband
- Radio frequency
- Peripheral interfaces

2.4. Pin Assignment

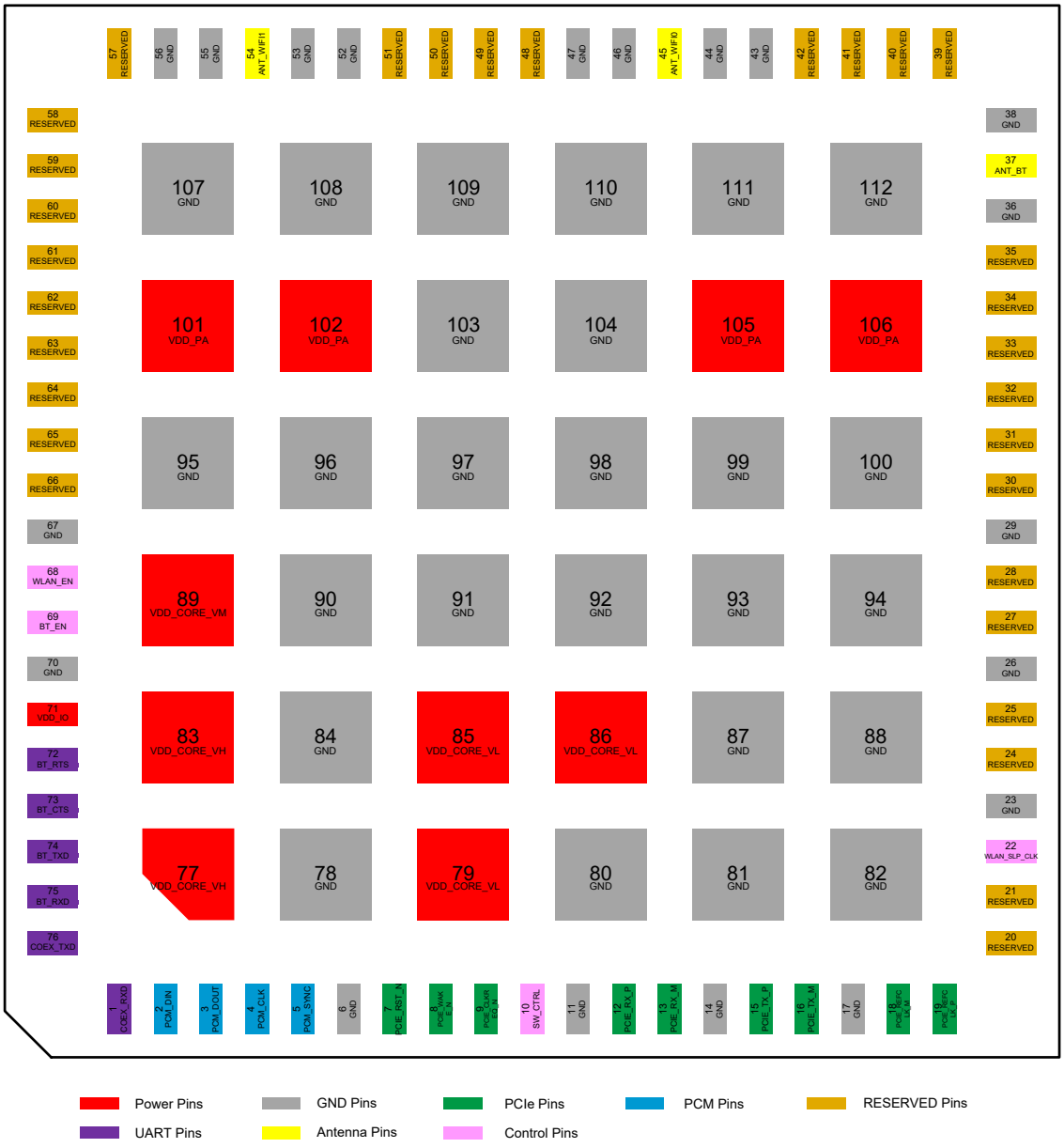


Figure 2: Pin Assignment (Top View)

NOTE

Keep all RESERVED and unused pins unconnected.

2.5. Pin Description

Table 4: Parameter Definition

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

DC characteristics include power domain and rate current, etc.

Table 5: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VDD_CORE_VL	79, 85, 86	PI	Voltage for core (low voltage)	Vmin = 0.9 V Vnom = 0.95 V Vmax = 1.2 V	It must be provided with sufficient current up to 1.7 A.
VDD_CORE_VM	89	PI	Voltage for core (mid voltage)	Vmin = 1.28 V Vnom = 1.35 V Vmax = 1.42 V	It must be provided with sufficient current up to 0.4 A.
VDD_CORE_VH	77, 83	PI	Voltage for core (high voltage)	Vmin = 1.85 V Vnom = 1.9 V Vmax = 2.0 V	It must be provided with sufficient current up to 0.4 A.
VDD_IO	71	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 50 mA.
VDD_PA	101, 102, 105, 106	PI	Power supply for the module's RF part	Vmin = 3.3 V Vnom = 3.85 V Vmax = 4.25 V	It must be provided with sufficient current up to 1.3 A.

GND	6, 11, 14, 17, 23, 26, 29, 36, 38, 43, 44, 46, 47, 52, 53, 55, 56, 67, 70, 78, 80–82, 84, 87, 88, 90–100, 103, 104, 107–112

Wi-Fi Application Interfaces

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
WLAN_EN	68	DI	WLAN enable control	1.8 V	Active high.
PCIE_REFCLK_P	19	AI	PCIe reference clock (+)		
PCIE_REFCLK_M	18	AI	PCIe reference clock (-)		
PCIE_TX_P	15	AO	PCIe transmit (+)		Require differential impedance of 85 Ω.
PCIE_TX_M	16	AO	PCIe transmit (-)		
PCIE_RX_P	12	AI	PCIe receive (+)		
PCIE_RX_M	13	AI	PCIe receive (-)		
PCIE_CLKREQ_N	9	DO	PCIe clock request	1.8 V	
PCIE_RST_N	7	DI	PCIe reset		
PCIE_WAKE_N	8	DO	PCIe wake up host		

Bluetooth Application Interfaces

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
BT_EN	69	DI	Bluetooth enable control	1.8 V	Active high.
PCM_DIN*	2	DI	PCM data input		
PCM_SYNC*	5	DI	PCM data frame sync		
PCM_CLK*	4	DI	PCM clock		
PCM_DOUT*	3	DO	PCM data output		
BT_TXD	74	DO	Bluetooth UART transmit		
BT_RXD	75	DI	Bluetooth UART receive		
BT_RTS	72	DO	DCE request to send signal to DTE		

BT_CTS	73	DI	DCE clear to send signal from DTE		
Control Signal					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SW_CTRL*	10	DO	Control PMIC output	1.8 V	Active high.
Coexistence UART					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
COEX_TXD	76	DO	LTE & Wi-Fi/ Bluetooth coexistence transmit	1.8 V	If unused, keep these pins open.
COEX_RXD	1	DI	LTE & Wi-Fi/ Bluetooth coexistence receive		
RF Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_WIFI0	45	AIO	Bluetooth antenna interface and 2.4/5 GHz Wi-Fi antenna interface 0		50 Ω characteristic impedance.
ANT_WIFI1	54	AIO	2.4/5 GHz Wi-Fi antenna interface 1		
ANT_BT	37	AIO	Reserved dedicated Bluetooth antenna interface		
WLAN_SLP_CLK Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WLAN_SLP_CLK	22	DI	External 32.768 kHz sleep clock input	1.8 V	It is necessary for the module.
RESERVED Pins					
Pin Name	**Pin No.**				**Comment**
RESERVED	20, 21, 24, 25, 27, 28, 30–35, 39–42, 48–51, 57–66				Keep these pins open.

2.6. EVB Kit

Quectel supplies a (V2X&5G EVB) with accessories to control or test the module. For more details, see ***document [1]***.

3 Operating Characteristics

3.1. Power Supply

3.1.1. Power Supply Pins

The following table shows the power supply pins and the ground pins of AF66T.

Table 6: Pin Definition of Power Supply

Pin Name	Pin No.	I/O	Description	Comments
VDD_CORE_VL	79, 85, 86	PI	Voltage for core (low voltage)	It must be provided with sufficient current up to 1.7 A.
VDD_CORE_VM	89	PI	Voltage for core (mid voltage)	It must be provided with sufficient current up to 0.4 A.
VDD_CORE_VH	77, 83	PI	Voltage for core (high voltage)	It must be provided with sufficient current up to 0.4 A.
VDD_IO	71	PI	Voltage supply for I/O	It must be provided with sufficient current up to 50 mA.
VDD_PA	101, 102, 105, 106	PI	Power supply for the module's RF part	It must be provided with sufficient current up to 1.3 A.
GND	6, 11, 14, 17, 23, 26, 29, 36, 38, 43, 44, 46, 47, 52, 53, 55, 56, 67, 70, 78, 80–82, 84, 87, 88, 90–100, 103, 104, 107–112			

3.1.2. Reference Design for Power Supply

VDD_CORE_VL, VDD_CORE_VM, VDD_CORE_VH and VDD_IO can be powered by AG55xQ series:

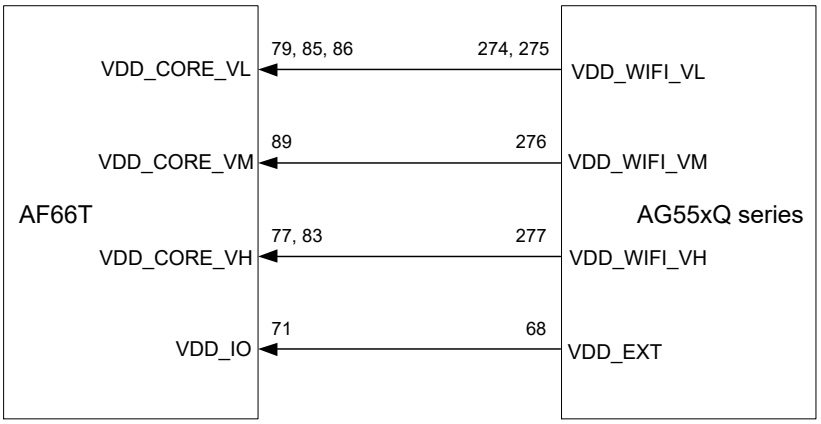


Figure 3: Reference Circuit for VDD_CORE_VL/VM/VH and VDD_IO

AF66T's VDD_PA is recommended to use a power supply chip with output current exceeding 1.3 A. When matching with AG55xQ series, WLAN_PWR_EN1 is used to control VDD_PA timing. EN pin from TPS62130A-Q1 is connected with WLAN_PWR_EN1 from AG55xQ series. The reference circuit is as follow:

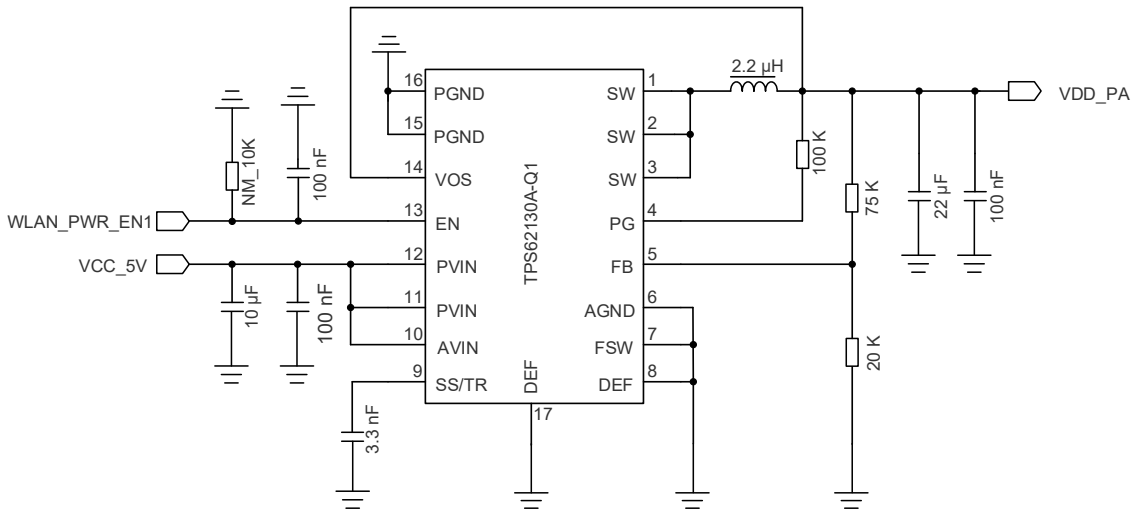


Figure 4: Reference Circuit for VDD_PA

3.1.3. Turn-on Timing

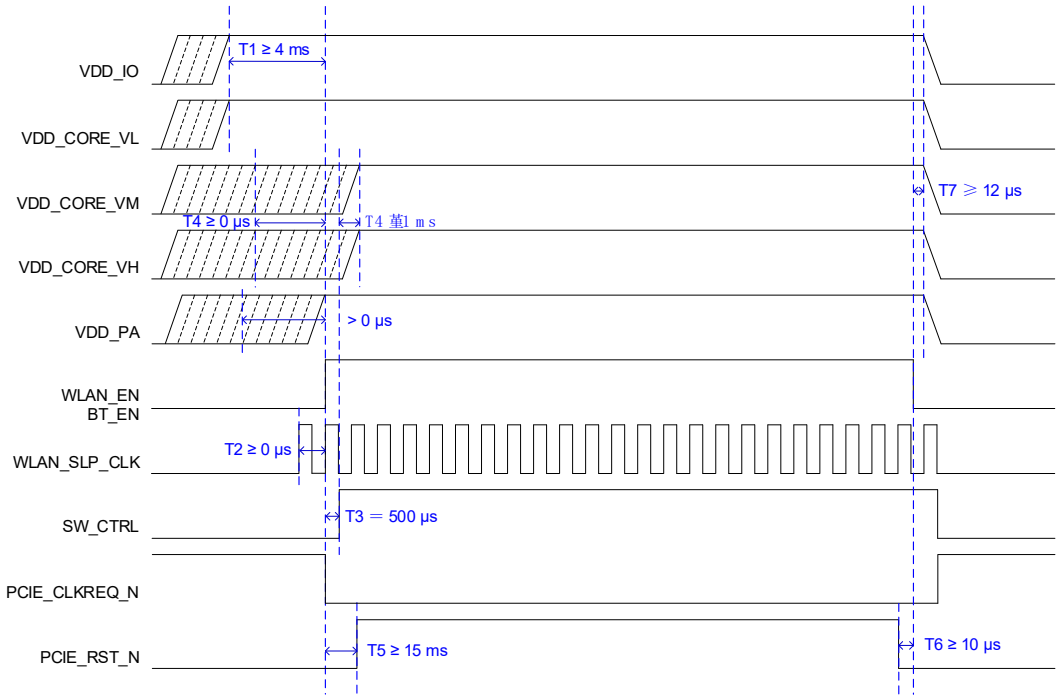


Figure 5: Turn-on Timing

Table 7: Turn-on Timing

Symbol	Parameter	Min.	Typ.	Max.	Unit
T1	VDD_IO's rising edge and VDD_CORE_VL's rising edge to WLAN_EN/BT_EN's rising edge	4	-	-	ms
T2	WLAN_SLP_CLK (32 kHz Sleep Clock)'s rising edge to WLAN_EN/BT_EN's rising edge	0	-	-	µs
T3	WLAN_EN's rising edge and BT_EN's rising edge to SW_CTRL output high level	-	500	-	µs
T4	SW_CTRL's rising edge to VDD_CORE_VM's rising edge and VDD_CORE_VH's rising edge	-	-	1	ms
	VDD_CORE_VM's rising edge and VDD_CORE_VH's rising edge to WLAN_EN/BT_EN's rising edge without SW_CTRL	0	-	-	
T5	WLAN_EN's rising edge to PCIE_RST_L's rising edge	15	-	-	ms
T6	PCIE_RST_L's falling edge to WLAN_EN's falling edge	10	-	-	µs

T7	WLAN_EN’s falling edge and BT_EN’s falling edge to power rail ramp down	12	-	-	μs

4 Application Interfaces

4.1. Wi-Fi & Bluetooth Application Interfaces

AF66T supports PCIe Gen 2 interface for Wi-Fi function, as well as UART and PCM interfaces for Bluetooth function.

4.1.1. Wi-Fi Application Interfaces

The following figure shows the Wi-Fi application interface connection between AF66T and AG55xQ series.

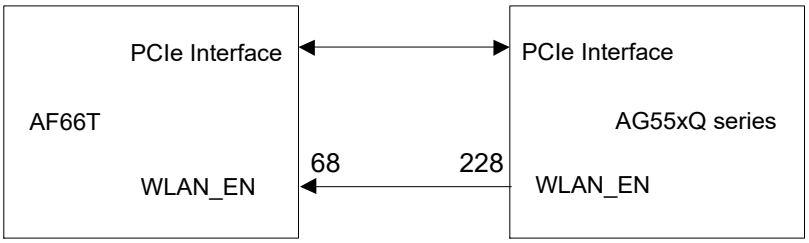


Figure 6: Wi-Fi Application Interface Connection

4.1.1.1. WLAN_EN

WLAN_EN is used to control the Wi-Fi function of AF66T. Wi-Fi function will be enabled when WLAN_EN is at high level.

Table 8: Pin Definition of WLAN_EN

Pin Name	Pin No.	I/O	Description	Comment
WLAN_EN	68	DI	WLAN enable control	High level effective.

NOTE

WLAN_EN is a sensitive signal, and it should be ground shielded and routed as close as possible to AF66T.

4.1.1.2. PCIe Interface

Table 9: Pin Definition of PCIe Interface

Pin Name	Pin No.	I/O	Description	Comment
PCIE_REFCLK_P	19	AI	PCIe reference clock (+)	Require differential impedance of 85 Ω.
PCIE_REFCLK_M	18	AI	PCIe reference clock (-)	
PCIE_TX_P	15	AO	PCIe transmit (+)	
PCIE_TX_M	16	AO	PCIe transmit (-)	
PCIE_RX_P	12	AI	PCIe receive (+)	
PCIE_RX_M	13	AI	PCIe receive (-)	
PCIE_CLKREQ_N	9	DO	PCIe clock request	1.8 V power domain.
PCIE_WAKE_N	8	DO	PCIe wakes up host	
PCIE_RST_N	7	DI	PCIe reset	

The following figure shows the PCIe interface connection between AF66T and AG55xQ series.

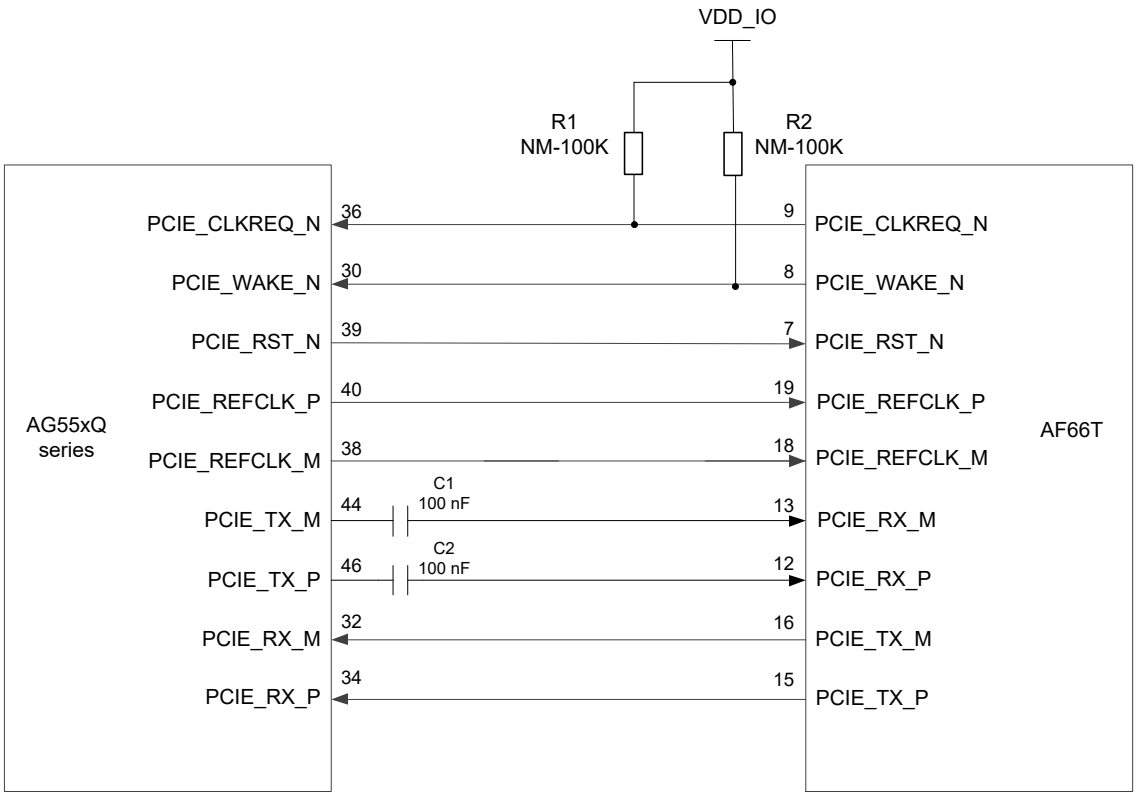


Figure 7: PCIe Interface Connection

In order to ensure the integrity of PCIe signal, C1 and C2 components must be placed close to AG55xQ series modules, The extra stubs of traces must be as short as possible.

The following principles of PCIe interface design should be complied with, to meet PCIe Gen2 specifications.

- It is important to route the PCIe signal traces (PCIE_TX/PCIE_RX/PCIE_REFCLK) as differential pairs with total grounding. And the differential impedance is 85 Ω ±10%.
- For PCIe signal traces, the maximum length of each differential data pair (PCIE_TX/PCIE_RX/PCIE_REFCLK) is recommended to be less than 300 mm, and each differential data pair matching should be less than 0.7 mm (5 ps).
- The trace space between TX differential data pair and RX differential data pair should be three times wider than PCIe trace width.
- The trace space between PCIe signals and the other signals should be four times wider than PCIe 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.

NOTE

1. For PCIE_TX_M and PCIE_TX_P, a 100 nF coupling capacitor has respectively been placed inside the module.
2. For PCIE_CLKREQ_N and PCIE_WAKE_N, a pull-up resistor has respectively been placed inside the module.

4.1.2. Bluetooth Application Interfaces

The following figure shows the block diagram of Bluetooth application interface connection between AF66T and AG55xQ series:

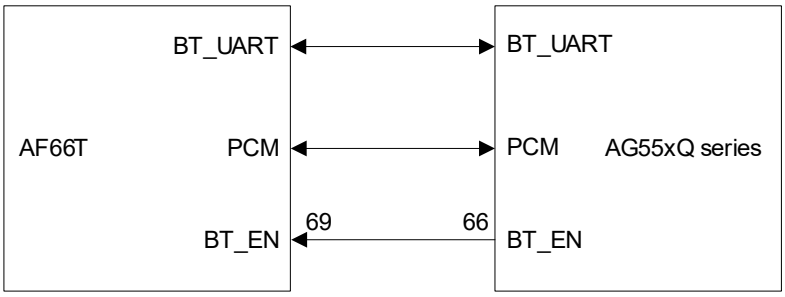


Figure 8: Bluetooth Application Interface Connection

4.1.2.1. BT_EN

BT_EN is used to control the Bluetooth function of AF66T. Bluetooth function will be enabled when BT_EN is at high level.

Table 10: Pin Definition of BT_EN

Pin Name	Pin No.	I/O	Description	Comment
BT_EN	69	DI	Bluetooth enable control	Active high.

4.1.2.2. PCM Interface*

AF66T provides a PCM interface for Bluetooth voice application.

Table 11: Pin Definition of PCM Interface

Pin Name	Pin No.	I/O	Description	Comment
PCM_DIN	2	DI	PCM data input	1.8 V power domain.
PCM_SYNC	5	DI	PCM data frame sync	
PCM_CLK	4	DI	PCM clock	
PCM_DOUT	3	DO	PCM data output	

The following figure shows the PCM interface connection between AF66T and AG55xQ series.

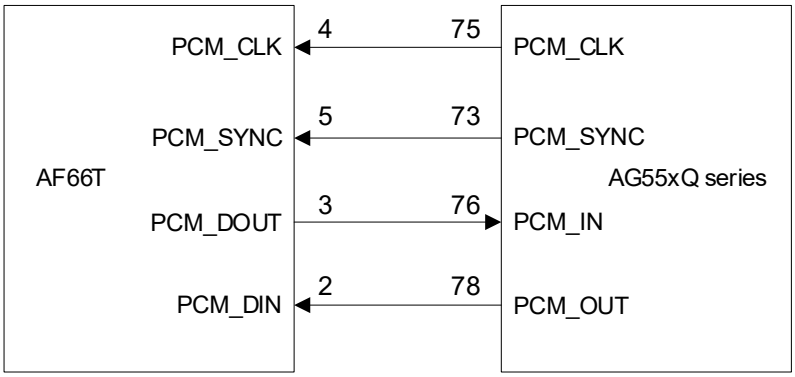


Figure 9: PCM Interface Connection

Example timing diagrams and specifications for slave and master configurations are described in the following figures and tables:

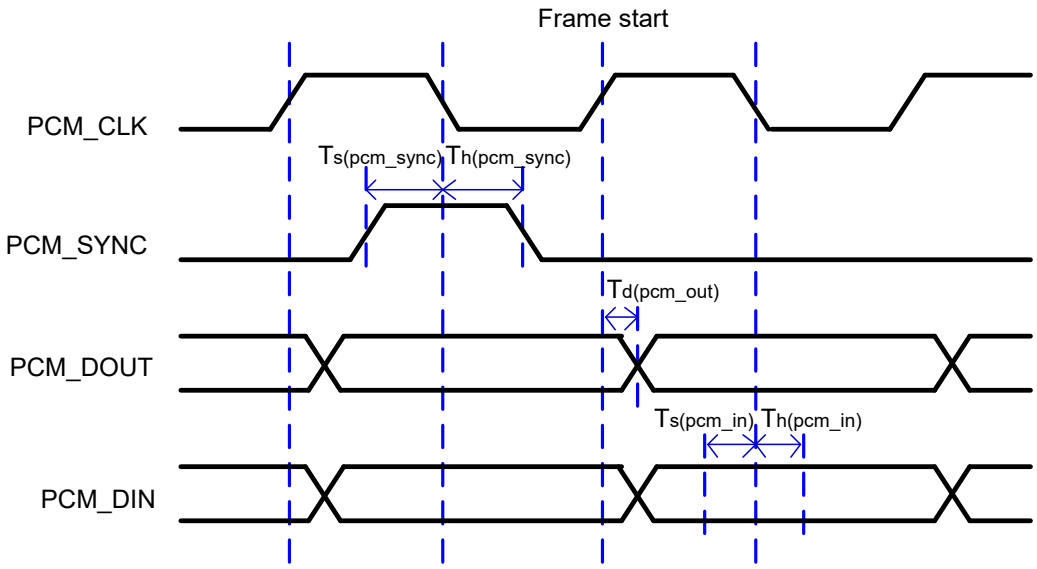


Figure 10: PCM Timing (Slave Mode)

Table 12: PCM Timing in Slave Mode

Symbol	Description	Min.	Typ.	Max.	Unit
$F_{(pcm\_clk)}$	PCM_CLK frequency	64	-	2048	kHz
$Ts_{(pcm\_sync)}$	Setup time PCM_SYNC to PCM_CLK fall	0	-	-	ns
$Th_{(pcm\_sync)}$	Hold time PCM_CLK fail to PCM_SYNC fall	150	-	-	us
$Td_{(pcm\_out)}$	Delay from PCM_CLK rise to PCM_OUT	0	-	150	ns
$Ts_{(pcm\_in)}$	Setup time PCM_IN to PCM_CLK fall	0	-	-	ns
$Th_{(pcm\_in)}$	Hold time PCM_IN after PCM_CLK fall	150	-	-	ns

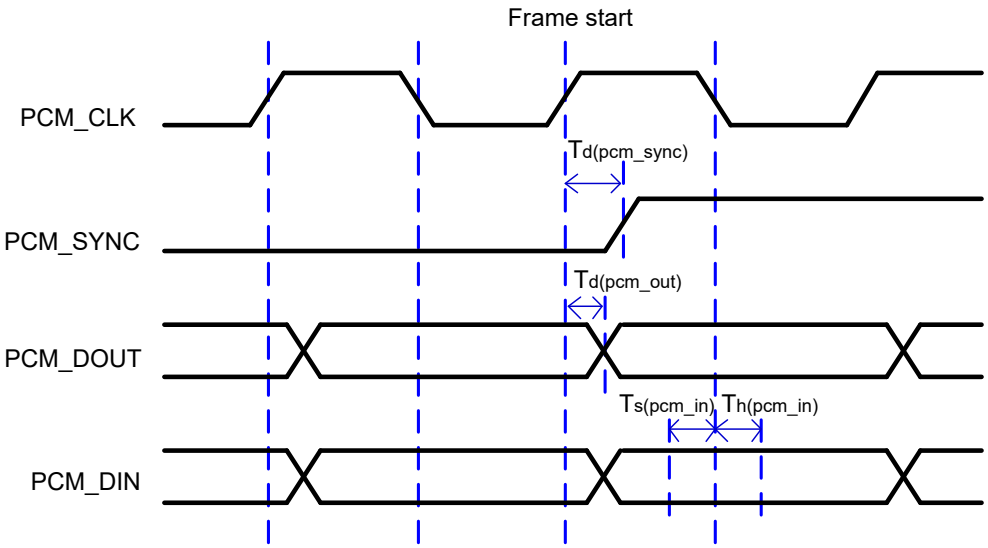


Figure 11: PCM Timing (Master Mode)

Table 13: PCM Timing in Master Mode

Symbol	Description	Min.	Typ.	Max.	Unit
$F_{(pcm\_clk)}$	PCM_CLK frequency	64	-	2048	kHz
$Td_{(sync)}$	Delay from PCM_CLK rise to long SYNC	-10	-	50	ns
$Td_{(pcm\_out)}$	Delay from PCM_CLK rise to PCM_OUT	-10	-	50	ns
$Ts_{(pcm\_in)}$	Setup time PCM_IN to PCM_CLK fall	50	-	-	ns
$Th_{(pcm\_in)}$	Hold time PCM_IN after PCM_CLK fall	150	-	-	ns

4.1.2.3. UART

Table 14: Pin Definition of UART

Pin Name	Pin No.	I/O	Description	Comment
BT_TXD	74	DO	Bluetooth UART transmit	
BT_RXD	75	DI	Bluetooth UART receive	
BT_RTS	72	DO	DCE request to send signal to DTE	

BT_CTS	73	DI	DCE clear to send signal from DTE

The following figure shows the reference design for UART interface connection between AF66T and AG55xQ series.

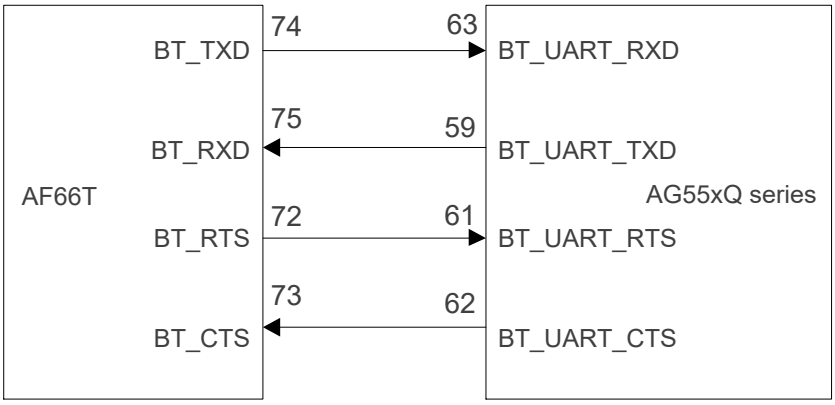


Figure 12: UART Connection

NOTE

1. If the module is matched with AG55xQ series, please note that the module CTS is connected to the AG55xQ series' CTS, and the module RTS is connected to the AG55xQ series' RTS.
2. If matching with other modules as the host, please note the module's connection according to the host requirements.

4.2. SW_CTRL*

Table 15: Pin Definition of SW_CTRL

Pin Name	Pin No.	I/O	Description	Comment
SW_CTRL	10	DO	Control PMIC output	Active high.

The following figure shows the SW_CTRL connection between AF66T and AG55xQ series.

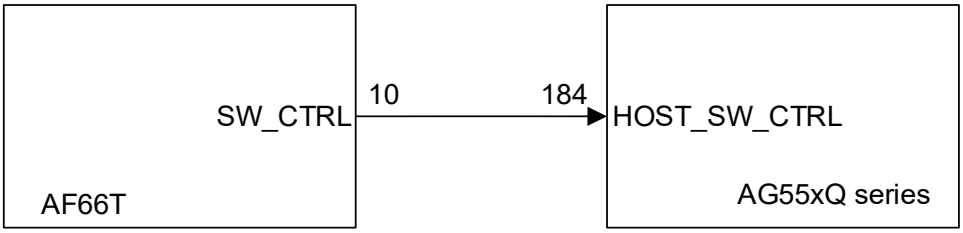


Figure 13: SW_CTRL Connection

4.3. Coexistence UART

Table 16: Pin Definition of Coexistence UART

Pin Name	Pin No.	I/O	Description	Comment
COEX_TXD	76	DO	LTE & Wi-Fi/Bluetooth coexistence transmit	If unused, keep these pins open.
COEX_RXD	1	DI	LTE & Wi-Fi/Bluetooth coexistence receive	

The following figure shows the coexistence UART connection between AF66T and AG5xx series.

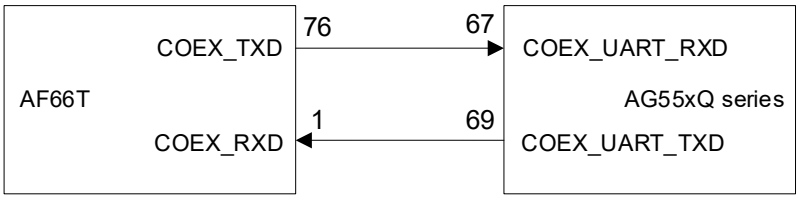


Figure 14: Coexistence UART Connection

4.4. WLAN_SLP_CLK

An external 32.768 kHz sleep clock connecting to WLAN_SLP_CLK is necessary. AF66T is unable to boot up and work without the sleep clock.

Table 17: Pin Definition of WLAN_SLP_CLK

Pin Name	Pin No.	I/O	Description	Comment
WLAN_SLP_CLK	22	DI	External 32.768 kHz sleep clock input	It is necessary for the module.

The following figure and table show the relevant requirements on sleep clock.

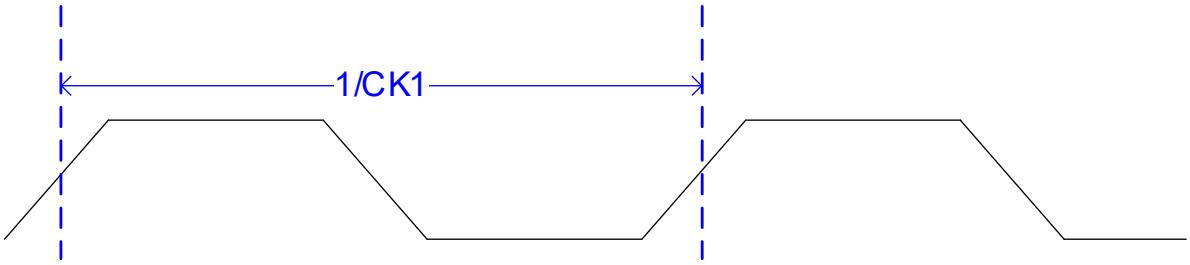


Figure 15: WLAN_SLP_CLK Signal Diagram

Table 18: WLAN_SLP_CLK Parameter Requirements

Parameter	Description	Min.	Typ.	Max.	Unit
CK1	Clock rate	-	32.768	-	KHz
CK2	Duty cycle	15	-	85	%
CK3	Frequency stability	-200	-	200	PPM

5 RF Specifications

5.1. RF Antenna

The module offers the following antenna interfaces. 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.

5.1.1. Antenna Interfaces & Frequency Bands

Table 19: Pin Definition of RF Antenna Interfaces

Pin Name	Pin No.	I/O	Description	Comment
ANT_WIFI0	45	AIO	Bluetooth antenna interface and 2.4/5 GHz Wi-Fi antenna interface 0	50 Ω characteristic impedance.
ANT_WIFI1	54	AIO	2.4/5 GHz Wi-Fi antenna interface 1	
ANT_BT	37	AIO	Reserved dedicated Bluetooth antenna interface	

Table 20: Operating Frequency of AF66T (Unit: GHz)

Parameter	Frequency Band
2.4 GHz Wi-Fi	2.412–2.472
5 GHz Wi-Fi	5.180–5.825
Bluetooth	2.402–2.480

5.1.2. Reference Design

AF66T provides three RF antenna interfaces for antenna connection. The RF trace in host PCB connected to the module's RF antenna pin should be microstrip line or other types of RF trace, with characteristic impendence close to 50 Ω. This module comes with grounding pins which are next to the antenna pins to give a better grounding.

It is recommended to reserve a π-type matching circuit for better RF performance, and the π-type matching components (like C1, C2, R1) should be placed as close to the antenna as possible. The capacitors are not mounted by default.

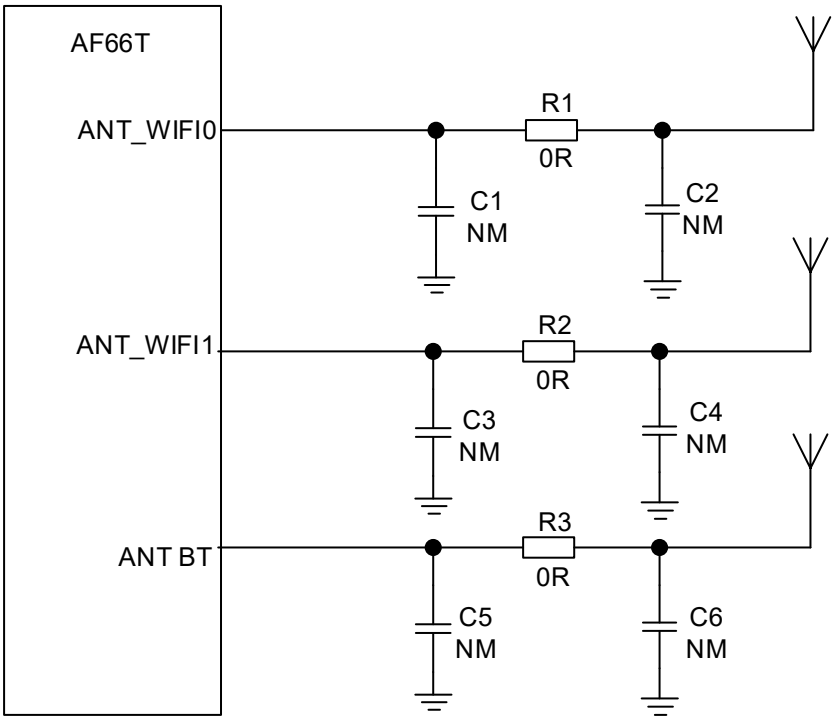


Figure 16: Reference Design for RF Antenna Interfaces

Another type of reference circuit for the RF antenna interfaces is shown below. It is designed for automotive applications. It is recommended to reserve two notch filter circuits and a π-type matching circuit for better RF performance. For ANT_WIFI0, L1/C2 and L2/C3 comprise two notch filter circuits for filtering out interference caused by a particular frequency. When L1, C2, L2 and C3 is NC, C1, 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 0 Ω by default. AN_WIFI1 and ANT_BT follow the same design.

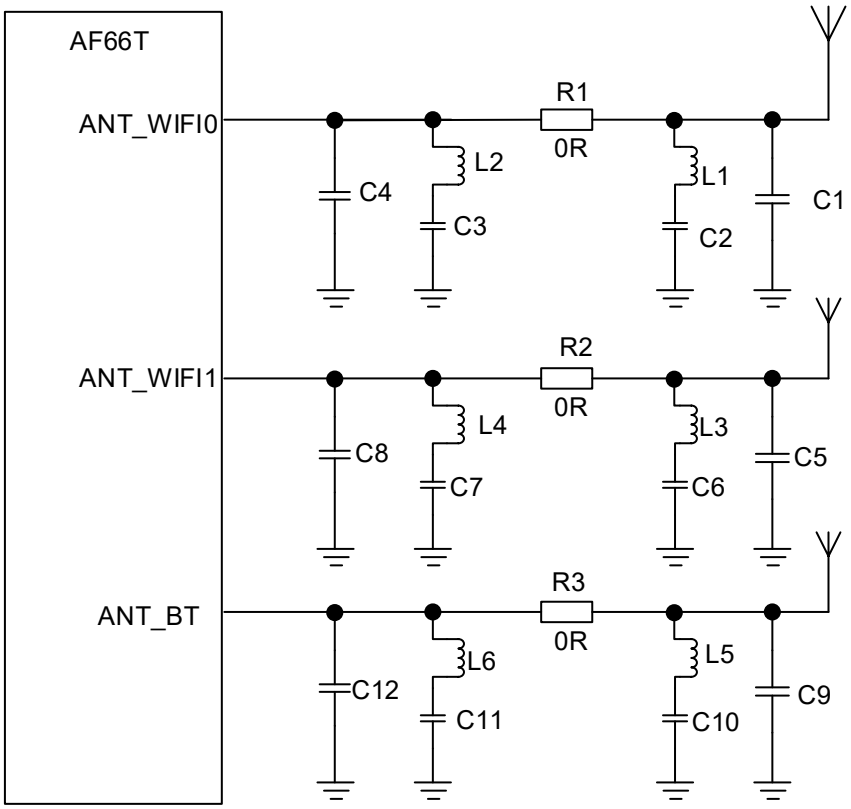


Figure 17: Reference Circuit for RF Antenna Interface (Automotive Applications)

5.2. RF Performances

5.2.1. Conducted RF Performance of Wi-Fi

Table 21: Conducted RF Output Power at 2.4 GHz (Unit: dBm)

Standard	Data Rate	Typ.
802.11b	1 Mbps	20
802.11b	11 Mbps	20
802.11g	6 Mbps	19
802.11g	54 Mbps	16
802.11n @ HT20	MCS 0	19

802.11n @ HT20	MCS 7	16
802.11n @ HT40	MCS 0	19
802.11n @ HT40	MCS 7	16
802.11ax @ HE20	MCS 0	19
802.11ax @ HE20	MCS 11	14
802.11ax @ HE40	MCS 0	19
802.11ax @ HE40	MCS 11	14

Table 22: Conducted RF Output Power at 5 GHz (Unit: dBm)

Standard	Data Rate	Typ.
802.11a	6 Mbps	17
802.11a	54 Mbps	15
802.11n @ HT20	MCS 0	17
802.11n @ HT20	MCS 7	15
802.11n @ HT40	MCS 0	17
802.11n @ HT40	MCS 7	15
802.11ac @ VHT20	MCS 0	17
802.11ac @ VHT20	MCS 8	14
802.11ac @ VHT40	MCS 0	17
802.11ac @ VHT40	MCS 9	13
802.11ac @ VHT80	MCS 0	17
802.11ac @ VHT80	MCS 9	13
802.11ax @ HE20	MCS 0	17
802.11ax @ HE20	MCS 11	12
802.11ax @ HE40	MCS 0	17

802.11ax @ HE40	MCS 11	12
802.11ax @ HE80	MCS 0	17
802.11ax @ HE80	MCS 11	12

Table 23: Conducted RF Receiving Sensitivity at 2.4 GHz (Unit: dBm)

Standard	Data Rate	Typ.
802.11b	1 Mbps	-96
802.11b	11 Mbps	-87
802.11g	6 Mbps	-92
802.11g	54 Mbps	-74
802.11n @ HT20	MCS 0	-92
802.11n @ HT20	MCS 7	-73
802.11n @ HT40	MCS 0	-89
802.11n @ HT40	MCS 7	-71
802.11ax @ HE20	MCS 0	-92
802.11ax @ HE20	MCS 11	-62
802.11ax @ HE40	MCS 0	-89
802.11ax @ HE40	MCS 11	-60

Table 24: Conducted RF Receiving Sensitivity at 5 GHz (Unit: dBm)

Standard	Data Rate	Typ.
802.11a	6 Mbps	-92
802.11a	54 Mbps	-75
802.11n @ HT20	MCS 0	-92
802.11n @ HT20	MCS 7	-74

802.11n @ HT40	MCS 0	-90
802.11n @ HT40	MCS 7	-72
802.11ac @ VHT20	MCS 0	-93
802.11ac @ VHT20	MCS 8	-71
802.11ac @ VHT40	MCS 0	-90
802.11ac @ VHT40	MCS 9	-67
802.11ac @ VHT80	MCS 0	-87
802.11ac @ VHT80	MCS 9	-62
802.11ax @ HE20	MCS 0	-93
802.11ax @ HE20	MCS 11	-63
802.11ax @ HE40	MCS 0	-90
802.11ax @ HE40	MCS 11	-60
802.11ax @ HE80	MCS 0	-87
802.11ax @ HE80	MCS 11	-56

5.2.2. Conducted RF Performance of Bluetooth

Table 25: Conducted RF Performance of Bluetooth (Unit: dBm)

Frequency	Transmitting Power (Typ.)	Receiving Sensitivity (Typ.)
BR	8	-93
EDR (π/4-DQPSK)	6	-92
EDR (8-DPSK)	6	-86
BLE (1M)	6	-97

5.3. RF Routing Guidelines

For user's PCB, the characteristic impedance of all RF traces should be controlled to 50 Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, the height from the reference ground to the signal layer (H), and the spacing between RF traces and grounds (S). Microstrip or coplanar waveguide is typically used in RF layout to control characteristic impedance. The following are reference designs of microstrip or coplanar waveguide with different PCB structures.

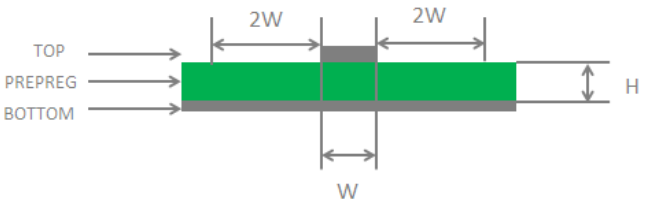


Figure 18: Microstrip Design on a 2-layer PCB

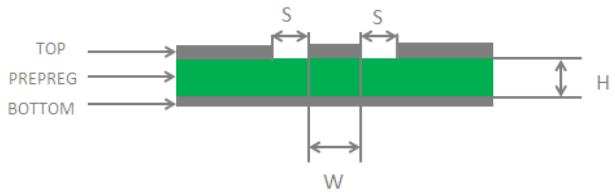


Figure 19: Coplanar Waveguide Design on a 2-layer PCB

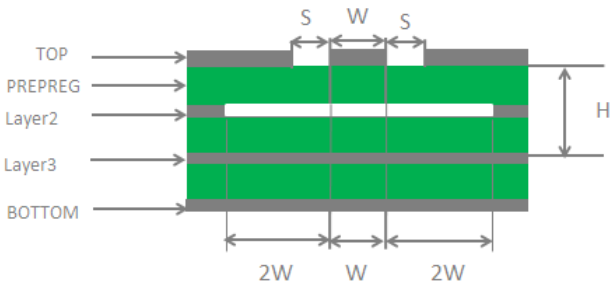


Figure 20: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

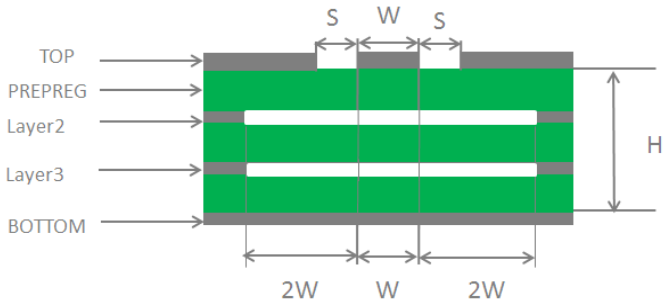


Figure 21: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

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 [2]***.

5.4. Antenna Design Requirements

Table 26: Antenna Requirements

Parameter	Requirements
Frequency range (GHz)	● 2.4 GHz Wi-Fi: 2.412–2.472 ● 5 GHz Wi-Fi: 5.180–5.825 ● Bluetooth: 2.402–2.480
Cable Insertion Loss (dB)	< 1
VSWR	< 2 (Typ.)

Max. Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Vertical

5.5. 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.

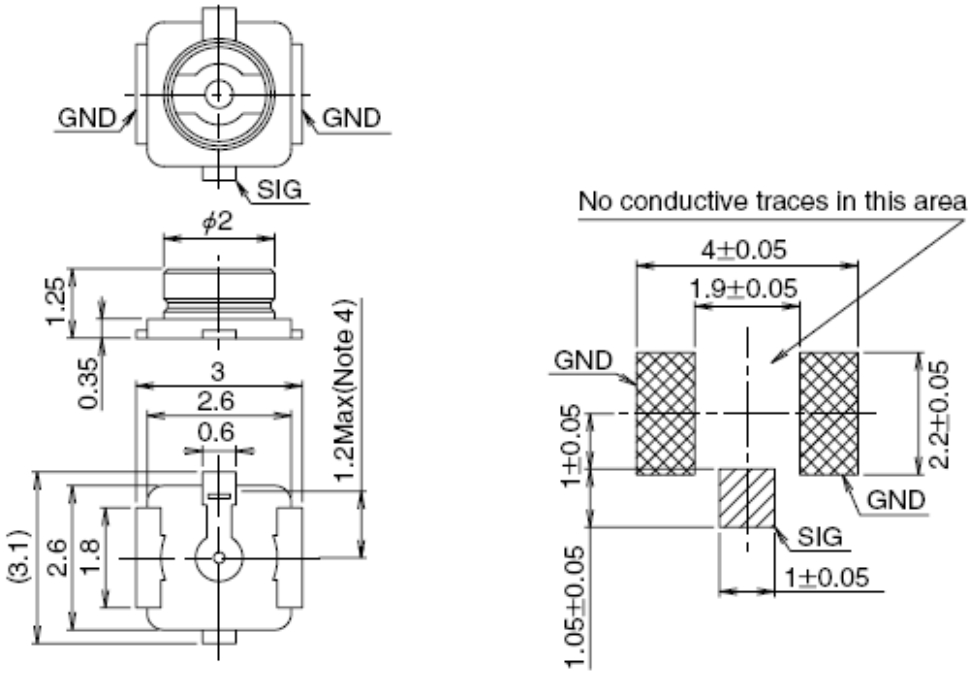


Figure 22: Dimensions of the Receptacle (Unit: mm)

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

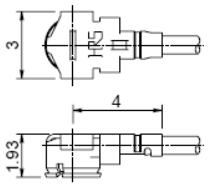
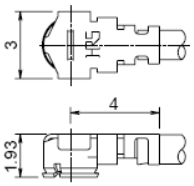
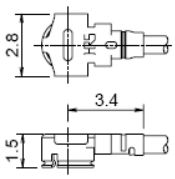
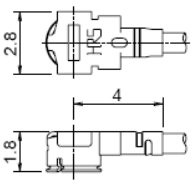
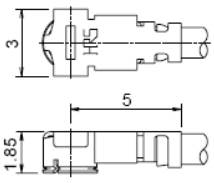
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 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 23: Specifications of Mated Plugs

The following figure describes the space factor of mated connectors.

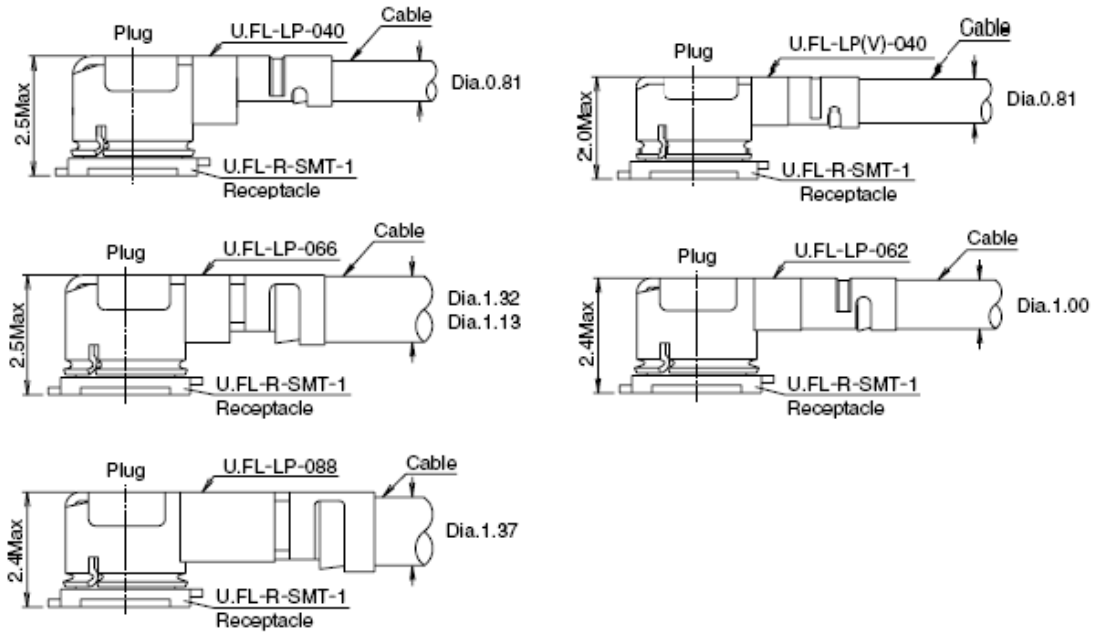


Figure 24: Space Factor of Mated Connectors (Unit: mm)

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

6 Electrical Characteristics & Reliability

6.1. Absolute Maximum Ratings

Table 27: Absolute Maximum Ratings (Unit: V)

Parameter	Min.	Max.
VDD_CORE_VL	-0.3	2.1
VDD_CORE_VM	-0.3	2.1
VDD_CORE_VH	-0.3	2.1
VDD_IO	-0.3	2.0
VDD_PA	3.0	+6
Voltage at digital pins	-0.3	2.0

The recommended operating conditions are as follows:

Table 28: Recommended Operating Conditions (Unit: V)

Parameter	Min.	Typ.	Max.
VDD_CORE_VL	0.9	0.95	1.2
VDD_CORE_VM	1.28	1.35	1.42
VDD_CORE_VH	1.85	1.9	2.0
VDD_IO	1.71	1.8	1.89
VDD_PA	3.3	3.85	4.25

6.2. Digital I/O Characteristics

Table 29: I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	High-level input voltage	0.7 × VDD_IO	VDD_IO + 0.3	V
V_{IL}	Low-level input voltage	-0.3	0.3 × VDD_IO	V
V_{OH}	High-level output voltage	VDD_IO - 0.45	-	V
V_{OL}	Low-level output voltage	-	0.45	V
I_I	Input leakage current	-	1.0	μA

6.3. Power Consumption

6.3.1. Wi-Fi Power Consumption

Under the maximum transmitting power, the Wi-Fi power consumption test results are as follows:

Table 30: Power Consumption of the Module (Normal Operation; Unit: mA)

Standard	Condition	$I_{VDD\_CORE\_VL}$	$I_{VDD\_CORE\_VM}$	$I_{VDD\_CORE\_VH}$	I_{VDD_IO}	I_{VDD_PA}
802.11b	Tx 1 Mbps @ 20 dBm	215.85	111.75	72.34	0.83	275.34
	Tx 11 Mbps @ 20 dBm	234.23	107.96	69.72	0.83	234.77
802.11g	Tx 6 Mbps @ 19 dBm	217.43	111.42	72.43	0.84	263.37
	Tx 54 Mbps @ 16 dBm	240.23	106.31	68.54	0.83	194.73
802.11n (2.4 GHz)	Tx HT20 MCS 0 @ 19 dBm	213.32	112.13	72.38	0.82	263.37
	Tx HT20 MCS 7 @ 16 dBm	213.30	111.76	71.96	0.82	235.37
	Tx HT40 MCS 0 @ 19 dBm	229.13	119.87	72.34	0.83	261.34
	Tx HT40 MCS 7 @ 16 dBm	229.05	119.62	72.01	0.83	231.43

802.11a (5 GHz)	Tx 6 Mbps @ 17 dBm	202.34	99.19	75.89	1.01	197.43
	Tx 54 Mbps @ 15 dBm	228.02	93.42	73.24	0.99	159.54
802.11n (5 GHz)	Tx HT20 MCS 0 @ 17 dBm	199.23	99.42	75.92	1.00	197.04
	Tx HT20 MCS 7 @ 15 dBm	198.82	99.10	75.95	1.00	186.21
	Tx HT40 MCS 0 @ 17 dBm	213.92	109.03	76.10	1.00	202.33
	Tx HT40 MCS 7 @ 15 dBm	213.67	109.11	75.78	1.00	188.75
802.11ac (5 GHz)	Tx VHT20 MCS 0 @ 17 dBm	200.04	99.37	75.92	1.04	197.21
	Tx VHT20 MCS 8 @ 14 dBm	199.56	99.18	75.81	1.02	181.67
	Tx VHT40 MCS 0 @ 17 dBm	217.31	109.12	76.10	1.01	201.45
	Tx VHT40 MCS 9 @ 13 dBm	216.12	108.79	75.91	1.02	178.43
	Tx VHT80 MCS 0 @ 17 dBm	270.41	111.05	76.31	1.03	200.03
	Tx VHT80 MCS 9 @ 13 dBm	269.47	110.87	75.78	1.03	178.65
802.11ax (2.4 GHz)	Tx HE20 MCS 0 @ 19 dBm	256.34	139.21	81.56	0.87	263.12
	Tx HE20 MCS 11 @ 14 dBm	256.33	138.89	81.10	0.86	220.03
	Tx HE40 MCS 0 @ 19 dBm	272.31	141.89	81.51	0.87	260.43
	Tx HE40 MCS 11 @ 14 dBm	272.34	141.85	81.23	0.86	217.65
802.11ax (5 GHz)	Tx HE20 MCS 0 @ 17 dBm	201.67	106.03	75.91	1.02	202.54
	Tx HE20 MCS 11 @ 12 dBm	202.78	106.01	75.61	1.02	177.21
	Tx HE40 MCS 0 @ 17 dBm	219.07	108.92	75.94	1.02	198.03
	Tx HE40 MCS 11 @ 12 dBm	219.21	108.62	75.92	1.02	172.56
	Tx HE80 MCS 0 @ 17 dBm	276.13	110.82	76.12	1.03	196.01
	Tx HE80 MCS 11 @ 12 dBm	276.08	110.76	75.81	1.03	171.48

6.3.2. Bluetooth Power Consumption

Bluetooth power consumption during non-signaling test is here as follows:

Table 31: Bluetooth Power Consumption During Non-signaling (Unit: mA)

描述	功率	$I_{VDD\_CORE\_VL}$	$I_{VDD\_CORE\_VM}$	$I_{VDD\_CORE\_VH}$	I_{VDD_IO}	I_{VDD_RF}
BR (DH5)	Max. Power @ 8 dBm	13.43	26.78	39.37	0.90	0.23
	Min. Power @ -23 dBm	13.37	25.01	8.52	0.90	0.23
EDR (2-DH5)	Max. Power @ 6 dBm	13.65	26.78	37.11	0.90	0.23
	Min. Power @ -21 dBm	13.58	25.03	8.56	0.90	0.23
EDR (3-DH5)	Max. Power @ 6 dBm	13.66	26.79	36.91	0.90	0.23
	Min. Power @ -21 dBm	13.59	25.04	8.51	0.90	0.23
LE5.0 (1M)	Max. Power @ 6 dBm	10.55	25.47	51.33	1.00	0.02

NOTE

For more details about power consumption, please contact Quectel Technical Supports for the power consumption test report of the module.

6.4. 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 32: Electrostatic Discharge Characteristics (Temperature: 25–30 °C, Humidity: 40 % ±5 %)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VDD, GND	TBD	TBD	kV
Antenna Interfaces	TBD	TBD	kV
Other Interfaces	TBD	TBD	kV

6.5. Operating and Storage Temperatures

Table 33: Operating and Storage Temperatures (Unit: °C)

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

[2] Within this range, the module's performance complies with IEEE and 3GPP requirements.

7 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.

7.1. Mechanical Dimensions

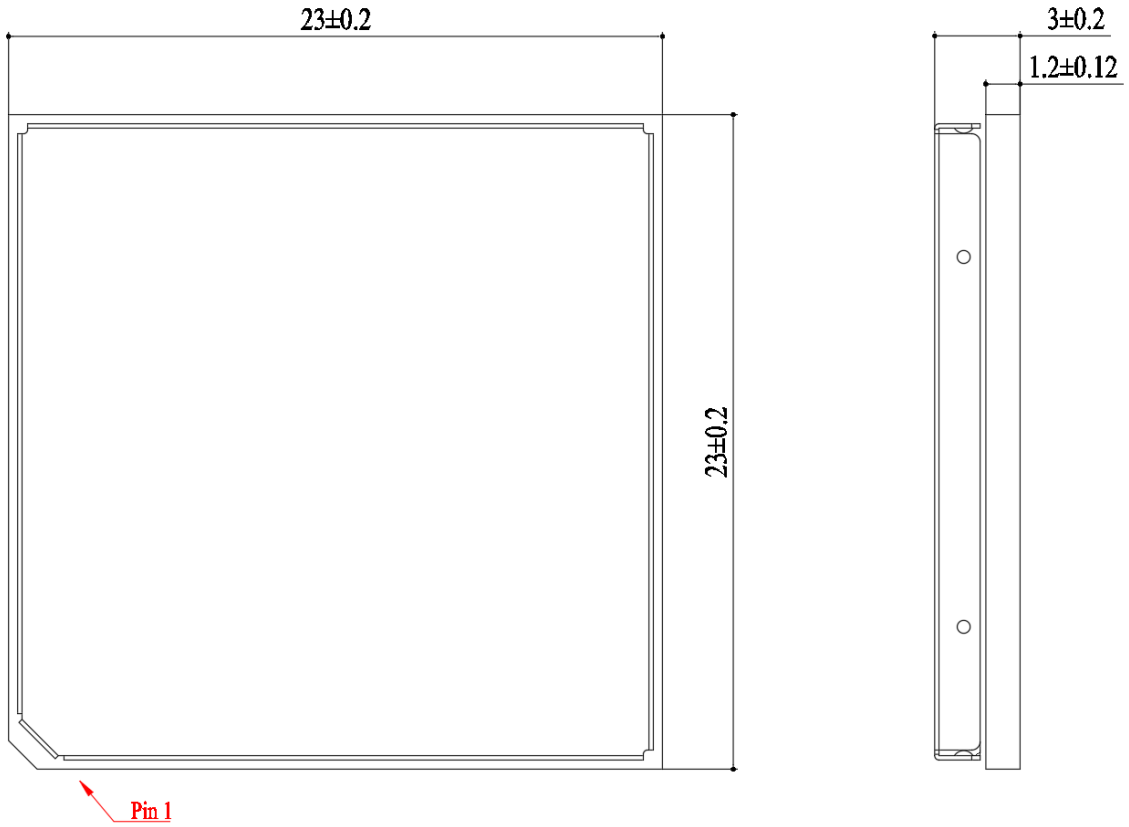


Figure 25: Module Top and Side Dimensions

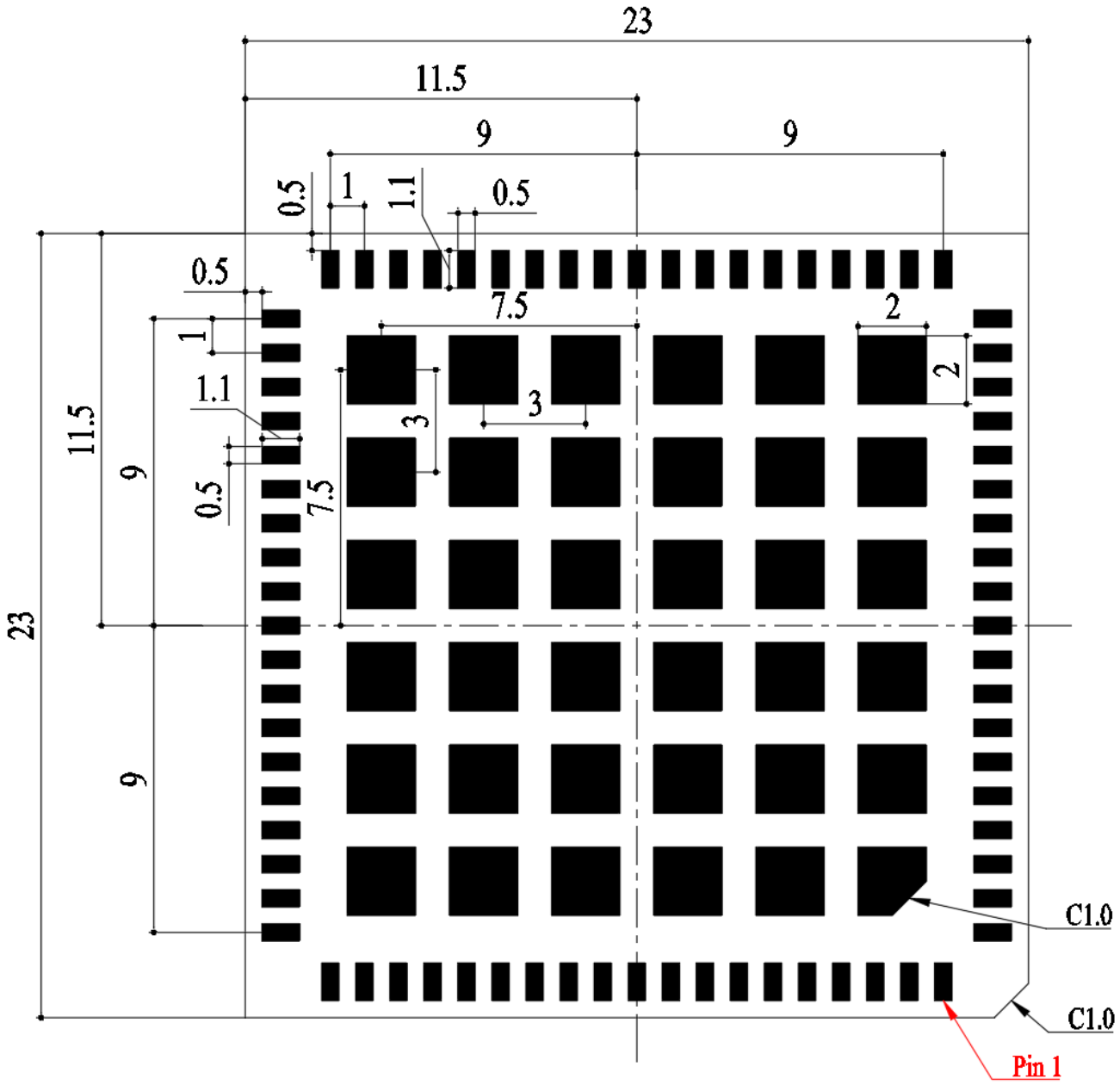


Figure 26: Module Bottom Dimensions (Bottom View)

NOTE

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

7.2. Recommended Footprint

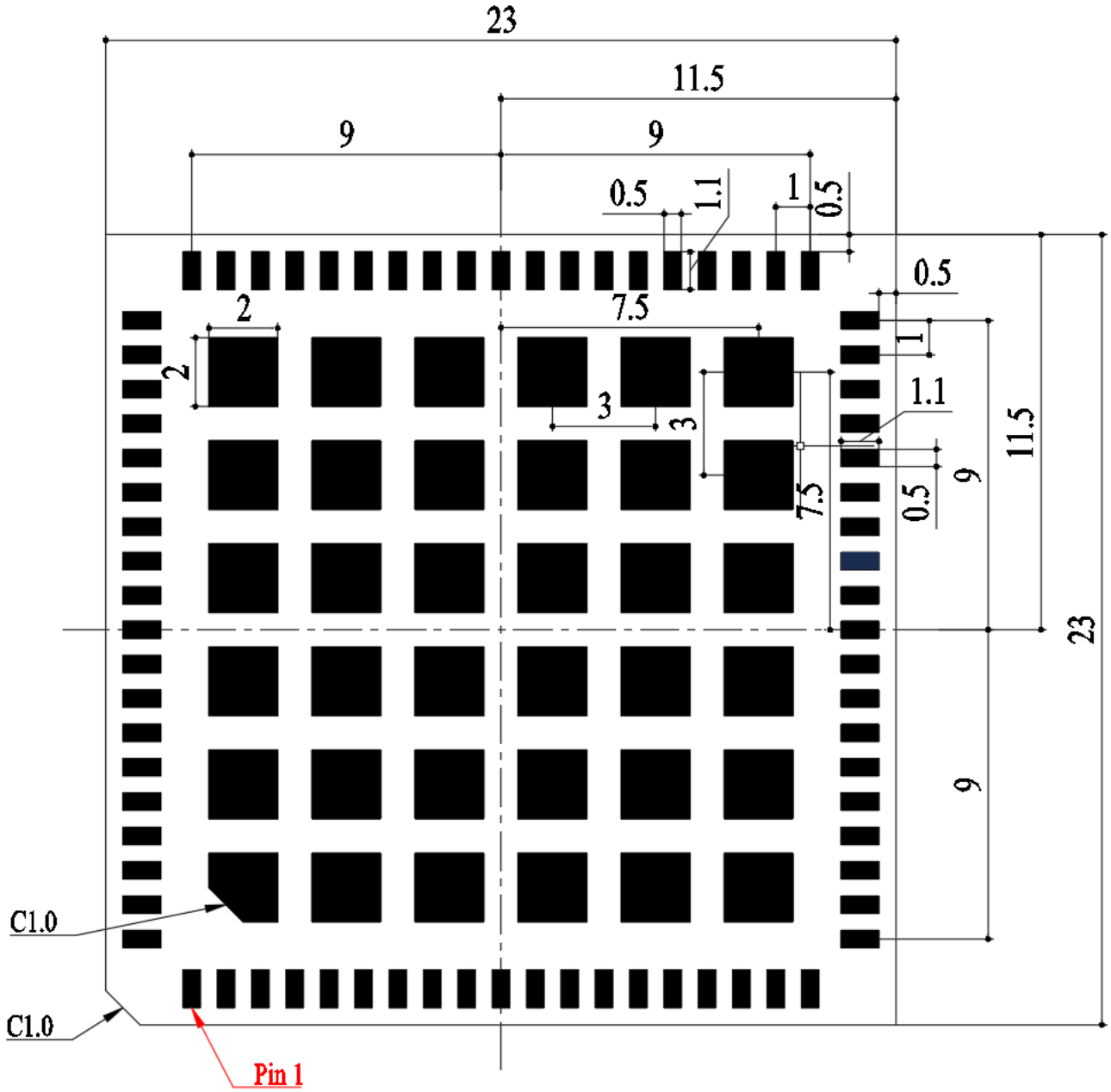


Figure 27: Recommended Footprint

NOTE

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

7.3. Top and Bottom Views

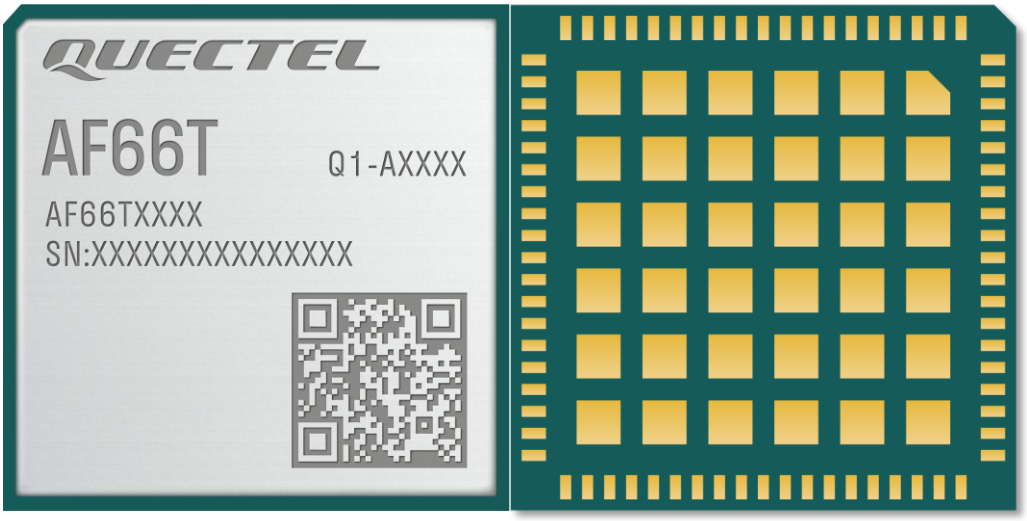


Figure 28: Top and Bottom Views of the Module

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.

8 Storage, Manufacturing & Packaging

8.1. 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.

8.2. 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 0.13–0.15 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.

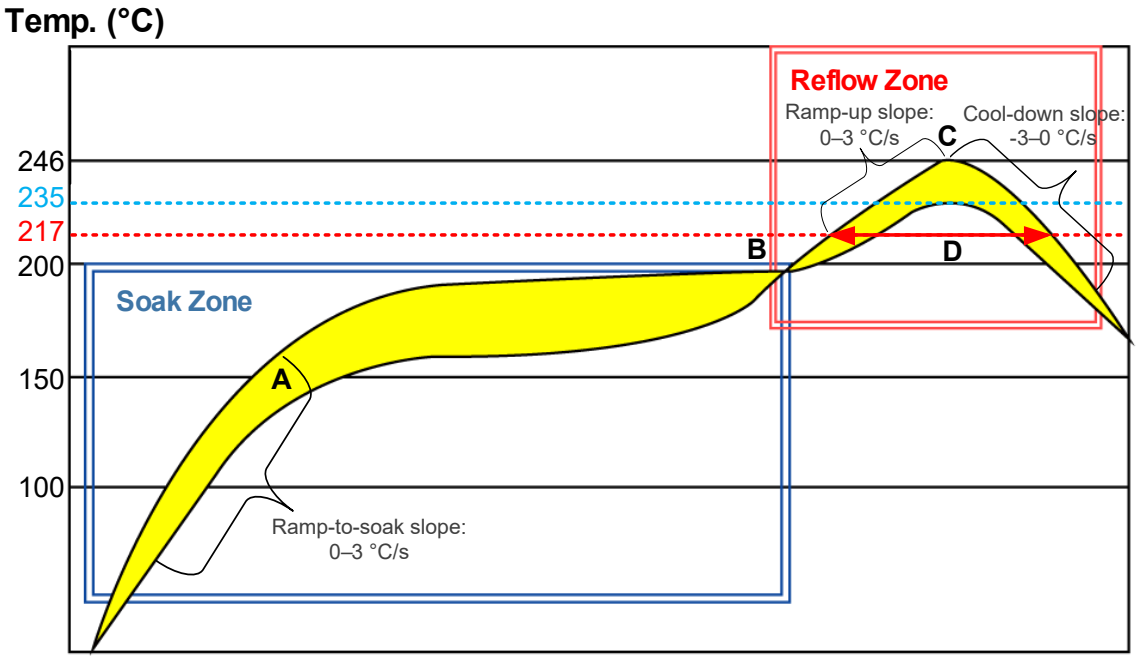


Figure 29: Recommended Reflow Soldering Thermal Profile

Table 34: 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. 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.
3. Avoid using ultrasonic technology for module cleaning since it can damage crystals inside the module.
4. Due to the complexity of the SMT process, please contact Quectel Technical Supports 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].***

8.3. Packaging Specification

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:

8.3.1. Carrier Tape

Dimension details are as follow:

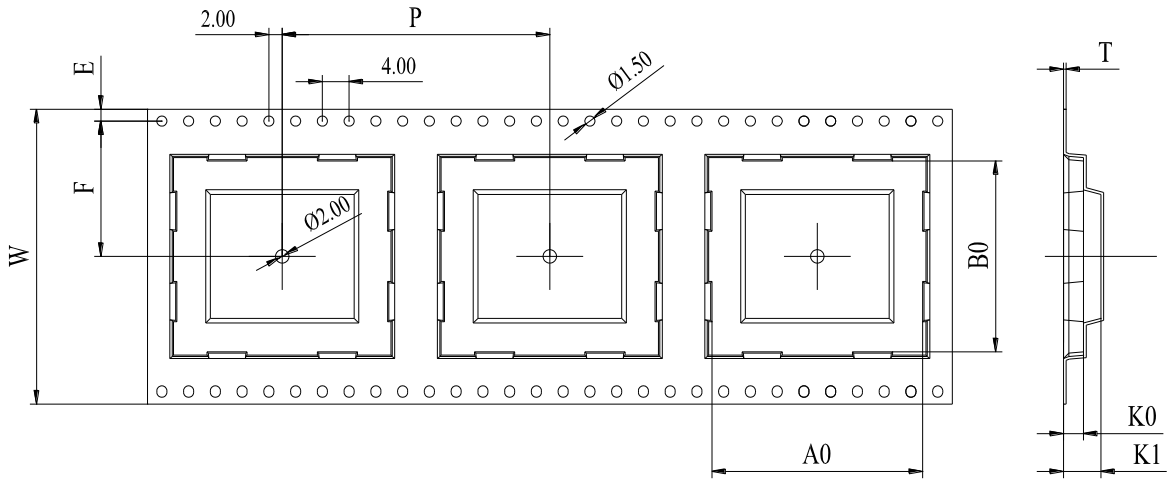


Figure 30: Carrier Tape Dimension Drawing

Table 35: Carrier Tape Dimension Table (Unit: mm)

W	P	T	A0	B0	K0	K1	F	E
44	32	0.4	23.5	23.5	3.5	6.8	20.2	1.75

8.3.2. Plastic Reel

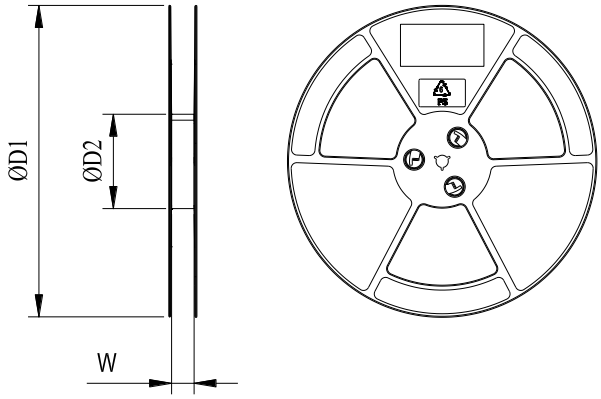


Figure 31: Plastic Reel Dimension Drawing

Table 36: Plastic Reel Dimension Table (Unit: mm)

øD1	øD2	W
330	100	44.5

8.3.3. Mounting Direction

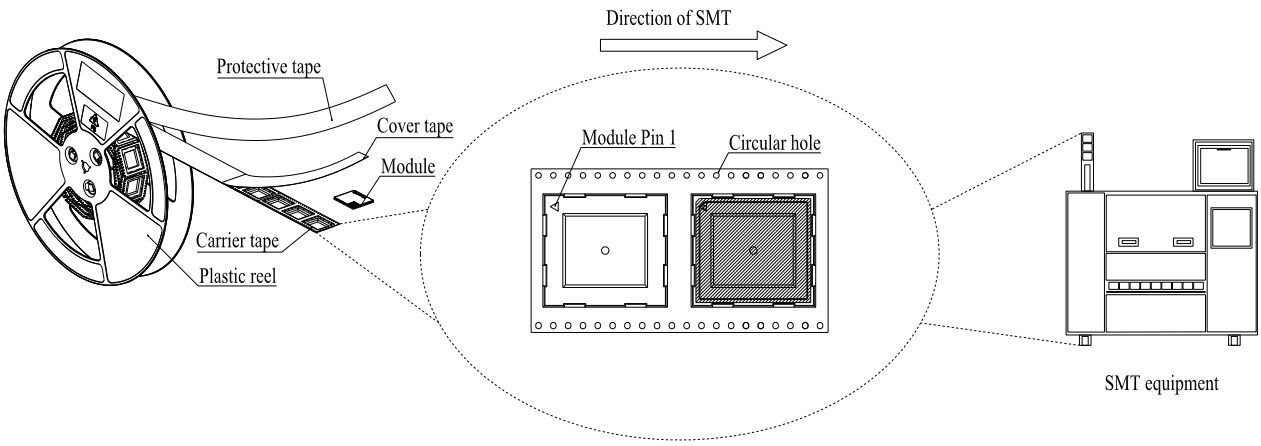
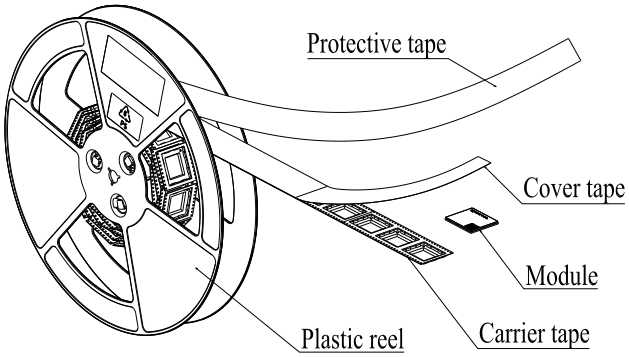


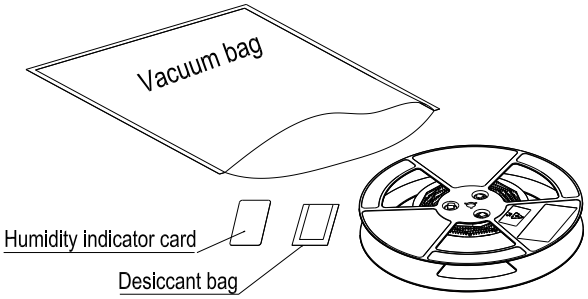
Figure 32: Mounting Direction

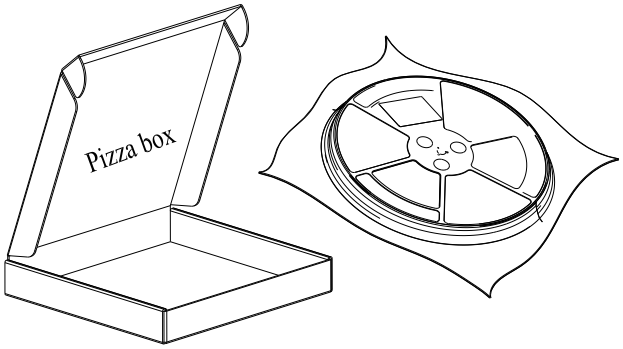
8.3.4. Packaging Process



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.

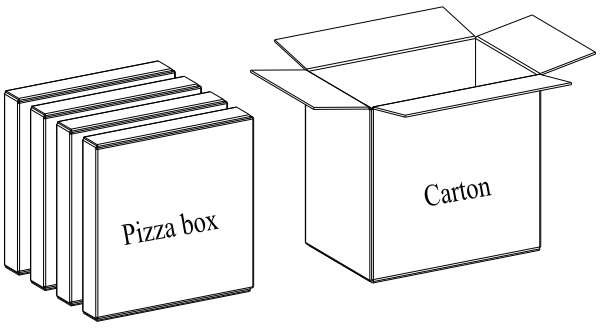


Figure 33: Packaging Process

9 Appendix References

Table 37: Related Documents

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

Table 38: Terms and Abbreviations

Abbreviation	Description
AP	Access Point/Application Processor
BLE	Bluetooth Low Energy
bps	Bytes per second
BPSK	Binary Phase Shift Keying
BR	Basic Rate
CCK	Complementary Code Keying
CS	Coding Scheme
CTS	Clear To Send
DPSK	Differential Phase Shift Keying
DQPSK	Differential Quadrature Reference Phase Shift Keying
EDR	Enhanced Data Rate
ESD	Electrostatic Discharge

GFSK	Gaussian Frequency Shift Keying
GND	Ground
HSIC	High Speed Inter Chip
HT	High Throughput
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
MSL	Moisture Sensitivity Levels
MU-MIMO	Multi-User Multi-Input Multi-Output
OFDMA	Orthogonal Frequency-Division Multiple Access
PCB	Printed Circuit Board
PCM	Pulse Code Modulation
PCIe	Peripheral Component Interconnect Express
PMIC	Power Management IC
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances
RTS	Request To Send
Rx	Receive
SMT	Surface Mount Technology

STA	Station
TBD	To Be Determined
Tx	Transmit
UART	Universal Asynchronous Receiver/Transmitter
VHT	Very High Throughput
Vmax	Maximum Voltage
Vnom	Nominal Voltage
Vmin	Minimum Voltage
VSWR	Voltage Standing Wave Ratio
WLAN	Wireless Local Area Network

Product Marketing Name：Quectel AF66T

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 timeaveraging 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: XMR202309AF66T
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:

Operating Band	Frequency (MHz)	Antenna Type	Antenna P/N	Antenna Gain (dBi)
Bluetooth	2400~2483.5	Dipole	YE0038AA	0.73 dBi
2.4G WiFi				0.73 dBi
5G WiFi	5150~5850			5150~5250 MHz: 1.14 dBi 5250~5350 MHz: 1.00 dBi 5470~5725 MHz: 0.60 dBi 5725~5850 MHz：0.95 dBi

5. This module must not transmit simultaneously with any other antenna or transmitter
6. The host end product must include a user manual that clearly defines operating requirements and

conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.
For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093
If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.
For this device, OEM integrators must be provided with labeling instructions of finished products.
Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:
A certified modular has the option to use a permanently affixed label, or an electronic label. For a permanently affixed label, the module must be labeled with an FCC ID - Section 2.926 (see 2.2 Certification (labeling requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labeling requirements, options and OEM user manual instructions that are required (see next paragraph).
For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module: "Contains Transmitter Module FCC ID: XMR202309AF66T" or "Contains FCC ID: XMR202309AF66T" 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.
To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Supplier's Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that the after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.
This device complies with Part 15.247, Part 15.407 of the FCC Rules. The FCC ID for this device is XMR202309AF66T.
Antenna change notice
If you desire to increase antenna gain and either change antenna type or use same antenna type certified , a Class II permissive change application is required to be filed by us , or you (host

manufacturer) can take responsibility through the change in FCC ID (new application) procedurefollowed by a Class II permissive change application

Information on test modes and additional testing requirements

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

Test software to access different test modes : QRCT4 tool

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

Manual Information To the End User

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

IC Statement

IRSS-GEN

"This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions: (1) This device may not cause interference; and (2) This device must accept any interference, including interference that may cause undesired operation of the device." or "Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1) l'appareil ne doit pas produire de brouillage; 2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement."

Déclaration sur l'exposition aux rayonnements RF

L'autre utilisé pour l'émetteur doit être installé pour fournir une distance de séparation d'au moins 20 cm de toutes les personnes et ne doit pas être colocalisé ou fonctionner conjointement avec une autre antenne ou un autre émetteur.

The host product shall be properly labeled 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-202309AF66T" or "where: 10224A-202309AF66T is the module's certification number".

Le produit hôte doit être correctement étiqueté pour identifier les modules dans le produit hôte.

L'étiquette de certification d'Innovation, Sciences et Développement économique Canada d'un module doit être clairement visible en tout temps lorsqu'il est installédans le produit hôte; sinon, le produit hôte doit porter une étiquette indiquant le numéro de certification d'Innovation, Sciences et Développement économique Canada pour le module, précédé du mot «Contient» ou d'un libellé semblable exprimant la même signification, comme suit:

"Contient IC: 10224A-202309AF66T " ou "où: 10224A-202309AF66T est le numéro de certification du module".

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

ii. 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 antenna(s), the maximum antenna gain permitted for devices in the band 5725-5850 MHz shall be such that the equipment still complies with the e.i.r.p. limits as appropriate;

iv. Omnidirectional antenna is recommended.

This radio transmitter [10224A-202309AF66T] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.