Fibocom

PERFECT WIRELESS EXPERIENCE

FIBOCOM L610 MiniPCIe Series Hardware Guide

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Applicability Type

No.	Product Model	Introduction
1	L610-CN-00-MiniPCIe-10-00	For the Chinese market, support FDD/TDD/GSM, with TTS, without diversity, WIFI-Scan, and BT; MiniPCIe package
2	L610-EU-00-MiniPCIe-10-00	For the Europe and Australia market, without diversity, with WIFI-Scan and BT; MiniPCIe package
3	L610-EU-01-MiniPCIe-10-00	For the Europe market, without band 28 and diversity, with WIFI-Scan and BT; MiniPCIe package
4	L610-LA-00-MiniPCIe-10-00	For the Latin America market, without diversity, with WIFI-Scan and BT; MiniPCIe package

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Change History

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1 Foreword

1.1 Introduction

This document describes the electrical characteristics, RF performance, structural dimensions, and application environment of the L610 MiniPCIe series module. With the help of this document and other related documents, application developers can quickly understand the hardware functions of the L610 MiniPCIe module and develop product hardware.

1.2 Safety Instructions

By following the safety guidelines below, you can ensure personal safety and protect the product and the working environment from potential damage. Product manufacturers need to communicate the following safety instructions to end users. In case of failure to comply with these safety instructions, Fibocom will not be responsible for the consequences caused by user misuse.

Road safety first! When you are driving, do not use a handheld mobile device, even if it has a hands-free function. Please stop before calling!

Please turn off the mobile device before boarding. The wireless function of the mobile device is not allowed on the aircraft to prevent interference with the aircraft communication system. Ignoring the prompt may cause flight safety and even violate the law.

When you are in a hospital or health care place, please pay attention to whether there are restrictions on the use of mobile devices. Radio frequency interference may cause malfunction of medical equipment, so it may be necessary to turn off the mobile device.

Mobile device does not guarantee effective connection under any circumstances, for example, when there is no prepayment for the mobile device or (U)SIM is invalid. When you encounter the above situation in an emergency, please remember to use emergency calls, and ensure that your device is turned on and in an area with strong signal.

Your mobile device will receive and transmit RF signals when it is turned on. RF interference occurs when it is near a TV, radio, computer, or other electronic device.

Keep mobile device away from flammable gases. Turn off the mobile device when you are near to gas stations, oil depots, chemical plants or explosive workplaces. There are potential safety hazards when operating electronic device in any potentially explosive area.

1.3 Reference Standards

The design of this product complies with the following standards:

- 3GPP TS 51.010-1 V10.5.0: Mobile Station (MS) conformance specification; Part 1: Conformance specification
- 3GPP TS 34.121-1 V10.8.0: User Equipment (UE) conformance specification; Radio transmission and reception (FDD); Part 1: Conformance specification
- 3GPP TS 34.122 V10.1.0: Technical Specification Group Radio Access Network; Radio transmission and reception (TDD)
- 3GPP TS 36.521-1 V13.6.0: User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance testing
- 3GPP TS 21.111 V10.0.0: USIM and IC card requirements
- 3GPP TS 51.011 V4.15.0: Specification of the Subscriber Identity Module -Mobile Equipment (SIM-ME) interface
- 3GPP TS 31.102 V10.11.0: Characteristics of the Universal Subscriber Identity Module (USIM) application
- 3GPP TS 31.11 V10.16.0: Universal Subscriber Identity Module (USIM) Application Toolkit (USAT)
- 3GPP TS 36.124 V10.3.0: Electro Magnetic Compatibility (EMC) requirements for mobile terminals and ancillary equipment
- 3GPP TS 27.007 V10.0.8: AT command set for User Equipment (UE)
- 3GPP TS 27.005 V10.0.1: Use of Data Terminal Equipment - Data Circuit terminating Equipment (DTE - DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)

1.4 Related Documents

- FIBOCOM EVK-GT8230-NL User Guide
- FIBOCOM Design Guide_RF Antenna
- FIBOCOM L610 Series AT Commands

2 Product Overview

2.1 Introduction

The L610 MiniPCIe series module is a broadband wireless terminal product applicable to multiple network formats such as FDD-LTE or TDD-LTE and GSM.

Band	**L610-CN-00-MiniPCIe-10-00**	**L610-EU-00-MiniPCIe-10-00**
LTE FDD	Band 1, 3, 5, 8	Band 1, 3, 7, 8, 20, 28
LTE TDD	Band 34, 39, 40, 41	-
GSM	900/1800	900/1800
ANT	Main	Main+WIFI
Band	**L610-EU-01-MiniPCIe-10-00**	**L610-LA-00-MiniPCIe-10-00**
LTE FDD	Band 1, 3, 7, 8, 20	Band 1, 2, 3, 4, 5, 7, 8, 28, 66
LTE TDD	-	-
GSM	900/1800	850/900/1800/1900
ANT	Main+WIFI	Main+WIFI

2.2 Specifications

Table 2-1 Product specifications

Specification		
Operating band	Please refer chapter 2.1	
Data transmission	LTE FDD Rel.13	10 Mbps DL or 5 Mbps UL
	LTE TDD Rel.13	8.2 Mbps DL or 3.4 Mbps UL
	GPRS	GPRS: 85.6 Kbps DL or 85.6 Kbps UL (multi-slot class 12)
Power supply	3.4 V to 4.3 V (3.8 V is recommended)	
Temperature	Normal operation: -30℃ to +75℃	
	Extended operation: -40℃ to +85℃	
	Storage: -40℃ to +90℃	
	Sleep mode: 3 mA	
	Idle mode: 12 mA	
	Package: PCI express Mini Card interface 52PIN	

Physical characteristics	Size: 50.8 mm×29.85 mm×3.4 mm
	Weight: < 9.5 g
Interface	
Antenna	Antenna: Main×1, WIFI×1
Function	USIM 3.0 V or 1.8 V
	USB 2.0×1
	System status indication
Software	
Protocol stack	Embedded TCP/IP and UDP/IP protocol stacks
AT Command	3GPP TS 27.007 and 27.005, and proprietary FIBOCOM AT
Firmware upgrade	USB
Voice service	HR, FR, EFR, AMR, caller ID, call forwarding, call hold, call waiting, and multi-party calling, etc.
SMS	Point-to-point MO and MT, cell broadcast, Text and PDU modes are supported

When the temperature is not within the normal operating temperature range of -30℃ to +75℃, the RF performance of the module may be slightly lower than the requirements of the 3GPP specifications.

2.3 Hardware Diagram

The main functions supported by the L610 MiniPCIe series module are shown as below, and also in figure 2-1:

- One (U)SIM card interface
- One USB 2.0 interface
- Sleep wake-up control
- Flight mode
- LED status indication function
- External reset function
- One RF antenna interface
- PCM digital audio interface*

* indicates RESERVED and applies to the entire document.

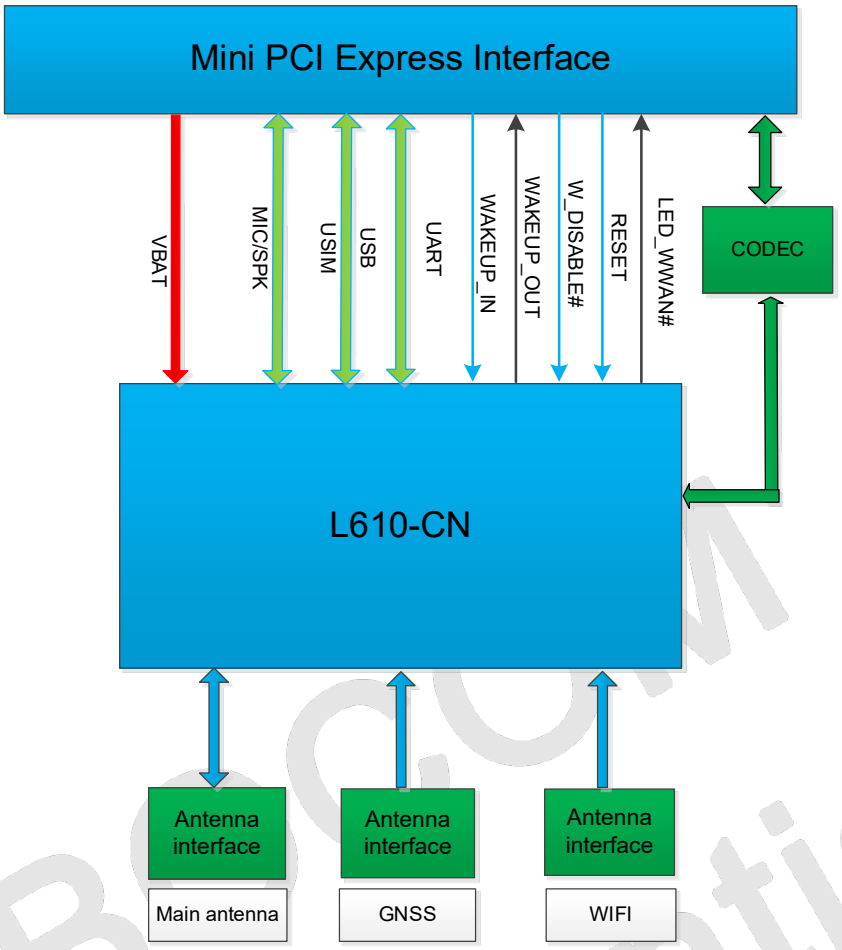

Figure 2-1 Hardware diagram

3 Application Interface

3.1 PCI Express Mini Card Interface

The L610 MiniPCIe series module uses PCI express Mini Card interface, with a total of 52 pins.

3.1.1 Pin Distribution

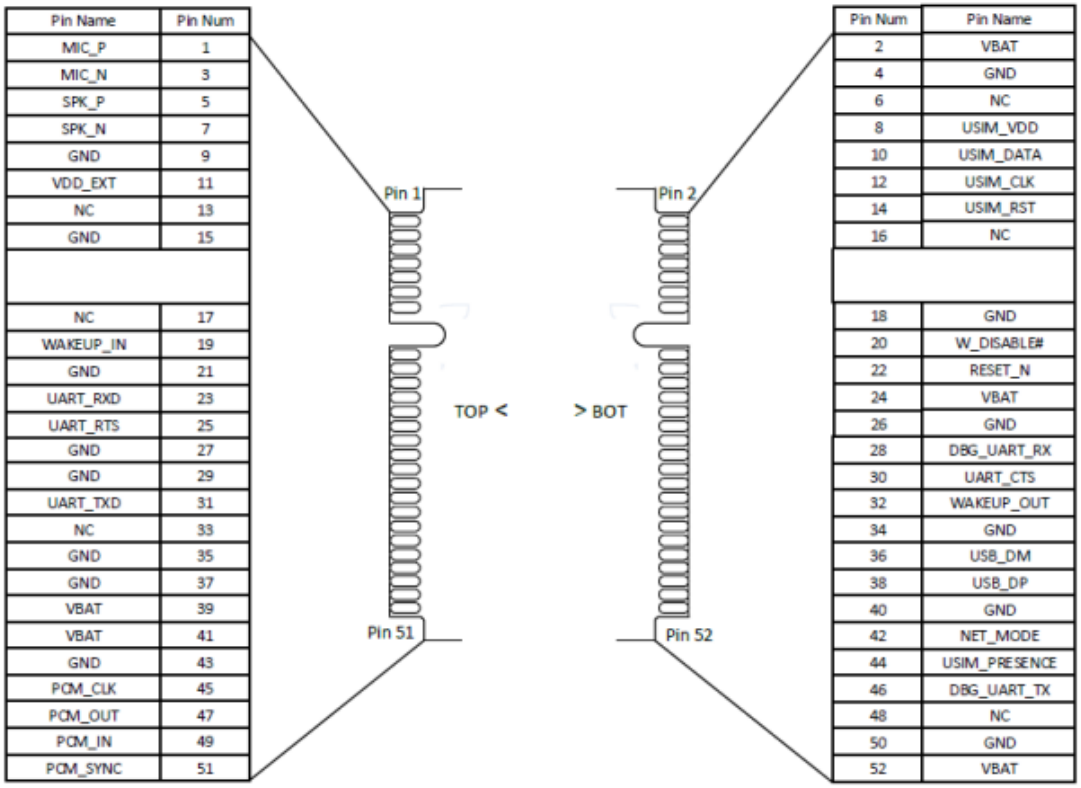

Figure 3-1 Pin distribution

3.1.2 Pin Definition

The pin definition is shown in the following table.

Table 3-1 Pin definition

Pin	Pin Name	I/O	Level	Description
1	MIC_P	I	-	MIC input positive
2	VBAT	PI	Vmax=4.3 V Vmin=3.4 V Vnorm=3.8 V	Module power supply
3	MIC_N	I	-	MIC input negative

Pin	Pin Name	I/O	Level	Description
4	GND	G	-	Ground
5	SPK_P	O	-	SPK input positive
6	NC	-	-	NC
7	SPK_N	O	-	SPK input negative
8	USIM_VDD	PO	For 1.8 V (U)SIM: Vmax=1.9 V Vmin=1.7 V For 3.0 V (U)SIM: Vmax=3.05 V Vmin=2.7 V IOmax=150 mA	(U)SIM power supply
9	GND	G	-	Ground
10	USIM_DATA	IO	For 1.8V USIM: VILmax=0.6 V VIHmin=1.2 V VOLmax=0.45 V VOHmin=1.35 V For 3.0 V (U)SIM: VILmax=1.0 V VIHmin=1.95 V VOLmax=0.45 V VOHmin=2.55 V	USIM data signal
11	VDD_EXT	PO	1.8 V	Module digital level, 1.8 V output 80 mA
12	USIM_CLK	O	For 1.8 V (U)SIM: VOLmax=0.45 V VOHmin=1.35 V For 3.0 V (U)SIM: VOLmax=0.45 V VOHmin=2.55 V	(U)SIM clock signal
13	NC	-	-	NC
14	USIM_RST	O	For 1.8 V (U)SIM: VOLmax=0.45 V VOHmin=1.35 V	(U)SIM reset signal

Pin	Pin Name	I/O	Level	Description
			For 3.0 V (U)SIM: VOLmax=0.45 V VOHmin=2.55 V	
15	GND	G	-	Ground
16	NC	-	-	NC
17	NC	-	-	NC
18	GND	G	-	Ground
19	WAKEUP_IN	I	VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	External device wakes up module
20	W_DISABLE#	I	VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	Module flight mode control
21	GND	G	-	Ground
22	RESET_N	I	VIHmax=VBAT VILmax=0.5 V	Module reset signal
23	UART_RXD	I	VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	Serial port receives data
24	VBAT	PI	Vmax=4.3 V Vmin=3.4 V Vnorm=3.8 V	Module power supply
25	UART_CTS	I	VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	Clear to send
26	GND	G	-	Ground
27	GND	G	-	Ground
28	DBG_UART_RX	I	VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	DEBUG serial port receives data
29	GND	G	-	Ground

Pin	Pin Name	I/O	Level	Description
30	UART_RTS	O	VOLmax=0.45 V VOHmin=1.35 V	Request to send
31	UART_TXD	O	VOLmax=0.45 V VOHmin=1.35 V	Serial port transmits data
32	WAKEUP_OUT	O	VOLmax=0.45 V VOHmin=1.35 V	Module wakes up external devices
33	NC	-	-	NC
34	GND	G	-	Ground
35	GND	G	-	Ground
36	USB_DM	IO	-	USB signal DM
37	GND	G	-	Ground
38	USB_DP	IO	-	USB signal DP
39	VBAT	PI	Vmax=4.3 V Vmin=3.4 V Vnorm=3.8 V	Module power supply
40	GND	G	-	Ground
41	VBAT	PI	Vmax=4.3 V Vmin=3.4 V Vnorm=3.8 V	Module power supply
42	NET_MODE	O	VOHmin=1.35 V VOLmax=0.45 V	Network status indicator signal
43	GND	G	-	Ground
44	USIM_PRESECE	I	1.8 V	(U)SIM card hot plug detection, when not in use, string 10 K resistor to ground
45	*PCM_CLK	IO	VOLmax=0.45 V VOHmin=1.35 V VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	PCM clock signal
46	DBG_UART_TX	O	VOLmax=0.45 V VOHmin=1.35 V	DEBUG serial port transmits data
47	*PCM_OUT	O	VOLmax=0.45 V	PCM data output

Pin	Pin Name	I/O	Level	Description
			VOHmin=1.35 V	
48	NC	-	-	NC
49	*PCM_IN/BOOT_CFG	I	VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	PCM data input/Forced download mode Pull up to 1.8 V before downloading the software
50	GND	G	-	Ground
51	*PCM_SYNC	IO	VOLmax=0.45 V VOHmin=1.35 V VILmin=-0.3 V VILmax=0.6 V VIHmin=1.2 V VIHmax=2.0 V	PCM sync signal
52	VBAT	PI	Vmax=4.3 V Vmin=3.4 V Vnorm=3.8 V	Module power supply

Unless otherwise specified, unused pins remain floating.

3.2 Power Supply

The power interface of the L610 MiniPCIe series module is shown in the following table.

Table 3-2 Power interface

Pin Name	I/O	Pin	Description
VBAT	PI	2, 24, 39, 41 and 52	Module power supply, 3.4 to 4.3 V Nominal value is 3.8 V
VDD_EXT	PO	11	Voltage output, 1.8 V, 80 mA
GND	G	4, 9, 15, 18, 21, 26, 27, 29, 34, 35, 37, 40, 43 and 50	Ground

3.2.1 Power Supply

The L610 MiniPCIe series module needs to be powered by the VBAT pin. The power design is shown in figure 3-2.

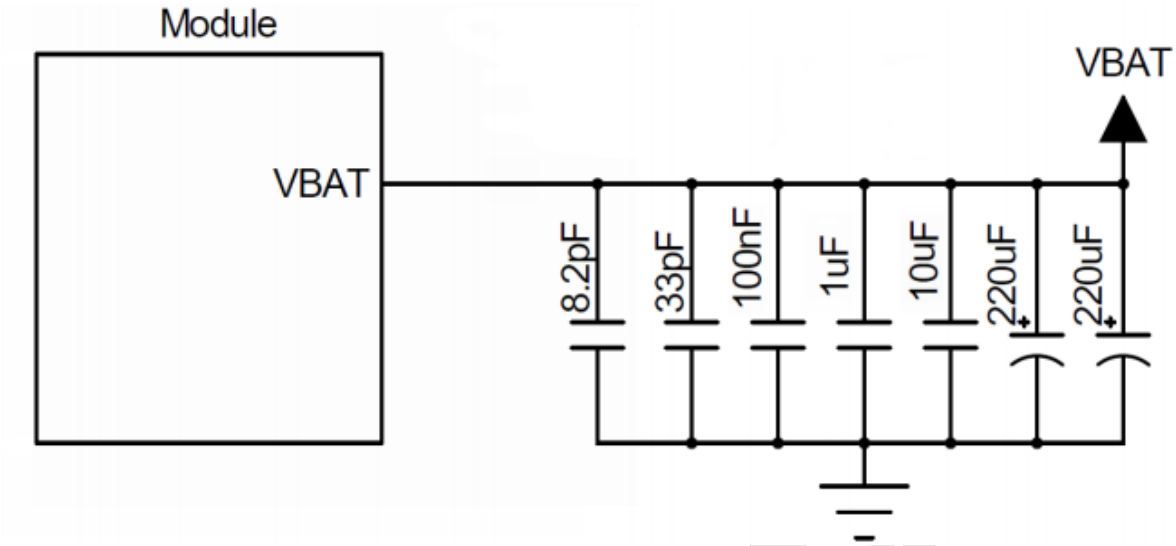

Figure 3-2 Power design

The filter capacitor design of the L610 MiniPCIe series module power supply is described in the following table.

Table 3-3 Filter capacitor design for power supply

Recommended Capacitance	Application	Introduction
220 uF×2, 10 uF	Regulating capacitor	To reduce power fluctuations during module operation, low ESR capacitors are required. ● LDO or DCDC power supply requires no less than 440 uF capacitor ● Battery power can be properly reduced to 100 to 220 uF capacitor
1 uF, 100 nF	Digital signal noise	Filter out interference caused by clock and digital signals
33 pF	700, 850/900 MHz band	Filter out low frequency RFI (Radio Frequency Interference)
8.2 pF	1700/1800/1900, 2100/2300, 2500/2600 MHz band	Filter out mid and high frequency RFI

The power stability ensures the normal operation of the L610 MiniPCIe series module. Pay attention to the design that the power supply ripple should be lower than 300 mV (the circuit ESR is less than 100mΩ). When the module works in GSM mode (burst transmit), the maximum working current can reach 2 A.

Ensure that the power supply voltage is not lower than 3.4 V, otherwise the module may be powered off or restarted.

The power supply restrictions are shown in Figure 3-4.

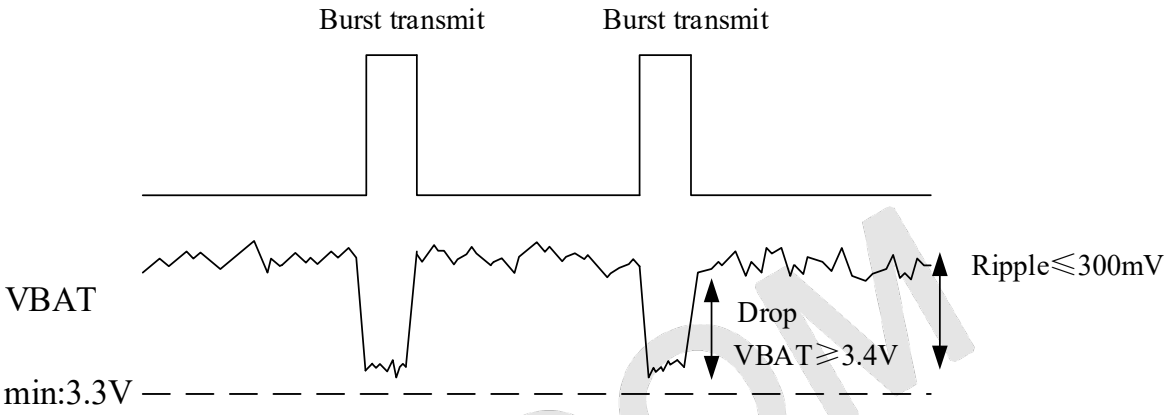

Figure 3-3 Power supply restrictions

3.2.2 1.8 V Output

The L610 MiniPCIe 10 series module outputs a 1.8 V voltage through VDD_EXT for the internal digital circuit of the module. This voltage is the logic level voltage of the module. It can be used to instruct the module to turn on, and can also be used for external small current (less than 80 mA) circuit applications. If not used, keep it floating. The logic level of VDD_EXT is defined in the following table.

Table 3-4 Logic level of VDD_EXT

Parameter	Minimum Value	Typical Value	Maximum Value	Unit
VDD_EXT	1.71	1.8	1.89	V

3.2.3 Power Consumption

The power consumption of the L610 MiniPCIe series module under 3.8 V power supply is shown in the following table.

Table 3-5 Power consumption

Parameter	Mode	Condition	Average Typ. Current (mA)
I/Off	Power off	Module power off	0.013
Iidle	Idle	Idle	12
Isleep	GSM	MFRMS=5	2.3
	LTE FDD	Paging cycle #128 frames	2.5
	LTE TDD	Paging cycle #128 frames	2.3
$I_{GSM-RMS}$	GSM	EGSM900 PCL5	260
		DCS1800 PCL0	200
		GSM850 PCL5	260
		PCS1900 PCL0	200
$I_{GPRS-RMS\ CS4}$	GPRS	GPRS Data transfer GSM850; PCL=5; 1Rx/4Tx	480
		GPRS Data transfer GSM900; PCL=5; 1Rx/4Tx	480
		GPRS Data transfer DCS1800; PCL=0; 1Rx/4Tx	400
		GPRS Data transfer PCS1900; PCL=0; 1Rx/4Tx	400
$I_{LTE-RMS}$	LTE FDD	LTE FDD Data transfer Band 1 @+23 dBm	730
		LTE FDD Data transfer Band 2 @+23 dBm	780
		LTE FDD Data transfer Band 3 @+23 dBm	730
		LTE FDD Data transfer Band 4 @+23 dBm	730
		LTE FDD Data transfer Band 5 @+23 dBm	600
		LTE FDD Data transfer Band 7 @+23 dBm	730
		LTE FDD Data transfer Band 8 @+23 dBm	600
		LTE FDD Data transfer Band 20 @+23 dBm	600
		LTE FDD Data transfer Band 28 @+23 dBm	600
		LTE FDD Data transfer Band 66 @+23 dBm	730
	LTE TDD	LTE TDD Data transfer Band 34 @+23 dBm	350
		LTE TDD Data transfer Band 39 @+23 dBm	350
		LTE TDD Data transfer Band 40 @+23 dBm	400
		LTE TDD Data transfer Band 41 @+23 dBm	400

3.3 Control Signals

The L610 MiniPCIe series module provides one control signal to reset the module. The pin definition is described in the following table.

Table 3-6 Reset control signal

Pin Name	I/O	Pin	Description
RESET_N	I	22	When the module is working, pull down the RESET_N pin greater than or equal to 100 ms then release, the module resets.

3.3.1 Module Reset

There are two ways to reset the L610 MiniPCIe series module: hardware reset and AT command reset.

Table 3-7 Module reset

Reset Method	Description
Hardware reset	Pull down the RESET_N pin greater than or equal to 100 ms, then release
AT command reset	AT+RESET

3.3.1.1 Reset Circuit

The reference circuit is shown in the following figure. Customers can use the OC/OD drive circuit or button to control the RESET_N pin.

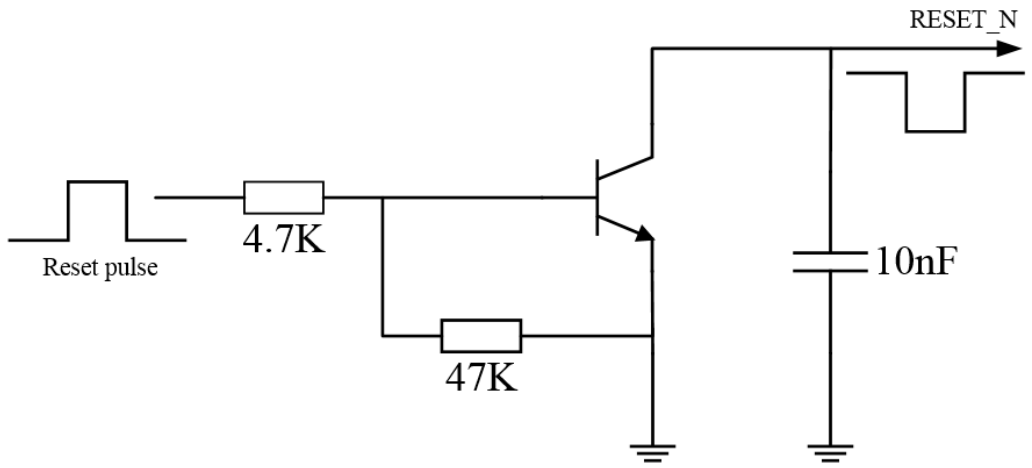

Figure 3-4 RESET_N reset OC/OD reference circuit

Another reset control method is shown in the following figure.

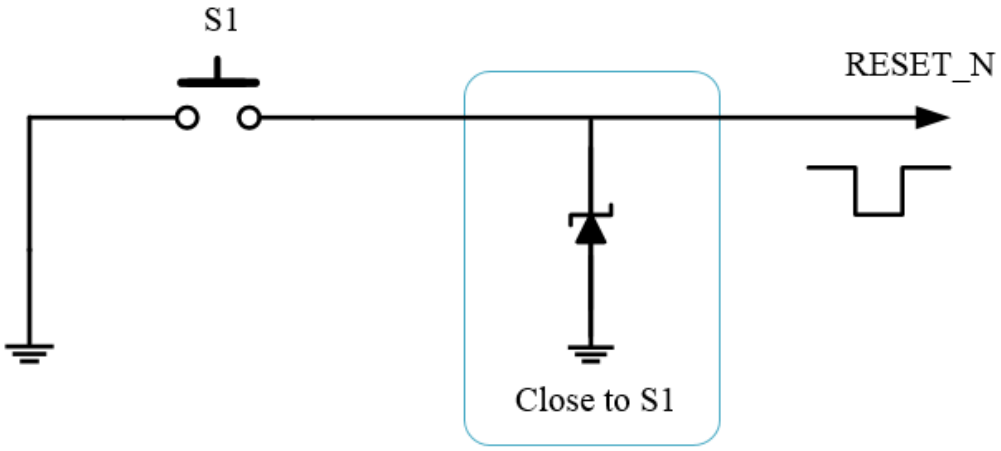

Figure 3-5 Button reset reference circuit

3.3.1.2 RESET_N Control Timing

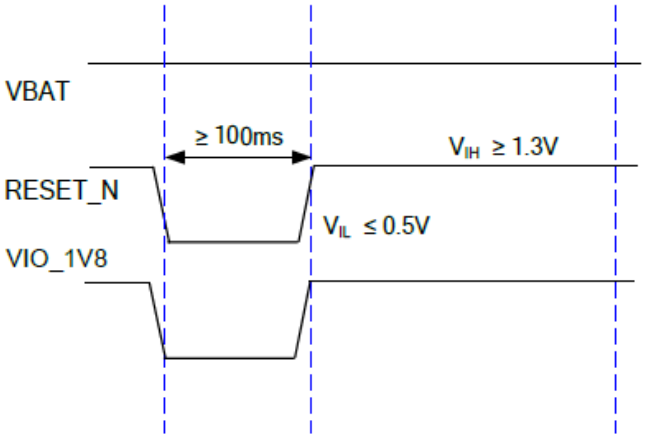

Figure 3-6 RESET_N control timing

RESET_N is a sensitive signal. It is recommended to add a debounce capacitor near the module. PCB layout should be far away from RF interference and do a good deal of ground treatment, while avoiding routing on the edge of the PCB and the surface layer (to avoid module reset caused by ESD).

3.4 USB Interface

The L610 MiniPCIe series module supports USB 2.0, and compatible with USB High-Speed (480 Mbit/s) and USB Full-Speed (12 Mbit/s). For details about the timing and electrical characteristics for the USB interface, see *Universal Serial Bus Specification 2.0*.

3.4.1 USB Interface Definition

Table 3-8 USB interface definition

Pin Name	I/O	Pin	Description
USB_DM	IO	36	USB data channel-
USB_DP	IO	38	USB data channel+

For more information about the USB 2.0 specification, please visit https://www.usb.org/home.

Since the module supports USB 2.0 High-Speed, the equivalent capacitance of the TVS tube on the USB_DM/DP differential signal line is required to be less than 1 pF, and it is recommended to use TVS with a capacitance of 0.5 pF.

It is recommended to connect 0Ω resistors in the USB_DM/DP differential line.

USB_DM and USB_DP are high-speed differential signal lines with a maximum transmission rate of 480 Mbits/s. The following rules must be strictly followed in PCB layout:

- The USB_DM and USB_DP signal lines control the differential impedance of 90Ω.
- The USB_DM and USB_DP signal lines must be of equal length and parallel to avoid running at right angles.
- The USB_DM and USB_DP signal lines are routed on the signal layer closest to the ground layer, and are grounded all around.

3.4.2 USB Upgrade

If the L610 MiniPCIe series module needs to be upgraded directly with USB, please fly out the pin 7 (VDD_EXT) and pin 115 (USB_BOOT) modules, short connect the pin 7 and pin 115 to enter the download mode before booting.

3.5 (U)SIM Interface

The L610 MiniPCIe series module supports (U)SIM card interface, supports 1.8 V and 3 V (U)SIM cards.

3.5.1 (U)SIM Pin

(U)SIM pins are shown in the following table.

Table 3-9 (U)SIM pin definition

Pin Name	I/O	Pin	Description
USIM_VDD	O	8	(U)SIM power
USIM_DATA	IO	10	(U)SIM data
USIM_CLK	O	12	(U)SIM clock
USIM_RST	O	14	(U)SIM reset
USIM_PRESENCE	I	44	Detect (U)SIM card for hot-plug

3.5.2 (U)SIM Interface Circuit

3.5.2.1 (U)SIM Card Slot with Detection Signal

(U)SIM design requires (U)SIM card slot (recommended model: SIM016-8P-220P). It is recommended to use a hot plug card slot with (U)SIM detection function.

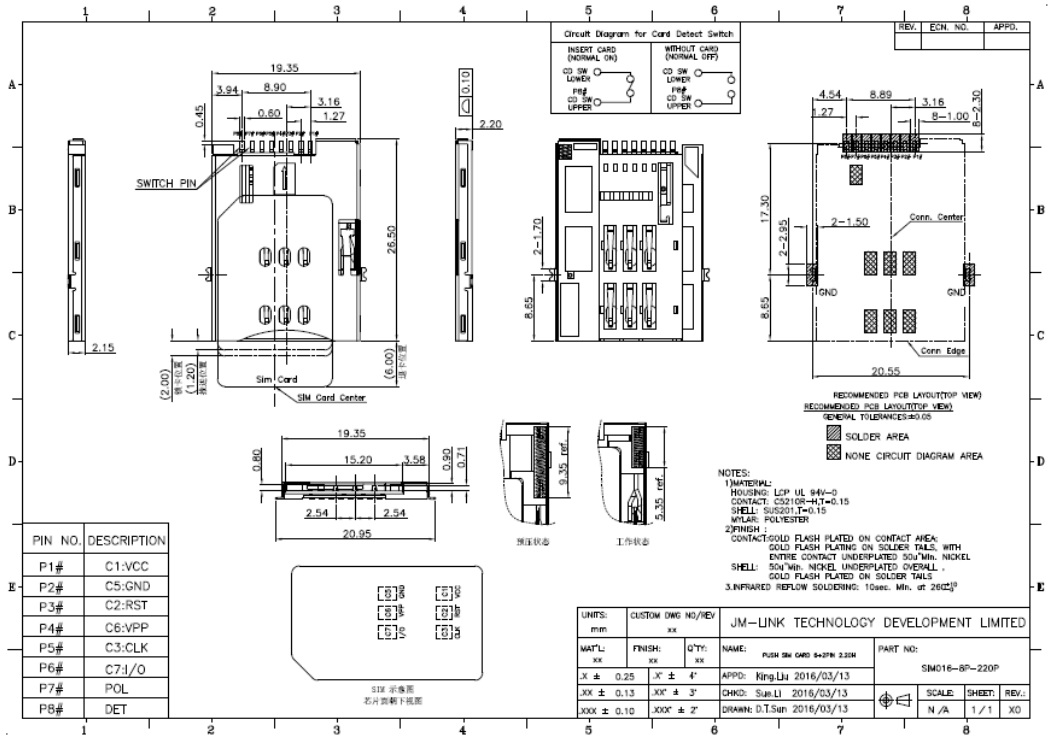

Figure 3-7 SIM card slot SIM016-8P-220P

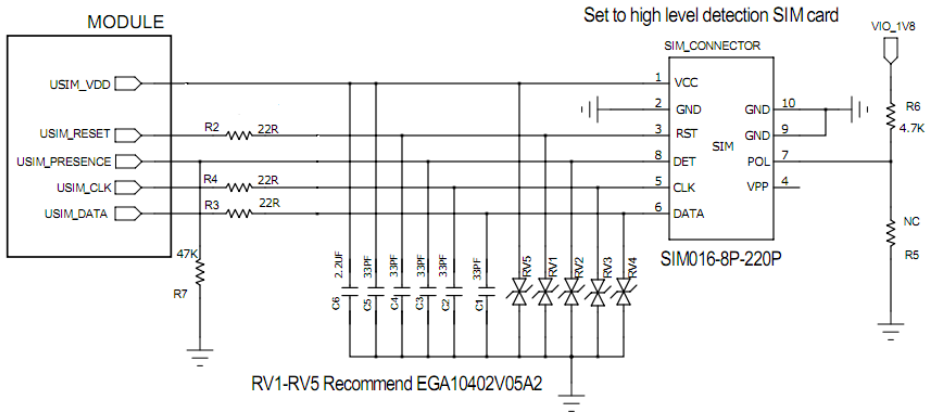

Figure 3-8 Reference design of (U)SIM interface with card detection function

The principle of (U)SIM card slot with card detection signal is explained as follows:

When (U)SIM card is inserted, USIM_PRESENCE is at a high level. When (U)SIM card is pulled out, USIM_PRESENCE is at a low level.

3.5.2.2 (U)SIM Card Slot Without Detection Signal

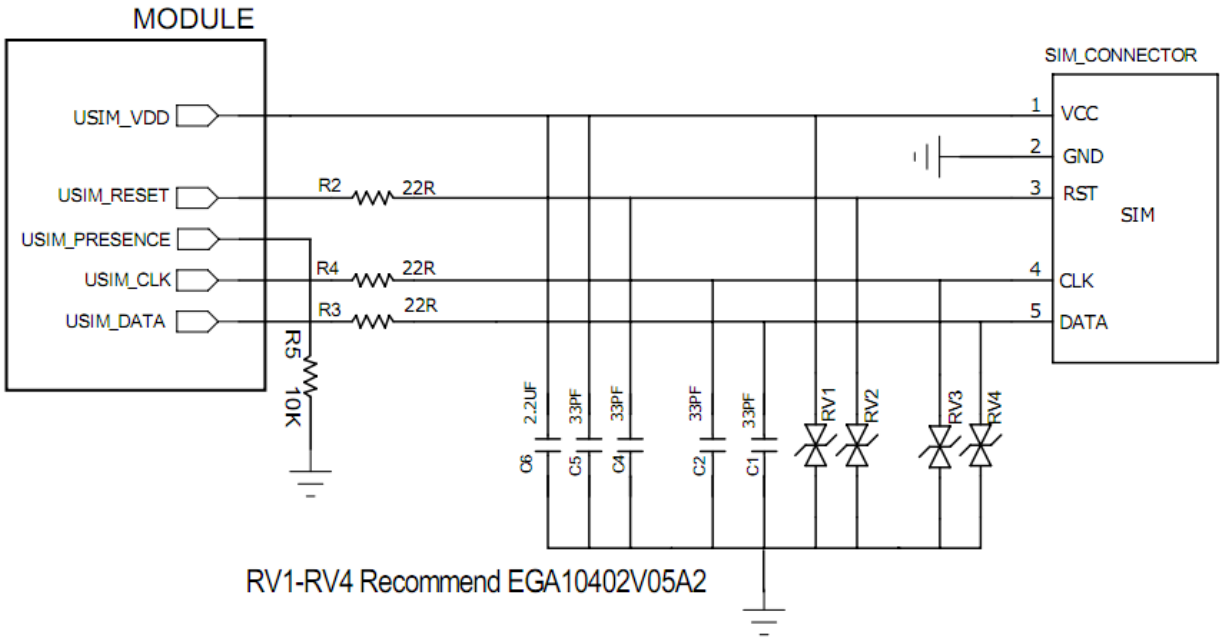

Figure 3-9 (U)SIM interface without card detection reference design

For (U)SIM card slot with no detection signal, USIM_ PRESENCE strings 10 K resistance to ground, and disable the hot plug detection function by AT commands.

3.5.3 (U)SIM Hot Plug

The L610 MiniPCIe series module supports the (U)SIM card hot plug function. The module determines whether the (U)SIM card is inserted or removed by detecting the pin status of USIM_ PRESENCE.

The (U)SIM card hot plug function can be configured through the **AT+MSMPD** command. The AT command is described in the following table.

Table 3-10 (U)SIM card hot plug function

AT Command	(U)SIM Card Hot Plug Detection	Function Description
AT+MSMPD=1	Enabled	(U)SIM card hot plug detection function is enabled. The module detects whether the card is inserted through the USIM_PRESENCE pin status.
AT+MSMPD=0	Disabled	Default value, which indicates that the (U)SIM card hot plug detection function is disabled. The module reads the (U)SIM card when starting up, and does not detect the USIM_PRESENCE status.

When the (U)SIM card hot plug detection function is enabled and USIM_PRESENCE is high, the module executes the (U)SIM card initialization procedure after the (U)SIM card is inserted, and registers the network after reading the (U)SIM card information. When USIM_PRESENCE is low, the module determines that the (U)SIM card is removed and does not read it.

USIM_PRESENCE is active high by default, and can be switched to active low by AT commands.

Table 3-11 USIM_PRESENCE effective level switching AT command

AT Command	Function Description
AT+GTSET="SIMPHASE",1	Default, high level detection
AT+GTSET="SIMPHASE",0	Low level detection

3.5.4 (U)SIM Design Requirements

(U)SIM card circuit design needs to meet EMC standards and ESD requirements, and at the same time, it needs to improve EMS (Electro Magnetic Susceptibility) to ensure (U)SIM card can work stably. The following principles must be strictly followed in the design:

- The layout of the (U)SIM card slot should be as close as possible to the module and away from strong interference sources such as RF antennas, DCDC power supplies, and clock signal lines.
- (U)SIM card slot with metal shielding shell is adopted to improve EMS.
- The length of the trace from the module to the (U)SIM card slot must not exceed 100 mm. Excessively long traces will reduce signal quality.
- The USIM_CLK and USIM_DATA signals are isolated on the ground to avoid mutual interference. If it is difficult to isolate them, at least the (U)SIM signal needs to be protected with the ground.
- The filter capacitor of the (U)SIM card signal line and the ESD device are placed close to the (U)SIM card slot.
- Please select ESD devices with an equivalent capacitance of less than 33 pF.
- USIM_DATA needs a 10 K resistor to be pulled up to USIM_VDD.

3.6 UART Interface

3.6.1 UART Interface Definition

The L610 MiniPCIe series module has two serial ports: main serial port and debug serial port. The following describes the main features of these two serial ports: the main serial port supports 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, and 1000000bps baud rate, the default baud rate is 115200bps, used for data and AT command transmission.

The debugging serial port supports 115200bps baud rate for FIBOCOM internal debugging.

The following table describes the main serial port pins.

Table 3-12 Main serial port pins

Pin Name	I/O	Pin	Description
UART_CTS	I	25	Clear to send
UART_RTS	O	30	Request to send
UART_TXD	O	31	Module transmits data
UART_RXD	I	23	Module receives data

The following table describes the debugging serial port pins:

Table 3-13 Debug serial port pins

Pin Name	I/O	Pin	Description
DBG_UART_RX	I	28	Module receives data
DBG_UART_TX	O	46	Module transmits data

3.6.2 UART Interface Application

The serial port level of the L610 MiniPCIe series module is 1.8 V. If the client host system level is 3.4 V or other, you need to add a level converter to the serial port connection between the module and the host. The following figure shows the reference circuit design using a level conversion chip.

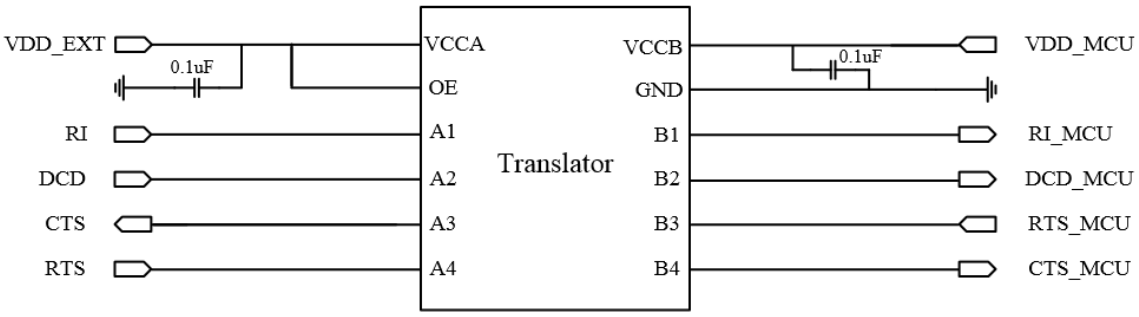

Figure 3-9 UART signal connection 1

The following figure shows another level conversion circuit. You can design the input and output circuit of the dashed line by referring to the solid line, but pay attention to the connection direction.

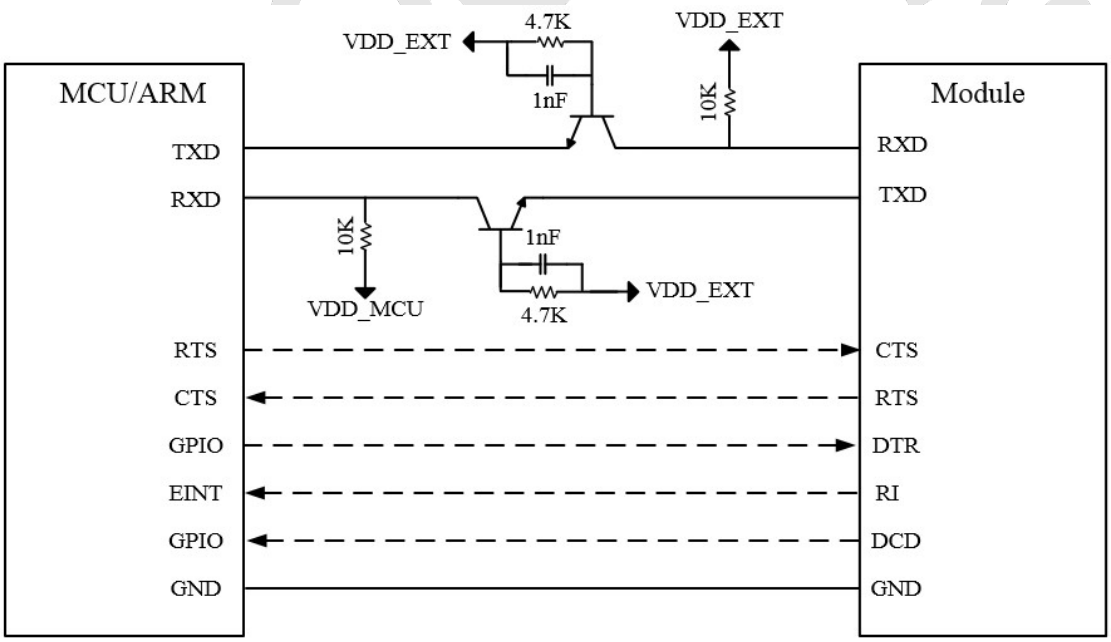

Figure 3-10 UART signal connection 2

This level conversion circuit is not suitable for applications where the baud rate exceeds 460 Kbps.

3.7 Status Indicator

The L610 MiniPCIe series module provides one signal to display the operating status of the module. The following table describes the status indication pin.

Table 3-14 Status indication

Pin Name	I/O	Pin	Description
NET_MODE	O	42	Module status indication

3.7.1 LPG Signal

The L610 MiniPCIe series module provides a network LED interface NET_MODE.

The reference circuit design of the NET_MODE interface is shown in the following figure.

Figure 3-11 NET_MODE reference design drawing

The following table describes the corresponding network LED status.

Table 3-15 Description of network indicator status

Mode	Level Status of Module Network Indicator Pin	LED Status	Description
1	600 ms low/600 ms high	Flash 600 ms on/600 ms off	• No SIM card • SIM PIN • Registering network (T < 15s) • Network registration failed
2	3000 ms low/75 ms high	Slow flash 3000 ms on/75 ms off	Standby
3	75 ms low / 75 ms high	Fast flash 75 ms on/75 ms off	Data link establishment
4	High	Off	Voice calls

3.8 Low Power Consumption Mode

3.8.1 Flight Mode

The L610- MiniPCIe series module provides one signal to control the interface for the module to enter the flight mode.

Table 3-16 Flight mode control

Pin Name	I/O	Pin	Description
W_DISABLE#	I	20	Module flight mode control

The L610 MiniPCIe series module supports two ways to enter the flight mode, as shown in the following table.

Table 3-17 Ways for the module to enter flight mode

1	Hardware I/O interface key control	Send **AT+WDISABLEEN=1** to enable W_DISABLE#. When you pull up or float W_DISABLE# pin (the default status is pull-up), the module is in normal mode, and when you pull down this pin, the module enters flight mode.
2	AT command control	**AT+CFUN=0,0**: The module enters flight mode **AT+CFUN=1,0**: The module enters normal mode.

3.8.2 Sleep Mode

For details of sleep mode, please refer to *FIBOCOM L610 Series AT Commands*.

3.9 Digital Audio Interface PCM

The L610 MiniPCIe series module provides a digital audio interface PCM, which can communicate with external CODEC and other digital audio devices. Interface signals include transmission clock PCM_CLK, frame synchronization signal PCM_SYNC, input and output PCM_IN/PCM_OUT.

3.9.1 PCM Interface Description

Table 3-18 PCM interface configuration

Pin Name	Frequency	Duty Ratio	Coded Format	Operation Mode	Description
*PCM_CLK	2.048 MHz	50%	16-bit liner mono	The module is master, and PCM slaves are supported	PCM clock
*PCM_OUT	-	-			PCM data output
*PCM_IN	-	-			PCM data input
*PCM_SYNC	8 KHz	Short pulse			PCM data synchronization signal (falling edge sampling)

The L610 MiniPCIe series module is configured as above, if you need to adjust the configuration, please contact technical support.

3.9.2 PCM Signal Description

The main chip of the L610 MiniPCIe series module provides PCM signals using the domestic mainstream European E1 standard. PCM_CLK is a 2.048 MHz clock, encoding in 16-bit linear format. PCM_SYNC is an 8 KHz short pulse (488 ns).

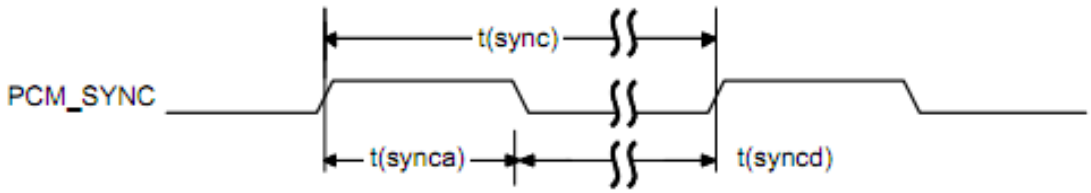

Figure 3-12 PCM_SYNC timing

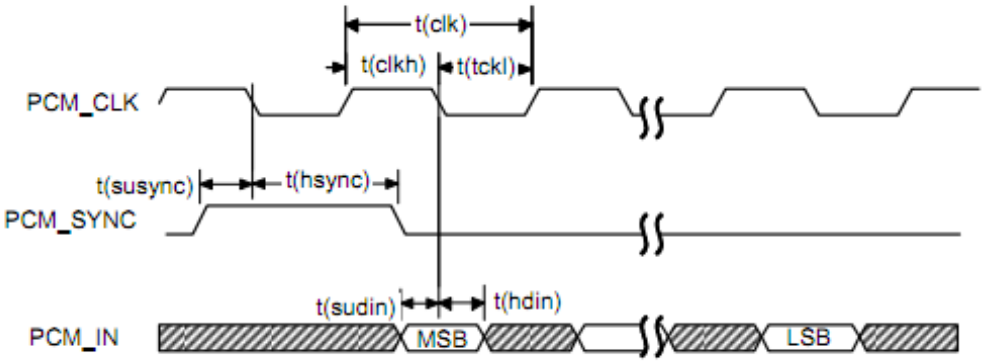

Figure 3-13 PCM_CODEC to NL668-AM-00-MiniPCIe-10 timing

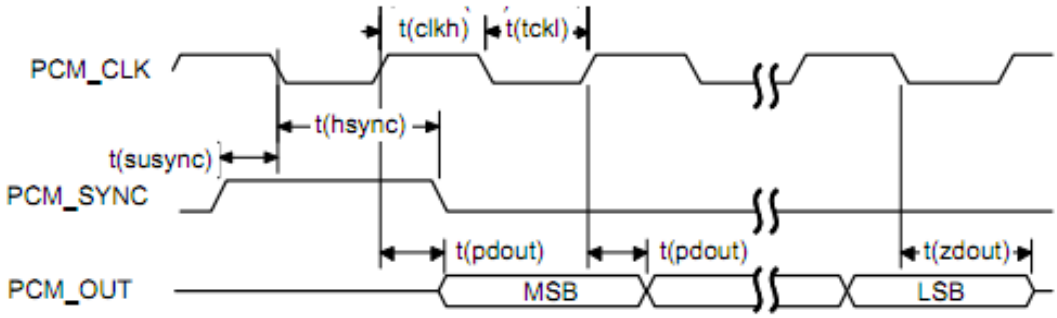

Figure 3-14 L610 MiniPCIe to PCM_CODEC timing

Table 3-19 CODEC timing parameters

Parameter		Min	Typical	Max	Unit
t(sync)	PCM_SYNC cycle time	–	125	–	μs
t(synca)	PCM_SYNC asserted time	–	488	–	ns
t(syncd)	PCM_SYNC deasserted time	–	124.5	–	μs
t(clk)	PCM_CLK cycle time	–	488	–	ns
t(clkh)	PCM_CLK high time	–	244	–	ns
t(clkl)	PCM_CLK low time	–	244	–	ns
t(susync)	PCM_SYNC offset time to PCM_CLK falling	–	122	–	ns
t(sudin)	PCM_DIN setup time to PCM_CLK falling	60	–	–	ns
t(hdin)	PCM_DIN hold time after PCM_CLK falling	10	–	–	ns
t(pdout)	Delay from PCM_CLK rising to PCM_DOUT valid	–	–	60	ns
t(zdout)	Delay from PCM_CLK falling to PCM_DOUT high impedance	–	160	–	ns

3.10 Analog Audio Interface

The L610 series module supports analog audio input and output. The module chip has a built-in audio codec chip, one differential MIC input, and one differential SPK output. You can directly connect the MIC and SPK to the periphery of the module, or add an audio PA (Power Amplifier).

3.10.1 Supported Models

Table 3-20 Supported models

No.	Product Model	Introduction
1	L610-CN-00-MiniPCIe-10-00	Support
2	L610-EU-00-MiniPCIe-10-00	Support
3	L610-EU-01-MiniPCIe-10-00	Support
4	L610-LA-00-MiniPCIe-10-00	Support

3.10.2 Analog Audio Interface Definition

Table 3-21 Interface definition

Pin Name	I/O	Pin	Description
MIC_P	I	1	MIC input positive
MIC_N	I	3	MIC input negative
SPK_P	O	5	Audio output positive
SPK_N	O	7	Audio output negative

The MIC_P and MIC_N channels are used as microphone differential inputs and do not support single-ended inputs. Electret microphones are usually used.

SPK_P and SPK_N channels are used for differential output of receivers or speakers (external audio PA is required), and do not support single-ended output.

SPK supports both Class-D and CLASS-AB output modes, Class-D mode gain level is 0, 1.5 or 3 dB, Class-AB mode gain level is -3, 0 or 1.16 dB (3-bit programmable gain).

SPK output power: 800 mW@4.2 V on 8Ω load in Class-D mode, 600 mW@4.2 V on 8Ω load in Class-AB mode.

When using an external PA, Class-AB output is required. The recommended model is AW87359FCR (8Ω 2 W).

3.10.3 Preventing TDD and Other Noises

For handsets and hands-free microphones, it is recommended to use built-in RF filter dual-capacitor (such as 10 pF and 33 pF) electret microphones to filter out RF interference from the interference source, which will greatly reduce the coupling TDD noise. The 33 pF capacitor is used to filter high-frequency interference when the module works at 900 MHz, and the 10 pF capacitor is used to filter high-frequency interference when the module works at 1800 MHz. If this capacitor is not added, TDD noise may be heard during a call. It should be noted that because the resonance point of the capacitor depends greatly on the capacitor material and manufacturing process, so when selecting the capacitor, you need to consult the capacitor supplier to select the most suitable value to filter out the high-frequency noise when working in EGSM900/DCS1800.

The severity of high-frequency interference during GSM transmission usually depends mainly on customer application design. In some cases, the TDD noise of EGSM900 is more serious, while in some cases, the TDD noise of DCS1800 is more serious. Therefore, customers can choose the required filter capacitor according to the test results.

The placement of the RF filter capacitor on the PCB should be as close as possible to the audio device or audio interface, and the trace should be as short as possible. It must pass through the filter capacitor before reaching other connection points. The antenna should be located as far away as possible from the audio components and audio traces to reduce radiated interference. The power traces and audio traces cannot be parallel, and the power traces should be as far away as possible from the audio traces. Differential audio traces must follow the wiring rules for differential signals.

3.10.4 Microphone Interface Circuit

The MIC_P or MIC_N channel has provided the electret microphone bias voltage internally, and there is no need to add an external bias circuit. The microphone channel reference circuit is shown in the following figure.

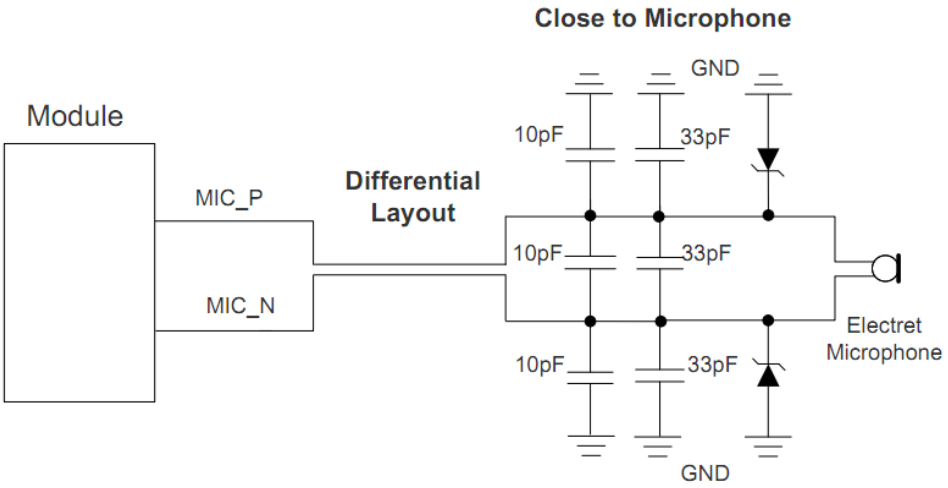

Figure 3-15 Microphone channel reference circuit

3.10.5 Speaker Interface Circuit

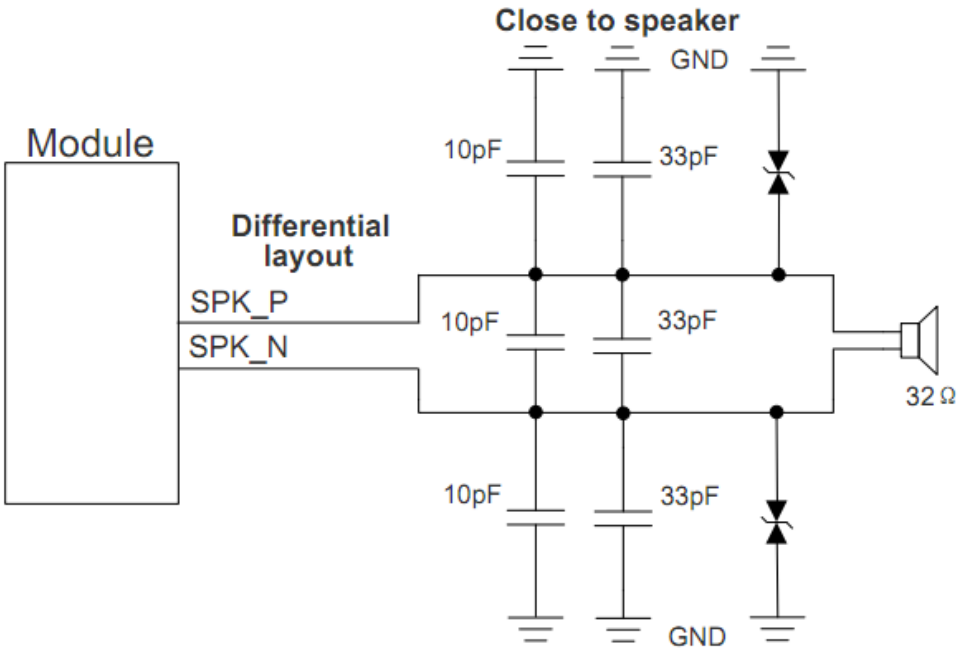

Figure 3-16 SPK output reference circuit

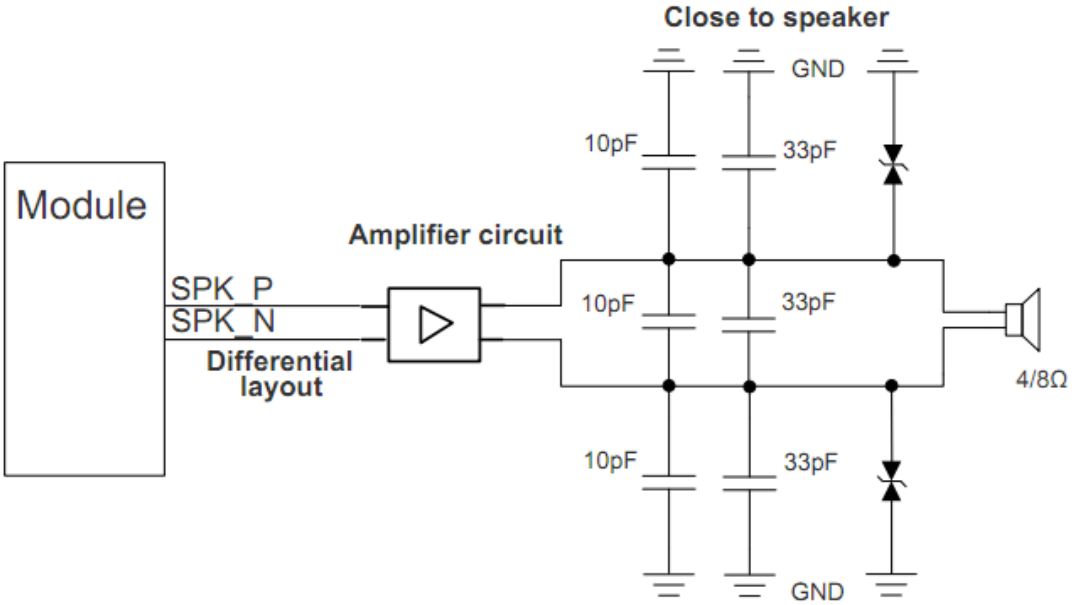

Figure 3-17 Reference circuit audio PA

It is recommended to use differential signal mode for analog voice to ensure efficient and EMS propagation of data.

4 RF Interface

The L610 MiniPCIe series module provides a MAIN antenna interface for sending and receiving RF signals. The operating band of the antenna is shown in the following table.

Table 4-1 Operating band

Operating Band	Description	Mode	Tx (MHz)	Rx (MHz)
Band 1	IMT 2100MHz	LTE FDD	1920 - 1980	2110 - 2170
Band 2	PCS 1900 MHz	LTE FDD	1850 - 1910	1930 - 1990
Band 3	DCS 1800MHz	LTE FDD/GSM	1710 - 1785	1805 - 1880
Band 4	AWS-1 1700	LTE FDD	1710 - 1755	2110 - 2155
Band 5	CLR 850MHz	LTE FDD	824 - 849	869 - 894
Band 7	IMT-E 2600MHz	LTE FDD	2500 - 2570	2620 - 2690
Band 8	E-GSM 900MHz	LTE FDD/GSM	880 - 915	925 - 960
Band 20	EU Digital Dividend 800 MHz	LTE FDD	832 - 862	791 - 821
Band 28	APAC 700MHz	LTE FDD	703 - 748	758 - 803
Band 66	AWS-1 1700	LTE FDD	1710 - 1780	2110 - 2180
Band 34	IMT 2100MHz	LTE TDD	2010 - 2025	
Band 39	TDD 1900MHZ	LTE TDD	1880 - 1920	
Band 40	IMT 2300MHz	LTE TDD	2300 - 2400	
Band 41	BRS/EBS 2500MHZ	LTE TDD	2555 - 2655	

4.1 Transmit Power

The transmission power of each frequency band of the L610 MiniPCIe series module is shown in the following table.

Table 4-2 Transmit power

Mode	Band	Tx Power (dBm)	Note
GSM	GSM 900	33±2	-
	DCS 1800	30±2	-
	GSM 850	33±2	-
	PCS 1900	30±2	-
LTE FDD	Band 1	23±2	10 MHz Bandwidth, 1 RB
	Band 2	23±2	10 MHz Bandwidth, 1 RB
	Band 3	23±2	10 MHz Bandwidth, 1 RB
	Band 4	23±2	10 MHz Bandwidth, 1 RB
	Band 5	23±2	10 MHz Bandwidth, 1 RB
	Band 7	23±2	10 MHz Bandwidth, 1 RB
	Band 8	23±2	10 MHz Bandwidth, 1 RB
	Band 20	23±2	10 MHz Bandwidth, 1 RB
	Band 28	23±2	10 MHz Bandwidth, 1 RB
	Band 66	23±2	10 MHz Bandwidth, 1 RB
LTE TDD	Band 34	23±2	10 MHz Bandwidth, 1 RB
	Band 39	23±2	10 MHz Bandwidth, 1 RB
	Band 40	23±2	10 MHz Bandwidth, 1 RB
	Band 41	23±2	10 MHz Bandwidth, 1 RB

4.2 Receiving Sensitivity

The sensitivity of each frequency band of the L610 MiniPCIe series module is shown in the following table.

Table 4-3 Receiving sensitivity

Mode	Band	Rx Sensitivity (dBm) Typical	Note
GSM	GSM 900	-109	BER < 2.43%
	DCS 1800	-108	BER < 2.43%
	GSM 850	-109	TBD
	PCS 1900	-108	TBD
LTE FDD	Band 1	-98.0	10 MHz Band width
	Band 2	-97.0	10 MHz Band width
	Band 3	-98.0	10 MHz Band width
	Band 4	-97.0	10 MHz Band width
	Band 5	-98.5	10 MHz Band width
	Band 7	-97.0	10 MHz Band width
	Band 8	-98.5	10 MHz Band width
	Band 20	-98.5	10 MHz Band width
	Band 28	-97.0	10 MHz Band width
	Band 66	-97.0	10 MHz Band width
LTE TDD	Band 34	-98.0	10 MHz Band width
	Band 39	-98.0	10 MHz Band width
	Band 40	-99.0	10 MHz Band width
	Band 41	-99.0	10 MHz Band width

4.3 Antenna Installation

4.3.1 Antenna RF Connector

The L610 MiniPCIe series module provides one RF connector. It is recommended that the application client uses a matching RF adapter cable. MAIN is the RF main antenna interface.

The RF connector of the L610 MiniPCIe series module uses I-PEX 20279 (MHF), the size is 3.1 mm×3.0

mm×1.25 mm, as shown in figure 4-1.

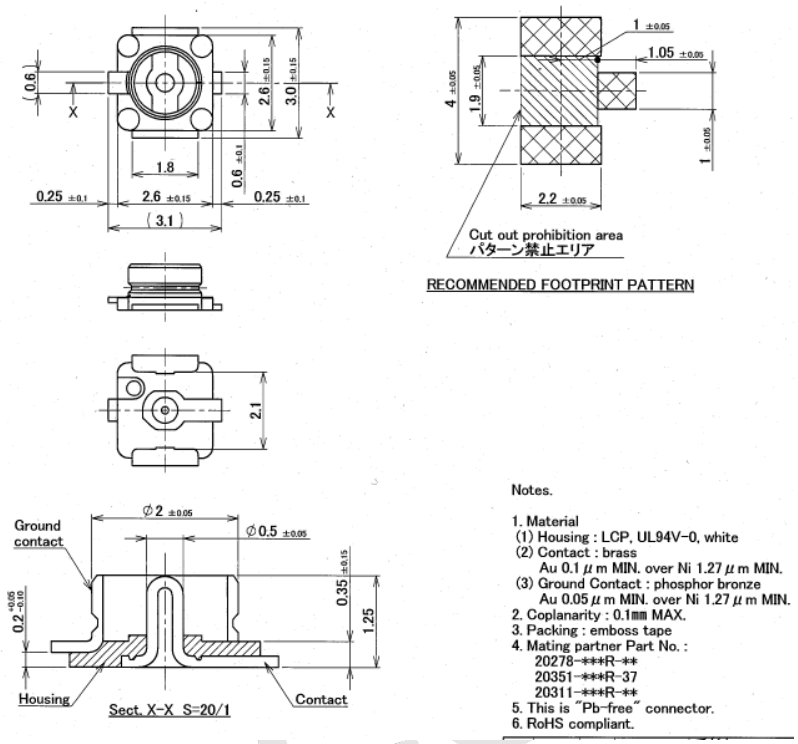

Figure 4-1 Dimensional drawing of RF connector

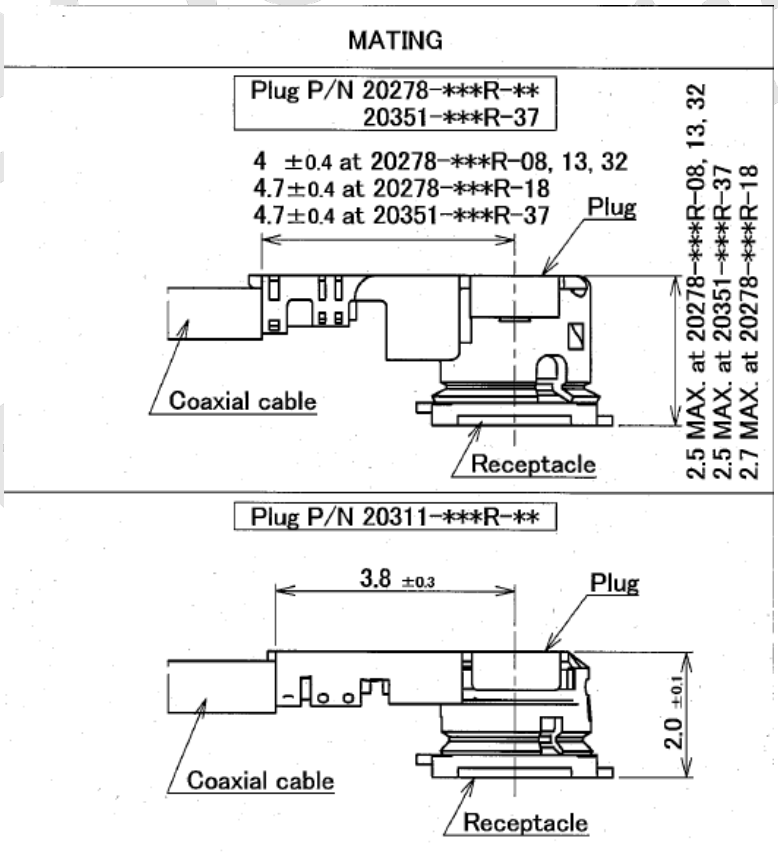

Figure 4-2 Coaxial RF connector snapped into the RF connector

4.4 Antenna Design

4.4.1 Antenna Design Requirements

1) Antenna efficiency

Antenna efficiency is the ratio of antenna input power to emissivity. Due to the antenna's return loss, material loss and coupling loss, the radiated power is always lower than the input power. In this case, a value greater than 40% (-4 dB) is recommended for antenna efficiency.

2) S11 or VSWR

S11 shows the matching degree of the 50Ω impedance of the antenna, which affects the antenna efficiency. This indicator can be measured by VSWR test. It is recommended that the value of S11 is less than -10 dB.

3) Polarization

Polarization is the rotation direction of the electric field of the antenna in the direction of maximum radiation.

Linear polarization is recommended.

4) Radiation direction pattern

The radiation direction pattern refers to the strength of the electromagnetic field of the antenna in each direction in the far field. The half-wave dipole antenna is the most suitable terminal antenna. For built-in antennas, PIFA or IFA antenna is recommended.

Antenna area: 6 mm high×10 mm wide×100 mm long

Antenna radiation direction: Omni_directional (omnidirectional)

5) Gain and directionality

The directivity of the antenna refers to the electromagnetic field strength of electromagnetic waves in each direction. Gain is a collection of antenna benefits and antenna directivity.

The recommended antenna gain is less than or equal to 2.5 dBi.

6) Interference

In addition to the antenna performance, other interference on the PCB board also affect the performance of the module. To ensure the high performance of the module, the interference must be well controlled. Suggestions: For example, LCD, CPU, FPC wiring, audio circuit and power supply should be as far as

possible from the antenna, and do corresponding isolation and shielding, or filter processing on the path.

7) Antenna index requirements

Table 4-4 Antenna index requirements

L610 MiniPCIe Series Module Main Antenna Requirement	
Frequency range	The most suitable antenna must be used to adapt to the relevant frequency band
Bandwidth (GSM/GPRS)	GSM850: 70 MHz GSM900 : 80 MHz GSM1800(DCS) : 170 MHz GSM1900(PCS): 140 MHz
Bandwidth (LTE)	LTE band 1 (2100): 250 MHz LTE Band 2(1900): 140 MHz LTE Band 3(1800): 170 MHz LTE Band 4(2100): 145 MHz LTE Band 5(850): 70 MHz LTE Band 7(2500): 190 MHz LTE Band 8(900): 80 MHz LTE Band 20(800): 71 MHz LTE Band 28(800): 100 MHz LTE Band 66(2100): 470 MHz LTE Band 34 (2100): 15 MHz LTE Band 39(1900): 40 MHz LTE band 40(2300): 100 MHz LTE band 41(2500): 100 MHz
Impedance	50Ω
Input power	> 33 dBm (2 W) peak power GSM > 23 dBm average power LTE
Recommended SWR	≤ 2:1

5 Electrical Characteristics

5.1 Limit Voltage Range

The limit voltage range refers to the maximum voltage range that the module power supply voltage, digital and analog input/output interfaces can withstand. Working outside this range may cause damage to this product.

The limit voltage range of the L610 MiniPCIe series module is shown in the following table.

Table 5-1 Limit voltage range

Parameter	Description	Min	Typical	Max	Unit
VBAT	Power supply	-0.3	-	4.7	V
GPIO	Digital IO level supply voltage	-0.3	-	2.0	V

5.2 Temperature Range

The L610-CN-MiniPCIe-10 series module is recommended to work in -30℃ to +75℃ environment.

Under harsh environmental conditions, i.e, the limited operating temperature range of the module, it is recommended that the application provides temperature control measures. Under this temperature condition, some RF performance may be degraded slightly.

It is recommended to store the module under storage temperature. Outside this range, the module may not work properly or be damaged.

Table 5-2 Temperature range

Temperature	Min	Typical	Max	Unit
Operating temperature	-30	25	75	℃
Limited operating temperature	-40		85	℃
Storage temperature	-40		85	℃

5.3 Electrical Characteristics of the Interfaces in Operating State

VL: logic low level

VH: logic high level

Table 5-3 Digital interface level

Signal	VL		VH		Unit
	Min	Max	Min	Max	
Digital input	-0.3	0.6	1.2	2.0	V
Digital output	-	0.45	1.35	-	V

Table 5-4 Power interface voltage

Parameter	I/O	Min	Typical	Max	Unit
VBAT	PI	3.4	3.8	4.3	V
USIM_VDD	PO	1.7/2.75	1.8/3	1.9/2.95	V

5.4 Environmental Reliability Requirements

Table 5-5 Environmental reliability requirements

Test Item	Test Condition
Low temperature storage test	Temperature -40℃±3℃, lasting 24 hours in shutdown state
High temperature storage test	Temperature +85℃±3℃, lasting 24 hours in shutdown state
Temperature shock test	In shutdown state, lasting 0.5 hours at the temperature of -40℃ and +85℃ respectively. The temperature conversion time is less than 3 minutes, a total of 24 cycles should be completed.
High temperature and high humidity test	Temperature +85℃±3℃, humidity 90 to 95% RH, lasting 24 hours in shutdown state
Low temperature operation test	Temperature -30℃±3℃, lasting 24 hours in operating status

<table>
<tr><th>Test Item</th><th>Test Condition</th></tr>
<tr><td>High temperature operation test</td><td>Temperature +75℃±3℃, lasting 24 hours in operating status</td></tr>
<tr><td>Vibration test</td><td>Perform the vibration test according to the following requirements:
<table>
<tr><td>Frequency</td><td>Random vibration ASD (acceleration spectral density)</td></tr>
<tr><td>5 to 20 Hz</td><td>0.96m^2/s^3</td></tr>
<tr><td>20 to 500 Hz</td><td>0.96m2/s3 (at 20 Hz)，others -3 dB/octave</td></tr>
</table></td></tr>
<tr><td>Connector life test</td><td>Plug and unplug RF antenna interface cable for 30 times</td></tr>
</table>

5.5 ESD Characteristics

The L610 MiniPCIe series module is a consumer terminal product. Although the ESD problem has been considered and ESD protection has been completed in the module design, ESD problems may also occur in transportation and secondary development, so developers should consider the protection of ESD in the final product. In addition to the antistatic treatment in packaging, please refer to the recommended circuit of the interface design in the document.

For the ESD allowable discharge range of the L610 MiniPCIe series module, see the following table.

Table 5-6 ESD allowable discharge range

Test Point	Air Discharge	Contact Discharge
VBAT, GND	±10 KV	±5 KV
Antenna interface	±8 KV	±4 KV
Other interface	±1 KV	±0.5 KV

6 Structure Specifications

6.1 Product Appearance

The appearance of the L610 MiniPCIe series module is shown in figure 6-1.

Figure 6-1 Module product appearance

There are three antenna interfaces in figure 6-1. The L610 MiniPCIe series module only supports the main antenna.

6.2 Structure Dimension

The structural dimensions of the L610 MiniPCIe series module are shown in figure 6-2.

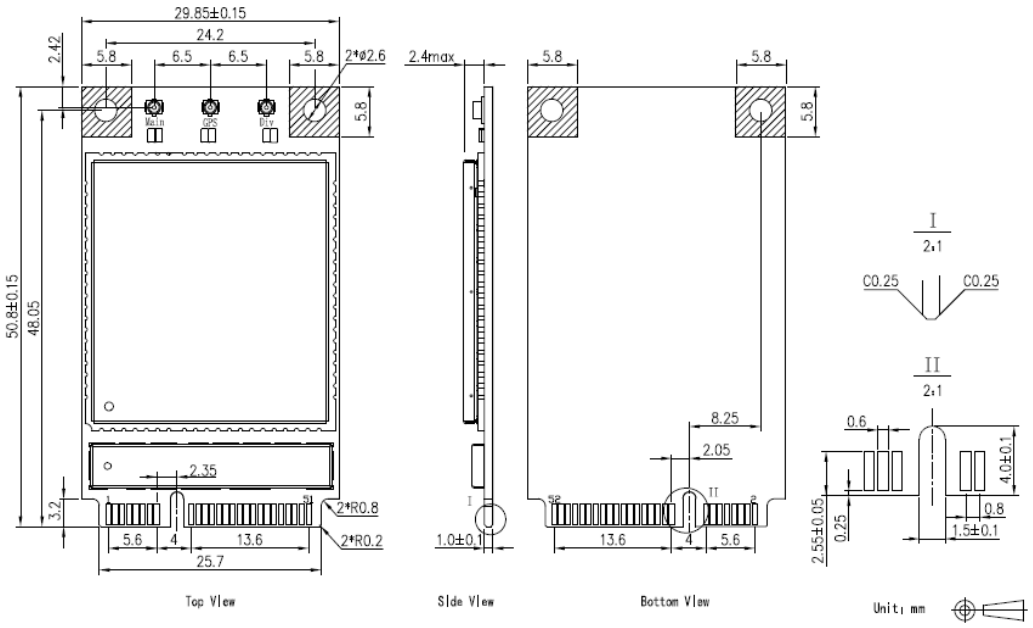

Figure 6-2 Structure dimension (unit: mm)

The user board can use Molex's Mini PCI Express connector of model 67910-0002, as shown in the following figure.

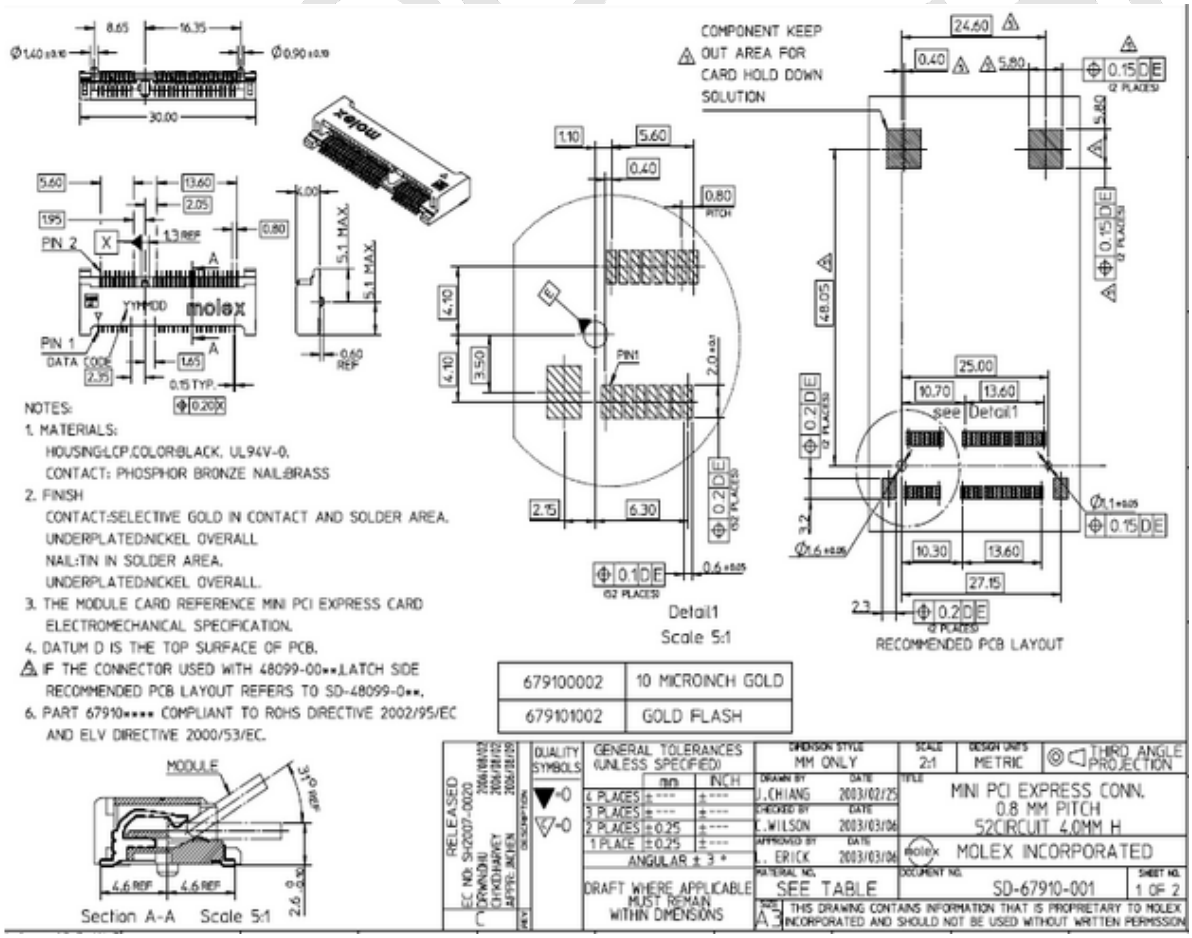

Figure 6-3 67910-0002 connector

6.3 Package

The L610 MiniPCIe series module adopts the tray sealed vacuum packaging, combined with the outer packaging method using the hard cartoon box, which can protect the storage, transportation and use of the module to the maximum extent.

Desiccant is included in the vacuum packaging bag. The module is a moisture sensitive device with a humidity sensitivity level of 3, which complies with the regulations of the American Joint Electron Device Engineering Council (JEDEC). Please avoid permanent damage due to product moisture.

The module is a precision electronic product, and may be permanently damaged if correct electrostatic protection measures are not taken.

6.3.1 Tray Packaging Process

The tray packaging process is shown in figure 6-5.

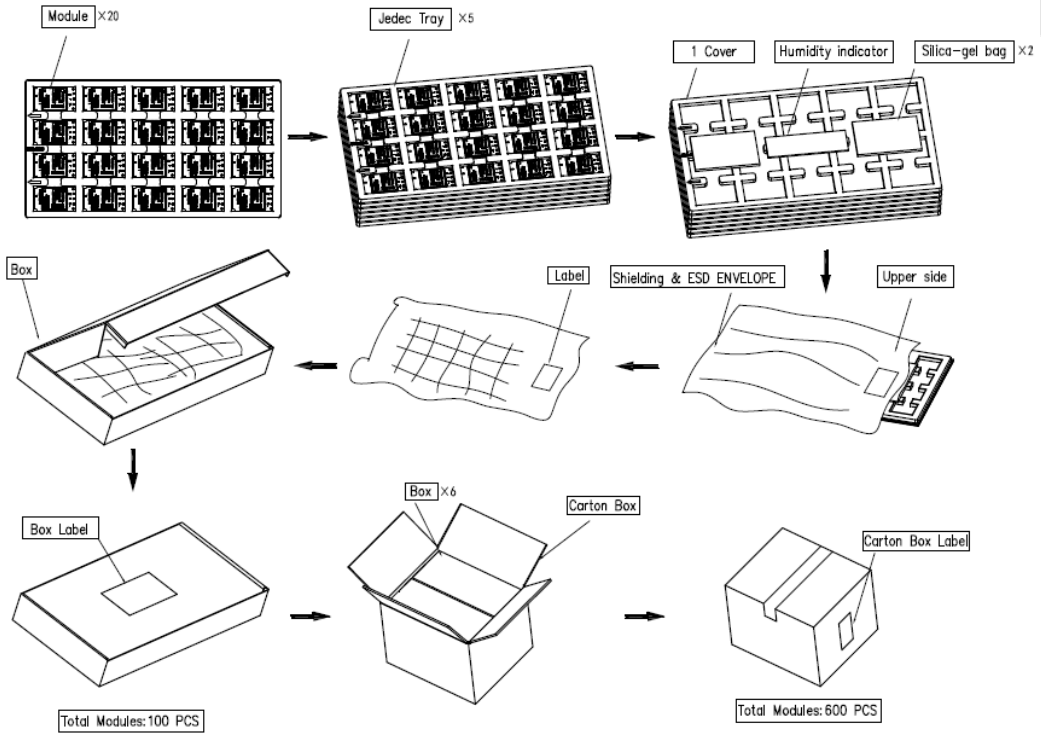

Figure 6-4 Tray packaging process

6.3.2 Tray Size

The size of the tray is 315 mm×170mm×6.5 mm. 20 pcs are packed in each tray, 5 trays are packed in each box and 6 boxes are packed in each case, as shown in figure 6-5.

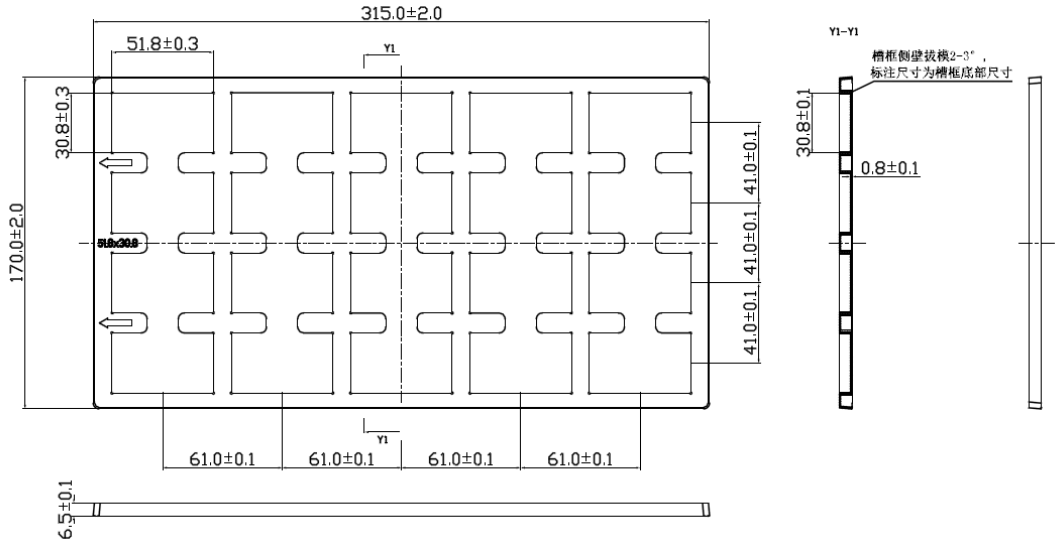

Figure 6-5 Tray size (unit: mm)

Appendix

A. Abbreviations

Abbreviation	Description
AMR	Adaptive Multi-rate
bps	Bits Per Second
CS	Coding Scheme
DRX	Discontinuous Reception
EGSM	Extended GSM900 Band
FDD	Frequency Division Duplexing
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile Communications
HSDPA	High Speed Down Link Packet Access
IMEI	International Mobile Equipment Identity
Imax	Maximum Load Current
LED	Light Emitting Diode
LSB	Least Significant Bit
LTE	Long Term Evolution
SCell	Secondary Cell for CA
ME	Mobile Equipment
MS	Mobile Station
MT	Mobile Terminated
PCB	Printed Circuit Board
PDU	Protocol Data Unit

Abbreviation	Description
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized RMS
RMS	Root Mean Square
RTC	Real Time Clock
Rx	Receive
SMS	Short Message Service
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TX	Transmitting Direction
TDD	Time Division Duplexing
UART	Universal Asynchronous Receiver & Transmitter
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identity Module
USSD	Unstructured Supplementary Service Data
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
VIHmax	Maximum Input High Level Voltage Value
VIHmin	Minimum Input High Level Voltage Value

Abbreviation	Description
VILmax	Maximum Input Low Level Voltage Value
VILmin	Minimum Input Low Level Voltage Value
VImax	Absolute Maximum Input Voltage Value
VImin	Absolute Minimum Input Voltage Value
VOHmax	Maximum Output High Level Voltage Value
VOHmin	Minimum Output High Level Voltage Value
VOLmax	Maximum Output Low Level Voltage Value
VOLmin	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access