Lierda NR90-HCN Mini PCIe-A module

Hardware Design Manual

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Revision History of the Document

Document Version	Change date	Reviser	Reviewer	Change content
Rev1.0	23-11-21	PK	YY，XL	Initial version
Rev1.1	24-01-29	PK	YY，XL	Update power consumption data.
Rev1.2	24-11-21	PK	YY，XL	Delete information about PC2 related to N41/N77/N78.
Rev1.3	25-04-25	PK	YY，XL	Standardization and optimization of documents

Safety Instructions

Users are responsible for following the relevant regulations of other countries regarding wireless communication modules and devices, as well as specific environmental regulations for use. By adhering to the following safety principles, personal safety can be ensured and help protect products and work environments from potential damage. Our company is not liable for any losses resulting from customers' failure to comply with these regulations.

	Safety first on the road! Please do not use handheld mobile devices while driving unless they have a hands-free function. Please pull over before making a call!
	Please turn off your mobile devices before boarding. The wireless function of mobile devices is prohibited from being turned on during the flight to prevent interference with the aircraft communication system. Ignoring this prompt may jeopardize flight safety and even violate the law.
	When in a hospital or healthcare facility, pay attention to whether there are restrictions on the use of mobile terminal devices. RF interference can cause medical equipment to malfunction, so it may be necessary to turn off mobile terminal devices.
	Mobile terminal devices do not guarantee effective connection in all situations, such as when there is no mobile phone balance or the SIM card is invalid. In case of emergency situations when you encounter the above conditions, remember to use emergency calls, and ensure that your device is powered on and in an area with sufficient signal strength.
	Your mobile terminal device will receive and emit radio frequency signals when starting up, causing radio frequency interference when approaching a TV, radio, computer, or other electronic devices.
	Please keep mobile terminal devices away from flammable gases. When you are near gas stations, oil depots, chemical plants, or explosive operation sites, please turn off mobile terminal devices. Operating electronic devices in any potentially explosive hazardous area poses a safety risk.

Module selection for application.

Serial number	Module model	Feature symbol	Support frequency band	Dimensions (mm)	Module introduction
1	NR90-HCN Mini PCIe-A		WCDMA/LTE/NR	30 x 51x 3.5mm	5G Redcap module

Content

1 Introduction

This document defines the hardware application specifications of the Lierda Group's NR90-HCN Mini PCIe-A 5G Redcap module, describing its hardware interfaces, electrical characteristics, application methods, and mechanical specifications.

This document can help users quickly understand the hardware interface specifications, electrical, mechanical characteristics, and other related information of the module. Combined with other relevant documents, users can quickly master the application methods of the module.

2 Product Overview

Lierda NR90-HCN Mini PCIe-A 5G Redcap module is based on 3GPP Release 17 technology, supports 5G Standalone (SA) mode, is compatible with 4G network standards, meets the frequency band requirements of the four major domestic operators, covers some overseas regional frequency bands, and supports 1.8GHz industrial private networks.

The NR90-HCN Mini PCIe-A module uses the PCI Express Mini Card 1.2 standard interface, with dimensions of 30*51*3.5mm, making it easy to install.

The NR90-HCN Mini PCIe-A module is compatible with various types of operating systems (Android, Linux, Windows, etc.), supports multiple drivers and network protocols, and can provide voice functions to meet different application scenarios.

Lierda NR90-HCN Mini PCIe-A module is designed for 5G RedCap applications with high reliability, low latency, and low power consumption. With a smaller size, lower power consumption, and fewer antennas, the NR90-HCN Mini PCIe-A module will better support the rapid commercialization of RedCap technology.

2.1 Frequency bands and functions

The frequency bands supported by the NR90-HCN Mini PCIe-A module are as shown in the table below:

Table 2-1 Description of supported frequency bands

Frequency band	Launch	Receive
WCDMA Band 1	1920MHz-1980MHz	2110MHz-2170MHz
WCDMA Band 5	824MHz-849MHz	869MHz-894MHz
WCDMA Band 8	880MHz-915MHz	925MHz-960MHz
FDD LTE Band 1	1920MHz-1980MHz	2110MHz-2170MHz
FDD LTE Band 3	1710MHz-1785MHz	1805MHz-1880MHz
FDD LTE Band 5	824MHz-849MHz	869MHz-894MHz
FDD LTE Band 8	880MHz-915MHz	925MHz-960MHz
TDD LTE Band 34	2010MHz-2025MHz	2010MHz-2025MHz

Frequency band	Launch	Receive
TDD LTE Band 38	2570MHz-2620MHz	2570MHz-2620MHz
TDD LTE Band 39	1880MHz-1920MHz	1880MHz-1920MHz
TDD LTE Band 40	2300MHz-2400MHz	2300MHz-2400MHz
TDD LTE Band 41	2496MHz-2690MHz	2496MHz-2690MHz
NR n1	1920MHz-1980MHz	2110MHz-2170MHz
NR n3	1710MHz-1785MHz	1805MHz-1880MHz
NR n5	824MHz-849MHz	869MHz-894MHz
NR n8	880MHz-915MHz	925MHz-960MHz
NR n28	703MHz-748MHz	758MHz-803MHz
NR n41	2496MHz-2690MHz	2496MHz-2690MHz
NR n78	3300MHz-3800MHz	3300MHz-3800MHz
NR n79	4400MHz-5000MHz	4400MHz-5000MHz

The NR90-HCN Mini PCIe-A module can be applied in the following terminal scenarios:

- Intelligent Industry
- Energy and power
- Video surveillance
- Mobile broadband
- Vehicle networking
- Smart wearable

2.2 Key Features

The following table shows the main features of the NR90-HCN Mini PCIe-A module.

Table 2-2 Main Characteristics of the Module

Type	Describe
Encapsulation	Adopt PCI Express Mini Card 1.2 standard interface
Physical properties	Dimensions: 30 x 51 x 3.5mm Weight: TBD
Working frequency	5G SA: n1/n3*/n5*/n8/n28/n41 (all bands)/n78/n79

Type	Describe
band	LTE FDD：B1/B3/B5/B8 LTE TDD: B34/B38/B39/B40/B41 (all bands) LTE 1.8G private network: B59/B62 WCDMA：B1/B5/B8
Transmission rate (theoretical value)	SA DL：220Mbps；UL：110Mbps LTE DL：192Mbps；UL：98Mbps WCDMA DL：384kbps；UL：384kbps
Power level	WCDMA：Class 3 LTE：Class 3 LTE B41：Class 2 5G NR n1/n3*/n5*/n8/n28/n41：Class 3 5G NR n78/n79：Class 3 5G NR n41/n78/n79 HPUE：Class 2
WCDMA characteristics	Support 3GPP FDD R6 protocol version. Maximum transmission rate (theoretical value): WCDMA: 384kbps (downlink speed) / up to 384kbps (uplink speed)
LTE features	Support 3GPP R13 protocol version. Support LTE FDD/TDD Support CAT4 Support 1.4/3/5/10/15/20 MHz RF bandwidth. Support uplink QPSK, 16QAM, 64QAM, 256QAM modulation modes. Support QPSK, 16QAM, 64QAM, 256QAM modulation schemes. Support downlink 2×2 MIMO. Maximum transmission rate (theoretical value): LTE: 192 Mbps (downlink speed) / 98 Mbps (uplink speed)
5G NR features	Support 3GPP R17 protocol version. Support uplink 256QAM modulation mode and downlink 256QAM modulation mode. n1/n3*/n5*/n8/n28/n41/n78/n79 support downlink 2×2 MIMO Support SCS 15kHz and 30kHz. Support SA working mode Support Option 3x, 3a, 3, and Option 2. Maximum transmission rate (theoretical value, related to network configuration and heat dissipation environment): SA: 220Mbps (downlink speed) / 110Mbps (uplink speed)
Operating voltage range	DC 3.3V ~ 4.4V (typical value 3.8V)
Application	Operating temperature: -30 ~ +75℃

Type	Describe
temperature range	Operating Temperature: -40 ~ +85°C Storage temperature: -40 ~ +90°C
USB interface	USB2.0 (High Speed) interface, with a maximum speed of 480Mbps.
UART interface	UART1
(U)SIM interface	1 Standard SIM Interface (Class B and Class C)
Time synchronization interface	B-Code*1；1PPS*1
Control interface	W_DISABLE# WAKEUP_IN RESET# WAKEUP_OUT
Antenna interface	ANT*2
Network Protocol	PPP/RNDIS/ECM TCP/IP MQTT
Drive	Linux 2.6-5.15 Windows 7/8/8.1/10 Andriod 4.x-12.x
AT command	Support AT commands compliant with 3GPP standards; Refer to the detailed design document of AT command for NR90-HCN.
FOTA	Support
OneNET	Support
Authentication	CCC/SRRC/NAL/Operator Certification* (Telecom/Unicom/Mobile)

Note

Under development, N3/N5* indicates N3/N5 certification in progress.

2.3 Function Block Diagram

The diagram below introduces the main functions of the NR90-HCN Mini PCIe-A module: power management, baseband section, memory, RF function blocks, peripheral interfaces.

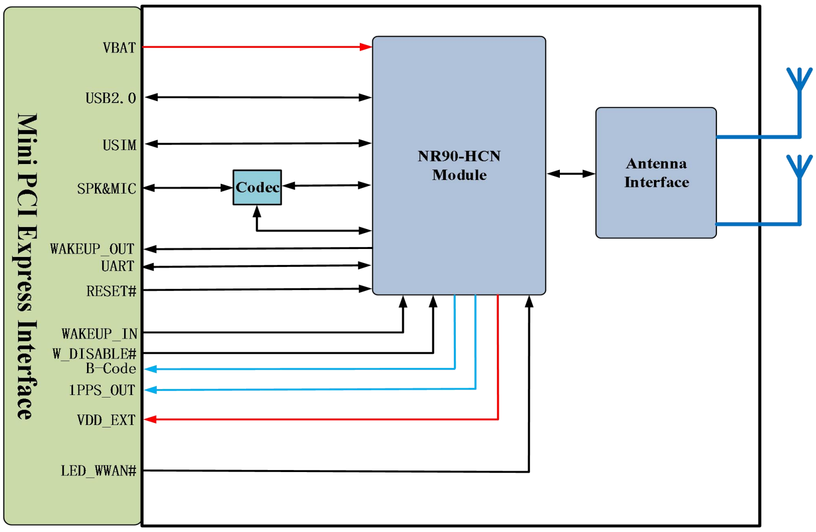


Figure 2.1 Hardware Diagram of NR90-HCN Mini PCIe-A Module

2.4 Pinout diagram

The following is the pin assignment diagram for the NR90-HCN Mini PCIe-A interface.

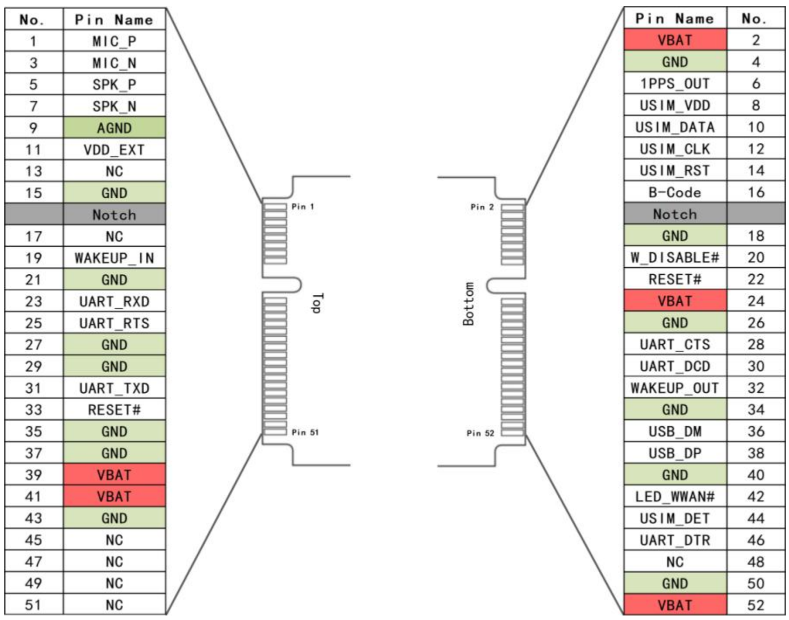


Figure 2.2 Module Pinout Diagram

2.5 Pin Description Table

Table 2-3 I/O Type Definitions

Type	Description
PI	Power input signal
PO	Power output signal

Type	Description
DI	Digital input signal
DO	Digital output signal
AI	Simulated input signal
AO	Simulated output signal
DIO	Bidirectional digital input and output signal
OD	Leakage opens the way.
VIL	Low-level input voltage
VIH	High-level input voltage
VOL	Low-level output voltage
VOH	High-level output voltage

Table 2-4 Pin Definitions

Pin number	Pin names	Type	Describe	Note
1	MIC_P	AI	Microphone input channel (+)	If not used, leave floating
2	VBAT	PI	Module main power supply	3.3-4.4V power supply input, typical value 3.8V
3	MIC_N	AI	Microphone input channel (-)	If not used, leave floating
4	GND	G	GND	
5	SPK_P	AO	Simulated audio differential output channel (+)	If not used, leave floating
6	1PPS_OUT	DO	1PPS output, timing function	If not used, leave floating
7	SPK_N	AO	Simulated audio differential output channel (-)	If not used, leave floating
8	USIM_VDD	PO	(U)SIM card power signal	1.8V/3V adaptive
9	AGND	G	Simulated GND	
10	USIM_DATA	DIO	(U)SIM card data signal	If not used, leave floating
11	VDD_EXT	PO	Output 1.8V power supply externally.	1.8V output, 50mA Max
12	USIM_CLK	DO	(U)SIM card clock signal	If not used, leave floating
13	NC			
14	USIM_RS	DO	(U)SIM card reset signal	If not used, leave floating

Pin number	Pin names	Type	Describe	Note
	T			
15	GND	G	GND	If not used, leave floating
16	B-Code	DO	B code output, high-precision time synchronization	If not used, leave floating
17	NC			
18	GND	G	GND	
19	WAKEUP_IN	DI	Wake up the module.	1.8V voltage domain
20	W_DISABLE#	DI	Flight mode control	Low level effective
21	GND	G	GND	
22	RESET#	DI	Module reset	Low level valid
23	UART_RXD	DI	Main serial port receiving	If not used, leave floating
24	VBAT	PI	Module main power supply	3.3-4.4V power supply input, typical value 3.8V
25	UART_RTS	DI	DTE requests to send data	If not used, leave floating
26	GND	G	GND	
27	GND	G	GND	
28	UART_CTS	DO	Module clear sent	If not used, leave floating
29	GND	G	GND	
30	UART_DCD	DO	Module output carrier detection	If not used, leave floating
31	UART_TXD	DO	Main serial port transmission	If not used, leave floating
32	WAKEUP_OUT	DO	Module wakes up the host, low effective	If not used, leave floating
33	RESET#	DI	Module reset	Low level effective
34	GND	G	GND	
35	GND	G	GND	
36	USB_DM	AIO	USB 2.0 differential data (-)	If not used, leave floating
37	GND	G	GND	
38	USB_DP	AIO	USB 2.0 differential data (+)	If not used, leave floating

Pin number	Pin names	Type	Describe	Note
39	VBAT	PI	Module main power supply	3.3-4.4V power supply input, typical value is 3.8V
40	GND	G	GND	
41	VBAT	PI	Module main power supply	3.3-4.4V power supply input, typical value 3.8V
42	LED_WWAN#	OD	Module status indicator LED	Maximum sink current 20mA
43	GND	G	GND	
44	USIM_DET	DI	(U)SIM card detection	If not used, leave floating
45	NC			
46	UART_DTR	DI	Serial port terminal data ready	1.8V voltage domain
47	NC			
48	NC			
49	NC			
50	GND	G	GND	
51	NC			
52	VBAT	PI	Module main power supply	3.3-4.4V power supply input, typical value 3.8V

3 Working characteristics

3.1 Working mode

Table 3-1 Module Operating Modes Description

Working mode	Function	
Normal working mode	IDLE	The software is running normally. The module is registered on the network and can receive and send data.
	Talk /Data	The network connection is working properly. In this mode, the module power consumption depends on the network settings and data transmission rate.
Minimum Function Mode	When the power is uninterrupted, using AT+CFUN=0 can set the module to the minimum functionality mode. In this mode, the RF does not work.	
Airplane mode	AT+CFUN=4 or pulling down the W_DISABLE# pin can set the module to flight mode. In this mode, the RF does not work.	
Sleep mode	In this mode, the module's power consumption will be reduced to a very low level, but the module can still receive paging, SMS, calls, and TCP/UDP data.	

3.2 Hibernate mode

In sleep mode, the DRX function of the module can reduce the power consumption of the module and broadcast the DRX index cycle value through the wireless network. The following figure shows the relationship between DRX operating time and the current consumption in sleep mode of the module. The longer the DRX cycle, the lower the power consumption.

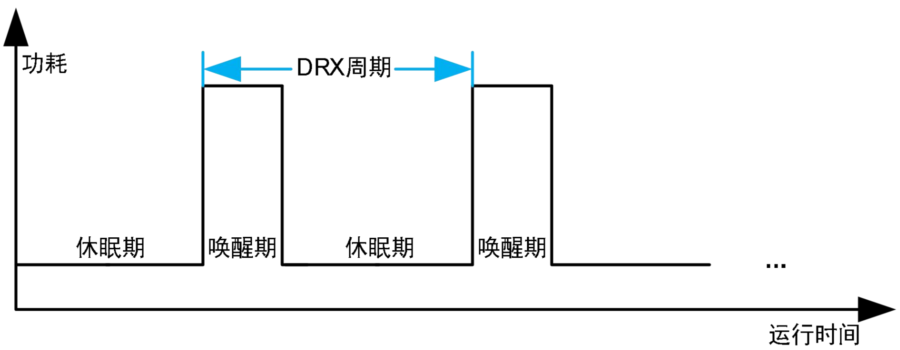


Figure 3.1 Relationship between DRX operation time and power consumption in sleep mode

The process of entering and exiting sleep mode for the NR90-HCN Mini PCIe-A module is as follows:

- When the module is in the wake-up state, the host pulls down the WAKEUP_IN pin through a GPIO, and this GPIO can remain at a low level during sleep.
- When the module is in sleep mode, the host pulls up the WAKEUP_IN pin through a GPIO, and this GPIO can remain at a high level in the wake-up state.

The reference design of the WAKEUP_IN interface is as follows.

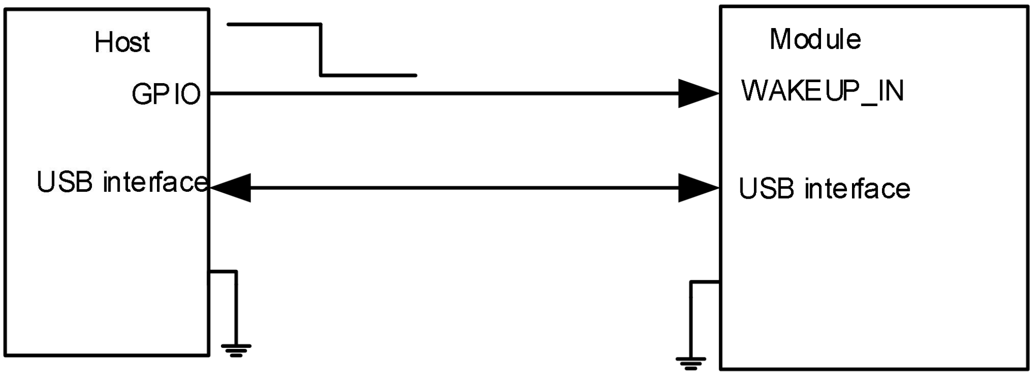


Figure 3.2 WAKEUP_IN Interface Reference Design Circuit

The host can pull up WAKEUP_IN through a GPIO to wake the module up from sleep mode.

3.3 Power supply design

Table 3-2 Power Supply Pin Definitions

Pin number	Type	Pin Names	Description	Minimum value	Typical value	Maximum value	Unit
2，24，39，41，52	PI	VBAT	Module main power supply	3.3	3.8	4.4	V
4，9，15，18，21，26，27，29，34，35，37，40，43，50	G	GND	GND				

To ensure the normal operation of the NR90-HCN Mini PCIe-A module, the system power supply VBAT needs to be maintained within the range of 3.3V-4.4V (typical value 3.8V). When the module is used with different external devices, attention should be paid to the power supply design of the module. In any case, it is necessary to ensure that the module power supply voltage is above 3.3V, otherwise the module will not work properly.

External power supply LDO or DCDC selection recommendations for devices that can provide a current of 3A or more, and at least 2 220uF energy storage capacitors are connected in parallel on VBAT. In addition, to reduce the impact of PCB traces on the power supply voltage, VBAT traces should be kept as short and wide as possible, with a width of no less than 2mm. To improve the stability of the power supply, it is recommended to add a voltage regulator diode near the VBAT pin of the module with a power dissipation greater than 0.5W and a reverse voltage of 5.1V. The reference circuit is shown in the diagram below.

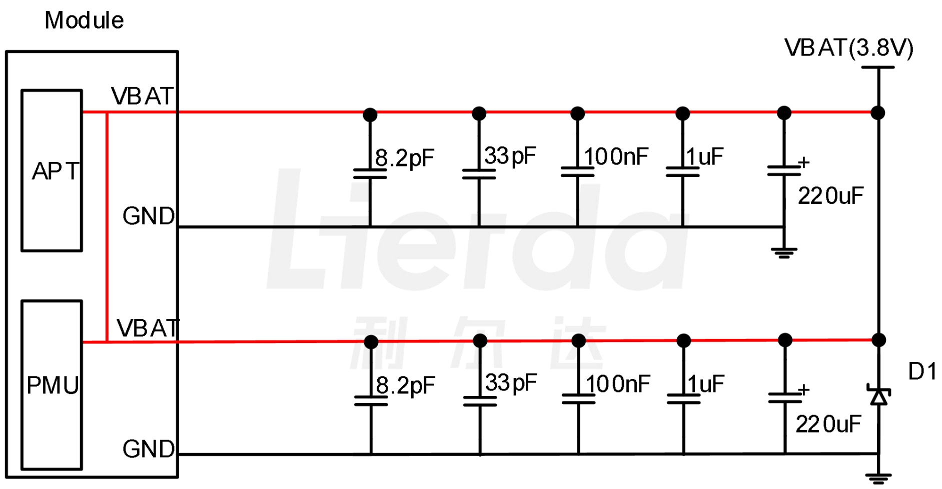


Figure 3.3 Power Supply Recommended Design

3.4 Reset

The NR90-HCN Mini PCIe-A module can be reset by using the RESET# pin.

Table 3-3 RESET# Interface Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
22，33	RESET#	DI	Module reset	VIH	1.17	1.8	1.98	
				VIL	-0.3	1.8	0.63	

When the module software stops responding, pull down the RESET# pin for 100ms or longer. The RESET# signal is sensitive to interference, so it is recommended to keep the traces on the module interface board as short as possible and ground them.

Customers can use an open-drain drive circuit or a button to control the RESET# pin, refer to the circuit as shown in the diagram below.

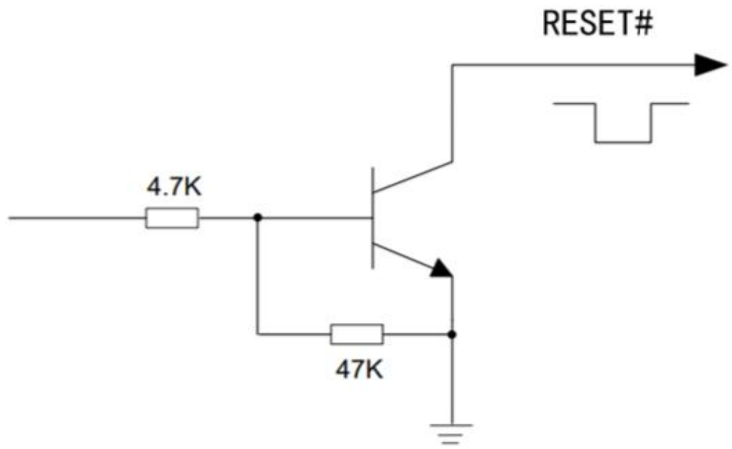


Figure 3.4 Open-Drain Driven Reset Reference Circuit

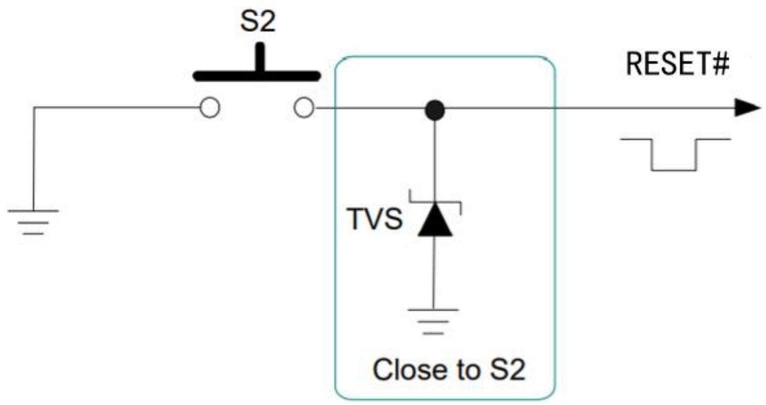


Figure 3.5 Key Reset Reference Circuit

The timing diagram for reset is as follows:

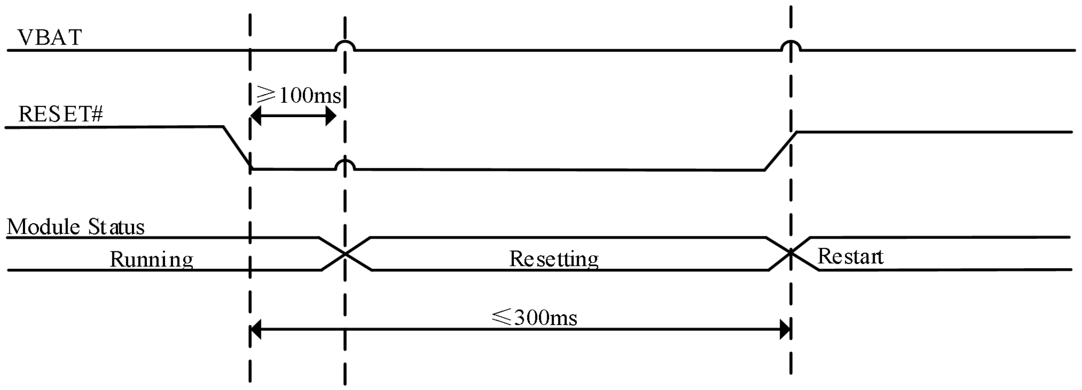


Figure 3.6 RESET# Timing Diagram

Note

- Ensure that the RESET# pin has a maximum capacitive load of no more than 47pF.
- RESET# is for hard reset.

4 Application interface

The physical interface and electrical characteristics of the NR90-HCN Mini PCIe-A module comply with the Mini PCI Express interface. This chapter mainly introduces the definition of the interface and its related applications.

- Simulated audio interface
- UART interface
- USB interface
- (U)SIM interface
- Control and status indicator interface
- Time synchronization interface
- Antenna interface

4.1 Simulated audio interface

The NR90-HCN Mini PCIe-A module has one analog audio input and one analog audio output channel.

Table 4-1 Description of Analog Audio Interface Pins

Pin number	Pin names	Type	Description	Note
1	MIC_P	AI	Microphone Input Channel (+)	If not used, leave floating
3	MIC_N	AI	Microphone input channel (-)	If not used, leave floating
5	SPK_P	AO	Simulated audio differential output channel (+)	If not used, leave floating
7	SPK_N	AO	Simulated audio differential output channel (-)	If not used, leave floating
9	AGND	G	Simulated GND	If not used, leave floating

MIC_P and MIC_N channels are differential inputs used for microphone input. Microphones typically use electret microphones. SPK_P and SPK_N channels are differential outputs used for earpiece or speaker, an external audio amplifier is required for connecting the speaker.

It is recommended to use built-in RF filtering dual capacitors (10pF and 33pF) electret condenser microphones to filter out RF interference from the source, which will greatly improve coupling noise.

To reduce interference from wireless or other signals, the RF antenna should be kept away from the audio interface and audio wiring. Power lines should not run parallel to audio wiring, and should also be kept away from audio wiring. Audio wiring must follow the rules of differential signal layout.

The microphone channel circuit reference diagram is as follows:

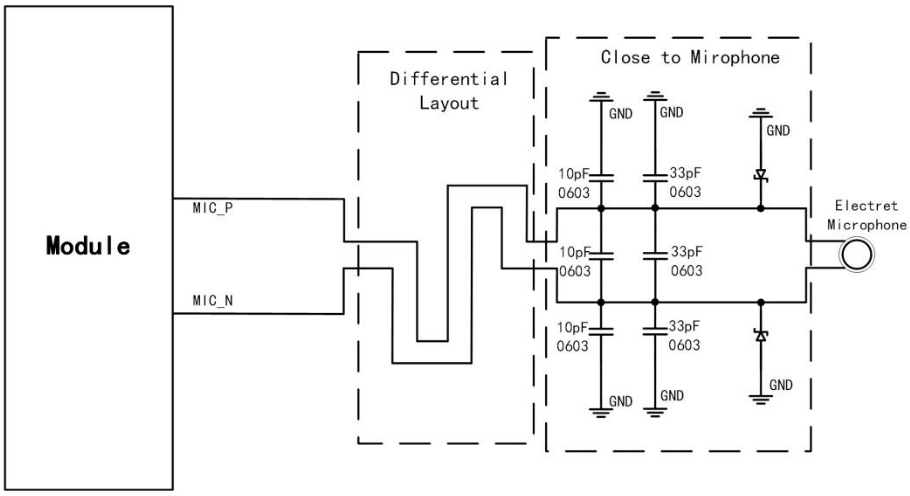


Figure 4.1 Reference Diagram of Microphone Channel Circuit

The receiver output channel circuit reference diagram is as follows:

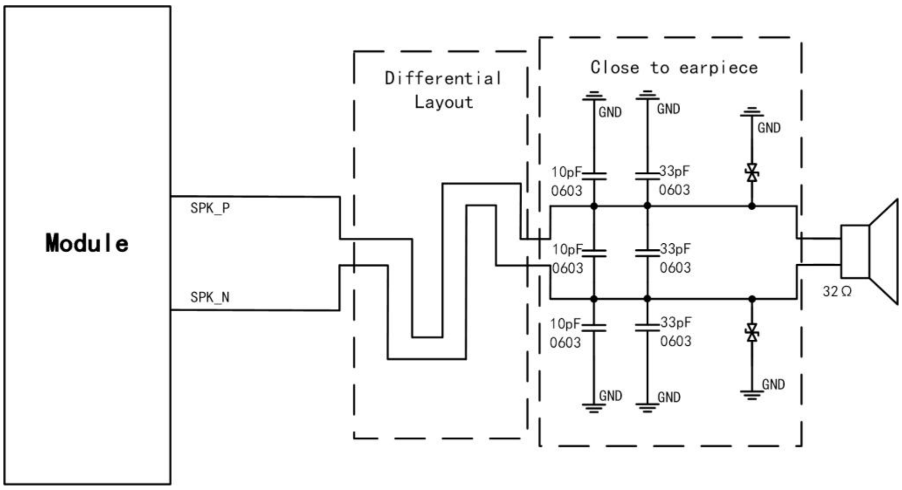


Figure 4.2 Reference Diagram of the Handset Output Channel Circuit

The speaker output channel circuit reference diagram is as follows:

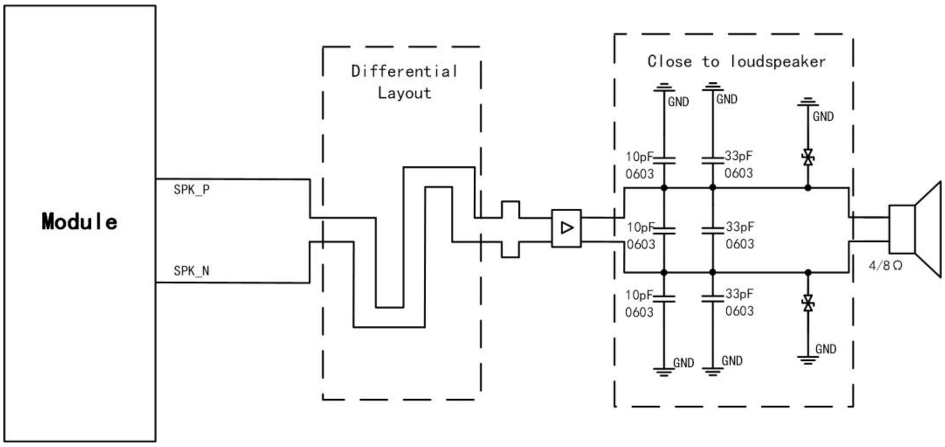


Figure 4.3 Speaker Output Channel Circuit

4.2 UART interface

The NR90-HCN Mini PCIe-A module has one serial port, which can be used for AT command sending and data transmission, with a default baud rate of 115200bps.

Table 4-2 UART Interface Pin Description

Pin numb	Pin name	Type	Description	Parameter	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
23	UART_RXD	DI	Main serial port reception	VIH	1.17	1.8	1.98	If not used, leave floating
				VIL	-0.3	-	0.63	
31	UART_TXD	DO	Main serial port transmission	VOH	1.35	1.8	1.98	If not used, leave floating
				VOL	-0.3	-	0.45	
28	UART_CTS	DI	DCE clear to send	VIH	1.17	1.8	1.98	If not used, leave floating
				VIL	-0.3	-	0.63	
25	UART_RTS	DO	DCE request sent	VOH	1.35	1.8	1.98	If not used, leave floating
				VOL	-0.3	-	0.45	
46	UART_DTR	DI	Serial port terminal data ready	VIH	1.17	1.8	1.98	If not used, leave floating
				VIL	-0.3	-	0.63	
30	UART_DCD	DO	Serial port output carrier detection	VOH	1.35	1.8	1.98	If not used, leave floating
				VOL	-0.3	-	0.45	

4.2.1 Serial port interface reference circuit

The serial port reference circuit is as shown in the following diagram:

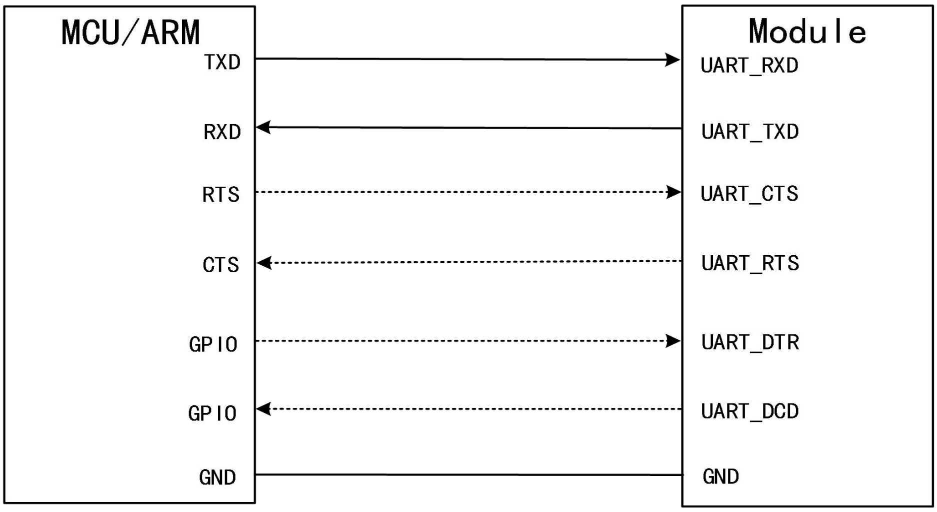


Figure 4.4 Serial Port Reference Circuit

4.2.2 Voltage level conversion reference circuit

Please pay attention to the consistency of the voltage levels when using the serial port interface.

(1) The reference circuit for transistor level conversion is as shown in the following figure.

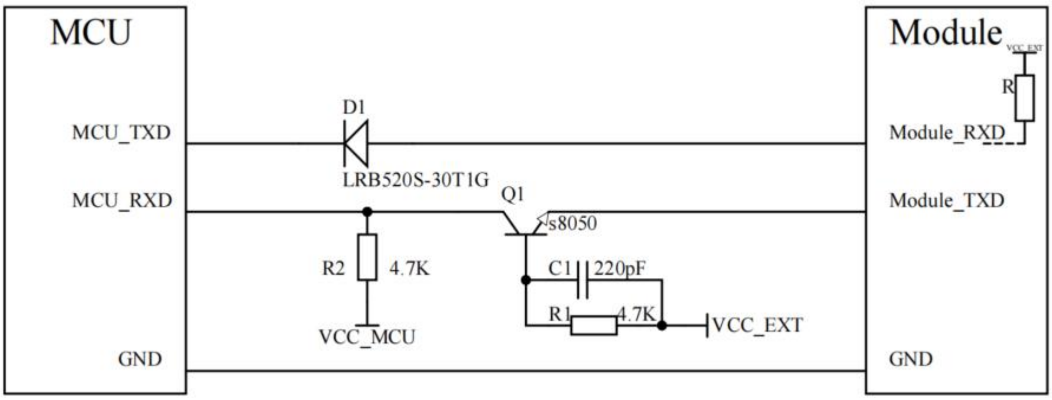


Figure 4.5 Transistor Level Conversion Reference Circuit

This circuit does not have special requirements for the power supply voltage of the module, and it has low cost, but there are restrictions on the serial port baud rate. The reference design is as follows, also pay attention to the direction of level conversion.

Note

- In this circuit, MCU_TXD defaults to outputting 3.3V, and VCC_EXT defaults to

1.8V. For the diode conversion circuit, it should be noted that the cathode voltage of the diode needs to be higher than the anode voltage in order to achieve the function of the circuit mentioned above.

- This level conversion circuit is not suitable for applications with a baud rate exceeding 460Kbps.

(2) MOSFET level conversion reference circuit

This circuit does not have special requirements for the power supply voltage of the module, and it is low cost, able to meet the requirement of serial port baud rate 921600bps. The reference design is as follows, pay attention to the direction of level conversion.

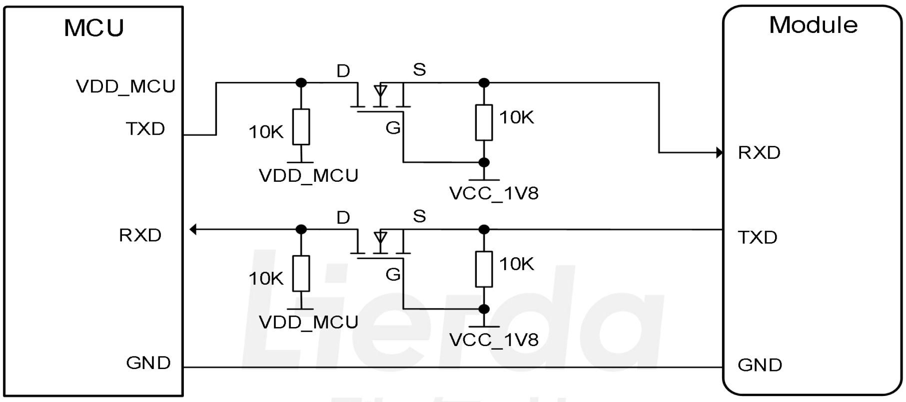


Figure 4.6 Reference Circuit for MOSFET Level Conversion

Recommend MOSFET for reference:

Brand: LRC; Specification Model: L2N7002LT1G, and its corresponding internal principle is as follows:

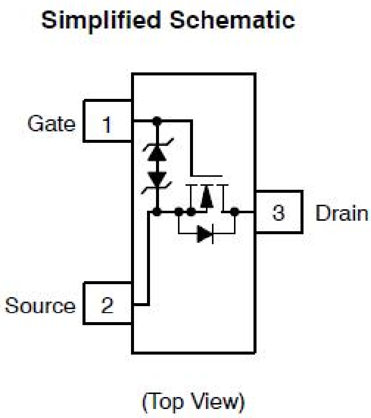


Figure 4.7 MOSFET device diagram

4.3 USB interface

The NR90-HCN Mini PCIe-A module complies with the USB2.0 specification. When acting as a host, it supports HS (480Mbps)/FS (12Mbps)/LS (1.5Mbps), and when acting as a device, it supports HS (480Mbps)/FS (12Mbps). The USB interface can be used for AT command transmission, data transfer, software debugging, and firmware upgrades. The table below shows the pin definitions of the USB interface.

Table 4-3 USB Interface Pin Description

Pin number	Pin names	Category	Description	Note
38	USB_DP	AIO	USB 2.0 differential data (+)	90Ω differential impedance
36	USB_DM	AIO	USB 2.0 differential data (-)	

It is recommended that customers retain the USB 2.0 interface for firmware upgrades while also reserving test points in the design circuit as shown below:

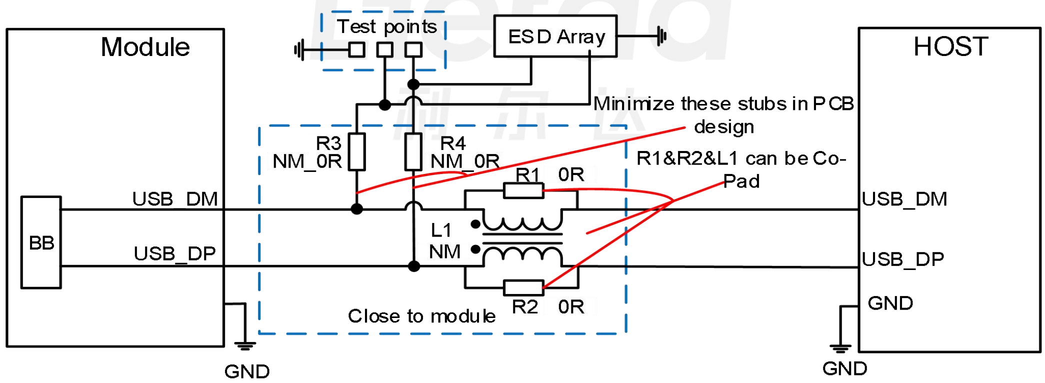


Figure 4.8 USB Reference Design

Note

- It is recommended to connect a common mode inductance L1 between the host and the module to prevent USB signal from generating EMI interference. Alternatively, a 0Ω resistor can be used for direct connection, designed with a common solder pad with L1. Depending on the debugging situation, either a common mode inductance or a resistor can be used. Additionally, it is suggested to connect resistors R3 and R4 to test points for debugging purposes, with resistors not populated by default. To meet the requirements for

USB data line signal integrity, L1, R1, R2, R3, and R4 need to be placed close to the module, with R3 and R4 placed close together. The routing of the lines connecting the test points should be kept as short as possible.

- In the circuit design of the USB interface, to ensure the performance of USB, the following principles are recommended to be followed in the circuit design: USB signal lines need to be surrounded by GND, with 90Ω differential impedance lines. Avoid running USB lines under crystal oscillators, oscillators, magnetic devices, DC-DC power inductors, and RF signals. It is recommended to use inner layer differential lines, and surround them with GND on all sides. When selecting ESD protection devices for USB data lines, pay attention to ensure that the parasitic capacitance of USB 2.0 does not exceed 1pF, place them as close as possible to the USB interface, and make sure the signal passes through the ESD protection device first.

4.4 (U)SIM card interface

(U)The SIM card interface complies with ETSI and IMT-2000 card specifications, supporting 1.8V and 3.0V (U)SIM cards, and supporting single card single standby function. The table below introduces the interface definition of (U)SIM.

Table 4-4 (U)SIM Card Interface Definition

Pin number	Pin name	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
14	USIM_RST	DO	(Re)SIM card reset	VOH	1.4/2.25	1.8/3.0	2.0/3.3	If not used, leave floating
				VOL	-	-	0.45/0.375	
12	USIM_CLK	DO	(U)SIM card clock	VOH	1.4/2.25	1.8/3.0	2.0/3.3	If not used, leave floating
				VOL	-	-	0.45/0.375	
10	USIM_DATA	DIO	(U)SIM card data	VIH	1.27/1.875	1.8/3.0	1.98/3.3	If not used, leave floating
				VIL	-0.3	-	0.58/0.75	
				VOH	1.4/2.25	1.8/3.0	2.0/3.3	
				VOL	-	-	0.45/0.375	

8	USIM_VDD	PO	(U)SIM card power	-	1.62	1.8/3.0	3.3	If not used, leave floating
44	USIM_DET	DI	(U)SIM card detection	VIH	1.17	1.8	1.98	Pay attention to logical insertion, software and hardware
				VIL	-0.3	-	0.63	

The schematic diagram of the (U)SIM interface circuit design is as follows:

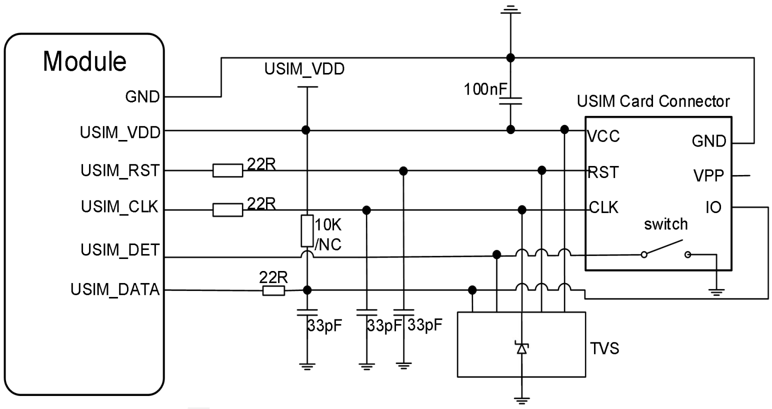


Figure 4.9 8-pin (U)SIM Interface Reference Circuit Diagram

The principle of the SIM card slot with detection signal is as follows (when designing the principle, pay attention to the logic of card insertion). Taking the model MUP-C792 card slot connector as an example, the specification sheet describes the Detect Switch as follows,

ELECTRIC FUNCTION	DETECT SWITCH
WITHOUT CARD	CLOSED
CARD INSERTED	OPEN

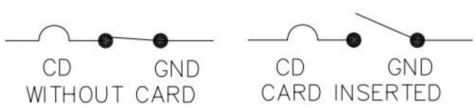


Figure 4.10 SIM card connector Detect Switch operation block diagram

Therefore:

- When the SIM card is inserted, USIM_DET is at a high level.
- When the SIM card is removed, USIM_DET is at a low level.

If the USIM card detection function is not required, please leave the USIM_DET pin floating. The following is the 6-pin USIM interface reference circuit:

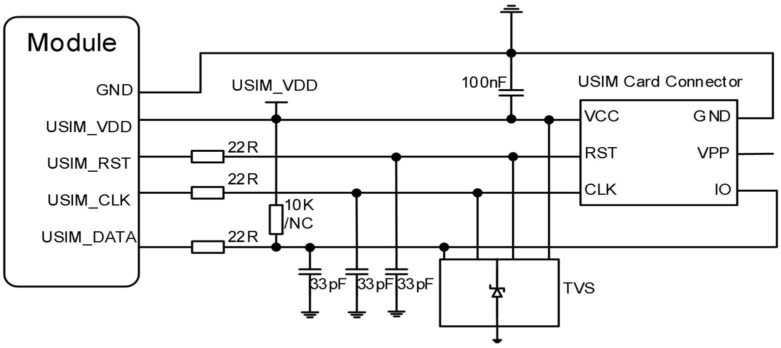


Figure 4.11 6-pin (U)SIM interface reference circuit diagram

4.4.1 (U)SIM hot swap

NR90-HCN Mini PCIe-A module supports (U)SIM card hot plug function, which determines the insertion and removal of (U)SIM card by detecting the USIM_DET pin status of the (U)SIM card slot, thus supporting (U)SIM card hot plug function. The (U)SIM card hot plug function can be configured using the AT+LSIMDET command.

Table 4-5 USIM_DET Control Voltage Description

AT format	AT command	SIM card hot plug detection	Function Description
Read Command AT+QSIMSTAT? Write Command AT+QSIMSTAT=<enable>,<insert_level>	AT+LSIMDET=1,0	Start	(USIM) SIM card hot plug detection function is enabled, the module detects whether the (USIM) SIM card is inserted through the USIM_DET pin status detection, low level detection.
	AT+LSIMDET=1,1	Start	The hot-plug detection function of the (U)SIM card is enabled, and the module detects whether the (U)SIM card is inserted through the USIM_DET pin status detection, with high-level detection.
	AT+LSIMDET=0,0 AT+LSIMDET=0,1	Close	SIM card hot plug detection function disabled, module reads (U)SIM card at power on, does not check USIM_DET status

Note

- The hot plug function of the (U)SIM card on the NR90-HCN Mini PCIe-A module is disabled by default.
- If hot swap is enabled, the <insert_level> value must match the insertion level designed in the hardware, otherwise the hot swap function will be invalid.
- If a (U)SIM card has been successfully detected, the command to control (U)SIM card detection function is no longer supported. The command can only be used to control (U)SIM card detection function after module restart or hot swapping (U)SIM card.

4.4.2 Requirements for (U)SIM card interface design

In the circuit design of the (U)SIM card interface, in order to ensure the good functional performance of the (U)SIM card and prevent damage, the following design principles are recommended to be followed in the circuit design:

- The distance between the (U)SIM card slot and the module holder should not be too far, the closer the better, try to ensure that the (U)SIM card signal line layout does not exceed 200mm.
- (U)SIM card signal line routing should be kept away from RF lines and VBAT power lines.
- To prevent possible crosstalk from the USIM_CLK signal to the USIM_DATA signal, they should not be wired too close together. Ground shielding should be added between the two traces, and ground protection is also required for the USIM_RST signal.
- To ensure good ESD protection, it is recommended to add TVS diodes placed near the (U)SIM card holder. The parasitic capacitance of the selected ESD device should not exceed 10pF. A 0-ohm resistor can also be placed in series between the module and the (U)SIM card for debugging purposes. 33pF capacitors can be connected in parallel on the USIM_DATA, USIM_CLK, and USIM_RST lines to filter out RF interference. Peripheral components of the (U)SIM card holder should be placed as close as possible to the (U)SIM card holder.

- The pull-up resistor of the USIM_DATA is beneficial for increasing the anti-interference ability of the (U)SIM card. When the wiring of the (U)SIM card is too long, or when it is close to the interference source, it is recommended to reserve a pull-up resistor near the (U)SIM card slot position.

4.5 Control and status indicator interface

4.5.1 Status indicator LED

The NR90-HCN Mini PCIe-A module drives the LED through the LED_WWAN# pin, which allows a maximum input current of 20mA.

Table 4-6 LED_WWAN# Interface Description

Pin number	Pin names	Type	Description	Parameters	Note
42	LED_WWAN#	OD	Module status indicator light	Maximum sink current 20mA	

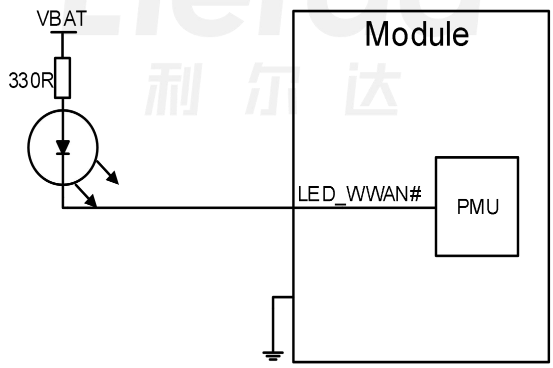


Figure 4.12 Module Status Indicator Light Interface Reference Circuit

4.5.2 Airplane mode

The NR90-HCN Mini PCIe-A module controls the activation or deactivation of the flight mode through the W_DISABLE# pin. In addition to this method, the flight mode can also be turned on or off through AT commands.

Table 4-7 W_DISABLE# Pin Description

Pin number	Pin names	Type	Description	Parameters	Note
20	W_DISABLE#	DI	Module flight mode control	1.8V voltage domain	If not used, leave floating

Table 4-8: The module supports two ways to enter flight mode.

Serial number	Control method	Control operation
1	Hardware I/O interface button control	Pull up or suspend (default is pull up) W_DISABLE# for normal mode, pull down for flight mode
2	AT command control	AT+CFUN=4--Enter flight mode AT+CFUN=0--Minimum functionality mode (turn off RF and SIM card)

The reference design of the W_DISABLE# interface is as shown in the figure below, with a typical value of 1.8V for VDD_EXT.

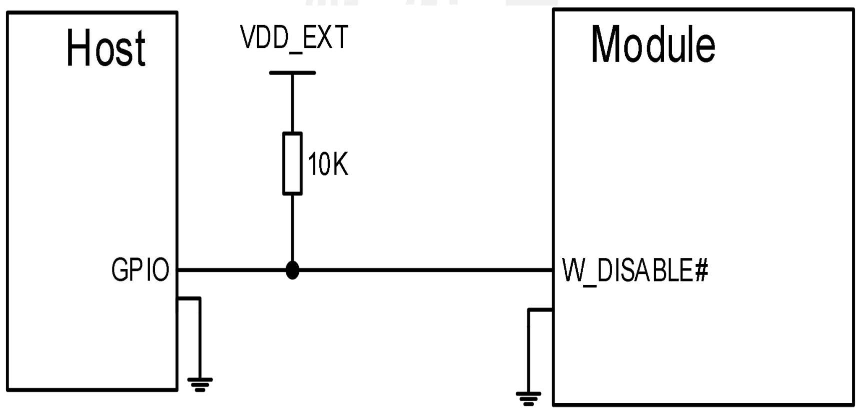


Figure 4.13 W_DISABLE# Interface Reference Circuit

4.5.3 Wake up the host.

The NR90-HCN Mini PCIe-A module wakes up the host via the WAKEUP_OUT pin. Table 4-9 provides the interface description.

Table 4-9 Module Wake-up Host Interface Description

Pin number	Pin name	Type	Describe	Parameters	Note
32	WAKEUP_OUT	OD	Wake up the host.	Low-level effective	If not used, leave floating

Table 4-10 Module Signal Status

Pin status	Module running status
Output a low-level pulse signal of 1s.	Phone/Short Message/Data incoming (Wake up host)
Always at a high level.	Idle state / Sleep mode

The reference design for the WAKEUP_OUT interface is shown in the following diagram.

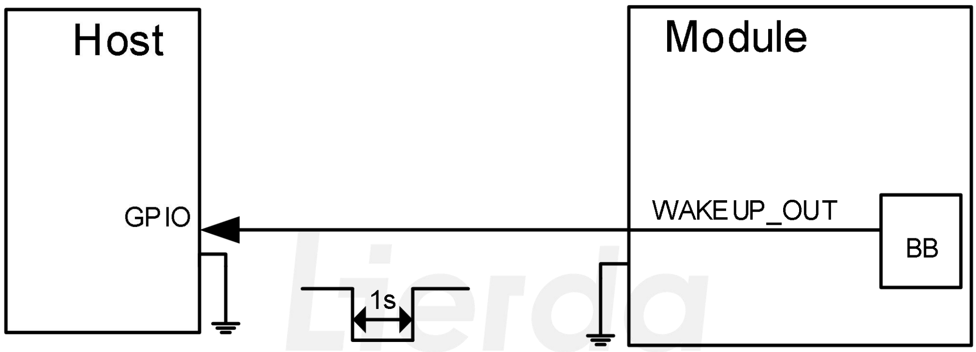


Figure 4.14 WAKEUP_OUT Interface Reference Circuit

4.6 Time synchronization interface

The NR90-HCN Mini PCIe-A module provides two timing interfaces for external devices. They are B-Code and 1PPS outputs respectively.

Table 4-11 Timing Interface Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
16	B-Code	DO	B code output	VOH	1.35	1.8	1.98	If not used, leave floating
				VOL	-0.3	-	0.45	
6	1PPS_OUT	DO	1PPS output	VOH	1.35	1.8	1.98	If not used, leave floating
				VOL	-0.3	-	0.45	

The following is the reference circuit for the B code output interface:

Figure 4.15 B-Code Output Interface Reference Circuit

The following is the reference circuit for the 1PPS output interface:

Figure 4.16 1PPS Output Interface Reference Circuit

4.7 Antenna interface

4.7.1 Antenna interface

The NR90-HCN Mini PCIe-A module provides two IPEX Gen1 antenna interfaces, the positions and interface definitions are as follows:

Figure 4.17 Antenna Interface Location Diagram

Table 4-12 NR90-HCN Mini PCIe-A Antenna Interface Definition

Antenna	Antenna type	Frequency band	Frequency range
M	TRX	**WCDMA:**B1/5/8 **LTE**: B1/3/5/8/34/38/39/40/41 **NR**: n1/3/5/8/28/41/78/79	703～5000
D	DRX	**WCDMA:**B1/5/8 **LTE**: B1/3/5/8/34/38/39/40/41 **NR**: n1/3/5/8/28/41/78/79	703～5000

When using it, directly lead the antenna from the antenna interface of the module.

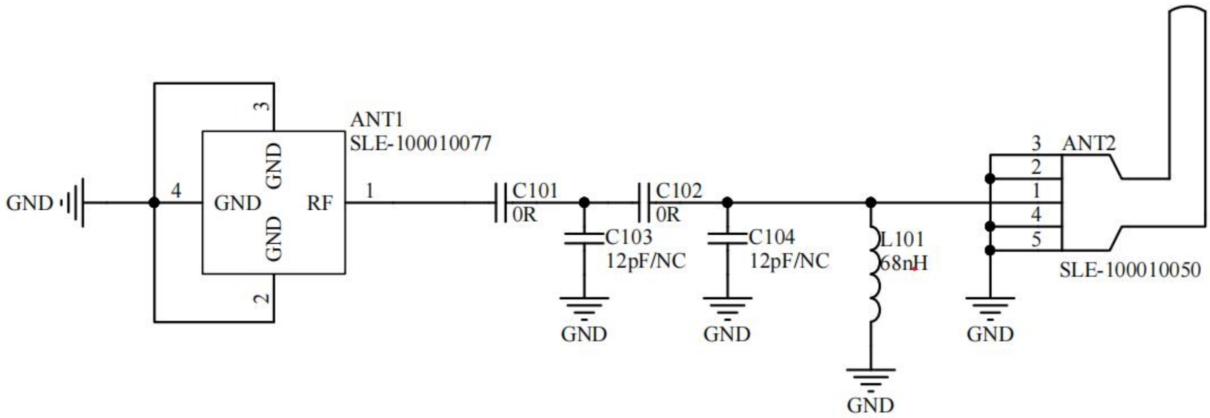


Figure 4.18 Antenna Matching Circuit

4.7.2 RF connector dimensions

The module antenna connector dimensions are as shown in the following figure:

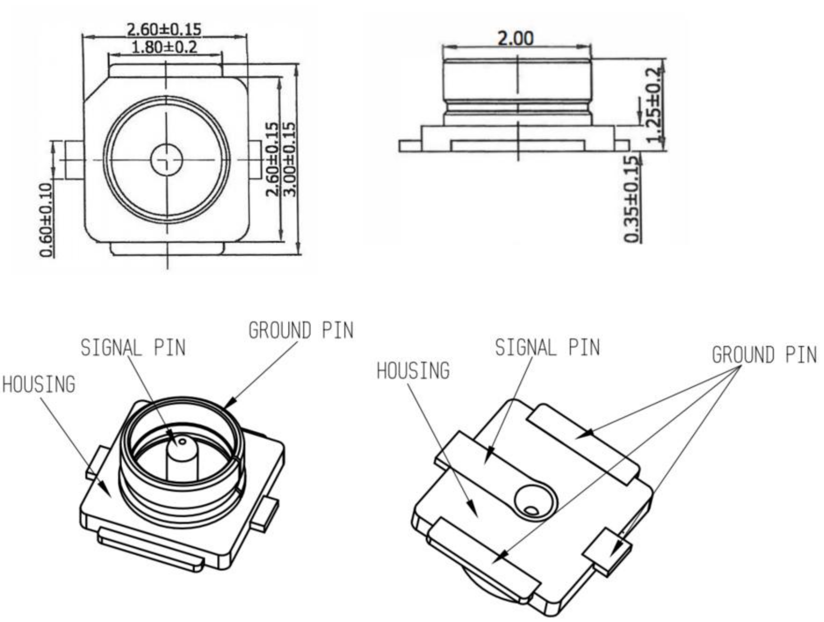


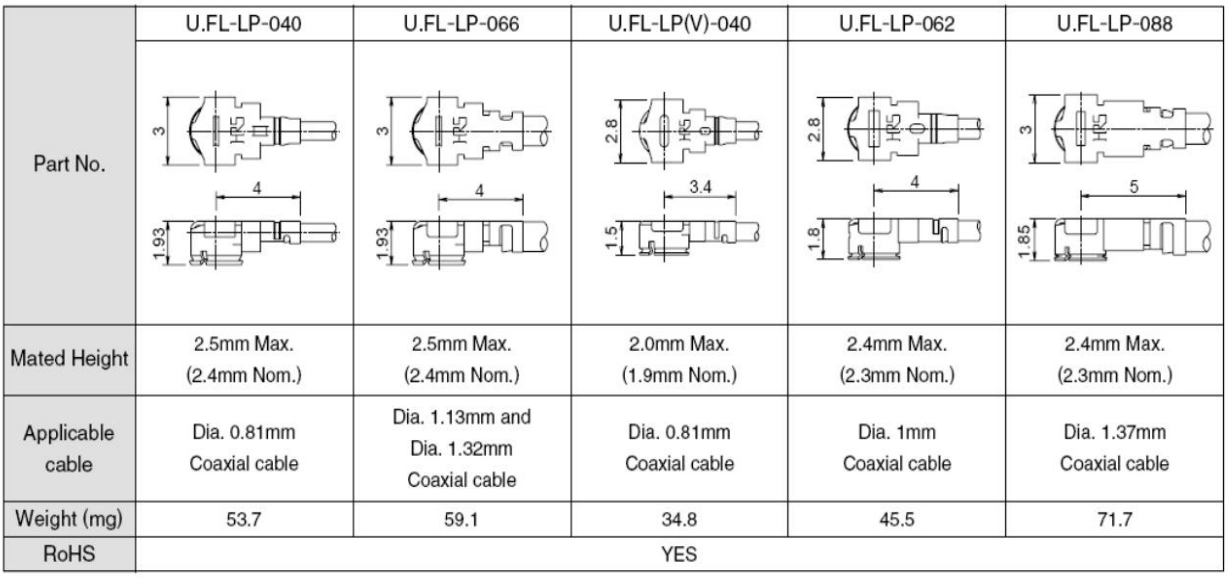
Figure 4.19 Motherboard RF Connector Dimension Diagram (unit:mm)

Table 4-13 Main Characteristics of RF Connectors

Parameters	Standard
Nominal frequency range	DC~6GHz
Characteristic impedance	50Ω
Temperature range	-40~90℃
Voltage Standing Wave Ratio (VSWR)	Maximum 1.3 (0~3 GHz); Maximum 1.4 (3~6 GHz)

4.7.3 RF coaxial cable requirements

Select the coaxial cable according to the following specifications that match the RF 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 4.20 Plug specifications matching the antenna base

The following diagram shows the installation dimensions of the connecting lines and connectors.

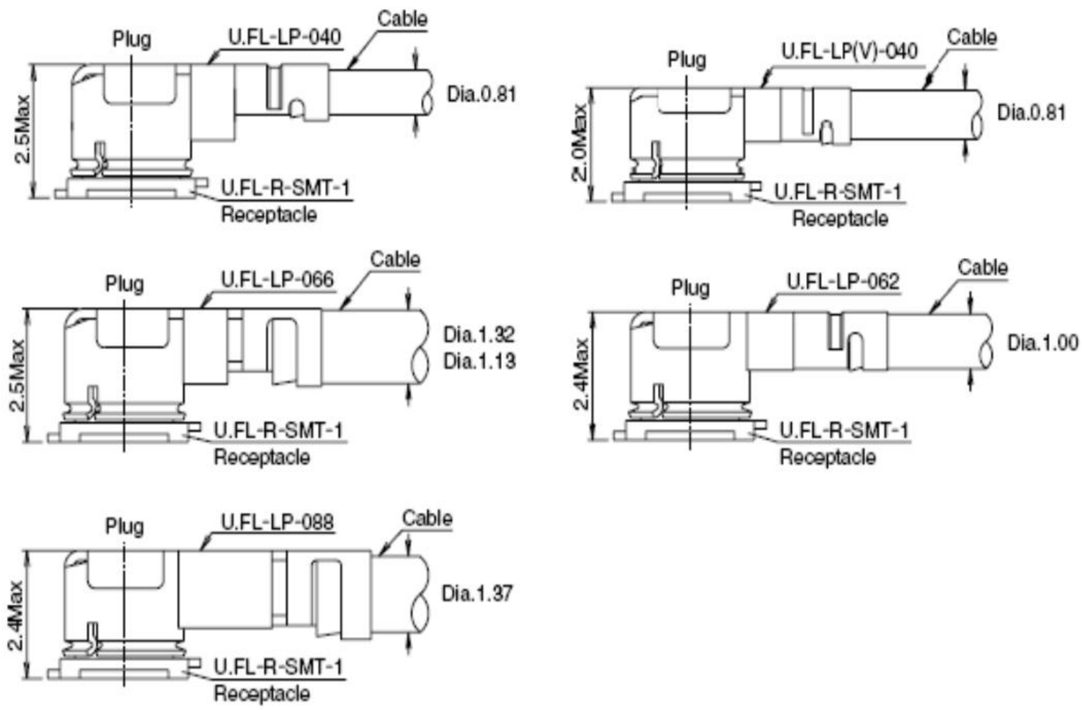


Figure 4.21 RF Connection Line and Connector Installation Dimensions

4.7.4 Antenna selection requirements

The passive parameter selection of the collapsible rod antenna is as follows.

Table 4-14 Module Antenna Selection Parameters

Parameters	Standard
Frequency range	700-5000MHz
Characteristic Impedance	50Ω
Standing wave ratio	≤ 2
Efficiency	> 30%
Connector	SMA

Passive parameters are for reference only, the actual selection should be based on the OTA data.

5 Radio Frequency Characteristics

This chapter mainly introduces the RF characteristics of the module:

- Conduction reception sensitivity
- Conduction Transmit Power

5.1 Conducting test data transmission.

5.1.1 Test environment

Test equipment: CMW500, MT8000A

Power: 66319D

5.1.2 Conduction reception sensitivity

The receive sensitivity indicator is an important parameter for evaluating the performance of the NR90-HCN Mini PCIe-A module, and the test results are shown in the table below.

Table 5-1 Description of Module Reception Sensitivity

Frequency band	MIMO test value (unit: dBm)	3GPP(MIMO)
WCDMA Band 1	-111.6	-106.7
WCDMA Band 5	-113	-104.7
WCDMA Band 8	-112.8	-103.8
LTE Band 1(10 MHz)	-100.7	-96.3
LTE Band 3(10 MHz)	-98.3	-93.3
LTE Band 5(10 MHz)	-99.3	-94.3
LTE Band 8(10 MHz)	-99.3	-93.3
LTE Band 34(10 MHz)	-101.2	-96.3
LTE Band 38(10 MHz)	-100.3	-96.3
LTE Band 39(10 MHz)	-100.3	-96.3
LTE Band 40(10 MHz)	-100	-96.3
LTE Band 41(10 MHz)	-98.2	-94.3

Frequency band	MIMO test value (unit: dBm)	3GPP(MIMO)
NR n1(20 MHz)	-97.1	-93.8
NR n3(20 MHz)	-96.3	-90.8
NR n5(20 MHz)	-96.8	-90.8
NR n8(20 MHz)	-96.2	-90
NR n28(20 MHz)	-96.8	-90.8
NR n41(20 MHz)	-96.7	-92
NR n78(20 MHz)	-98.8	-92.9
NR n79(20 MHz)	-98.6	-92.9

5.1.3 Transmitting power

Conduction emission power is an important indicator for measuring the performance of the NR90-HCN Mini PCIe-A module, and the test results are shown in the table below.

Table 5-2 Description of Module Transmission Power

Frequency band	Measurement value	3GPP
WCDMA B1	23.51	24dBm +1.7/-3.7dB
WCDMA B5	23.53	24dBm +1.7/-3.7dB
WCDMA B8	23.68	24dBm +1.7/-3.7dB
LTE B1	22.07	23dBm ±2.7dB
LTE B3	22.08	23dBm ±2.7dB
LTE B5	22.58	23dBm ±2.7dB
LTE B8	22.86	23dBm ±2.7dB
LTE B34	22.08	23dBm ±2.7dB
LTE B38	21.78	23dBm ±2.7dB
LTE B39	21.98	23dBm ±2.7dB
LTE B40	22.48	23dBm ±2.7dB
LTE B41 (PC3)	24.51	23dBm ±2.7dB
LTE B41 (PC2)	TBD	26dBm +2.7/-3.7dB(Class2)
NR n1	22.34	23dBm ±2.7dB(Class 3)
NR n3	22.51	23dBm ±2.7dB(Class 3)

Frequency band	Measurement value	3GPP
NR n5	22.56	23dBm ±2.7dB(Class 3)
NR n8	22.77	23dBm ±2.7dB(Class 3)
NR n28	23.02	23dBm +2.7/-3.2dB(Class 3)
NR n41 (PC3)	22.93	23dBm +2.7/-3.2dB(Class 3)
NR n78 (PC3)	23.04	23dBm +2.7/-3.7dB(Class3)
NR n79 (PC3)	24.12	23dBm +2.7/-3.7dB(Class3)

6 Electrical performance and reliability

This chapter mainly introduces the electrical characteristics and reliability characteristics of the NR90-HCN Mini PCIe-A module interface.

6.1 Work and storage environment

The operating and storage temperature ranges of the NR90-HCN Mini PCIe-A module are shown in the table below.

Table 6-1 Module Operating and Storage Temperature

Parameters	Minimum value (°C)	Maximum value (°C)
Normal operating temperature	-30	+75
Expand operating temperature.	-40	+85
Storage temperature	-40	+90

6.2 Power Characteristics

The input voltage requirements for the NR90-HCN Mini PCIe-A module are as shown in the table below.

Table 6-2 Module Operating Voltage

Symbol	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Ripple (V)
VBAT	External power supply	3.3	3.8	4.4	0.1

The launch status power waveform is as shown in the following figure:

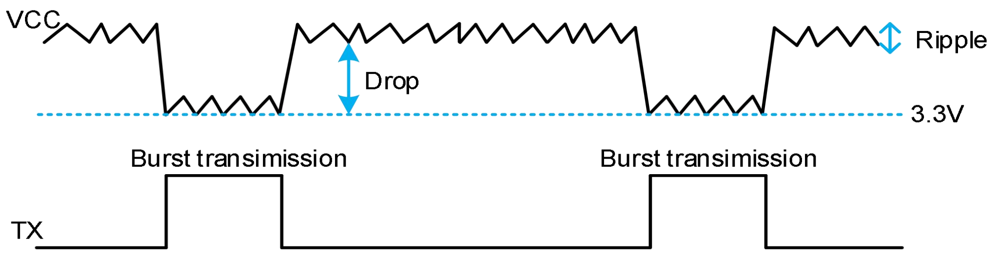


Figure 6.1 Power Requirements for RF Transmission

6.3 Absolute maximum rated value

Table 6-3 Absolute Maximum Ratings

Symbol	Minimum value	Maximum value	Unit
VBAT	-0.3	5.0	V
Digital interface voltage	-0.3	1.98	V

6.4 Power consumption characteristics

Table 6-4 Module Power Consumption

Module status	Condition	Channel	Average Typ.Current(mA)@ 3.8V
Sleep mode	Idle(AT+cfun=0)	--	1.059
Maximum transmission power of WCDMA	WCDMA B1	9612	541.682
		9750	647.460
		9888	646.591
	WCDMA B5	4132	619.806
		4182	689.016
		4233	707.459
	WCDMA B8	2712	682.889
		2788	700.093
		2863	741.770
Maximum transmission power of LTE	LTE-FDD B1	18050	477.530
		18300	564.182
		18550	534.280
	LTE-FDD B3	19250	508.568
		19575	491.475
		19900	565.789
	LTE-FDD B5	20450	463.516
		20525	494.023
		20600	536.294
	LTE-FDD B8	21500	524.961
		21625	515.037
		21750	516.673
	LTE-TDD B34	36250	367.670
		36275	371.082
		36300	371.487
	LTE-TDD B38	37800	363.684
		38000	344.842
		38200	319.494
	LTE-TDD B39	38300	327.733
		38450	331.613

Module status	Condition	Channel	Average Typ.Current(mA)@ 3.8V
		38600	335.947
	LTE-TDD B40 (PC3)	38700	353.348
		39150	293.025
		39600	335.647
	LTE-TDD B41 (PC2)	39700	517.669
		40620	602.428
		41540	584.621
Maximum transmission power of 5G NR	5G NR-FDD n1	423000	504.898
		428000	564.928
		433000	520.257
	5G NR-FDD n3	362000	666.535
		368000	559.333
		375000	630.230
	5G NR-FDD n5	174800	482.963
		176300	494.334
		177800	503.807
	5G NR-FDD n8	186000	518.551
		188500	515.569
		191000	526.587
	5G NR-FDD n28	152600	568.863
		156100	575.963
		158600	588.788
	5G NR-TDD n41 (PC3)	500202	252.113
		518598	226.338
		537000	245.903
	5G NR-TDD n78 (PC3)	620334	243.558
		636666	268.257
		653000	259.582
	5G NR-TDD n79 (PC3)	693722	235.927
		713328	248.630
		733000	264.631

6.5 ESD protection

6.5.1 ESD design recommendations

The overall ESD performance is mainly determined by: structural shielding, PCB layout protection, and device protection performance. Here are some considerations for device selection:

- Reverse leakage current IR: Excessive reverse current not only increases system power consumption but may also affect signal functionality, especially more pronounced in high-speed, low-drive capability signals.
- Reverse working voltage VRWM: This voltage should be higher than the normal operating voltage at the protected network terminal;
- IPP, Clamping Voltage, and Peak Pulse Power: These three parameters follow the P=UI relationship, the lower the clamping voltage, the safer the rear device; ESD is easily weakened by factors such as structure, PCB capacitance, etc., so the discharged static electricity will not be fully applied to the network to be protected, making it difficult to estimate these parameters;
- Interlayer capacitance CJ: Interlayer capacitance that is too large will affect high-speed signal integrity;

We suggest:

(1) High-speed signal interface: CJ<1pF for USB2.0 interface

(2) Low-speed signal interface: (U)SIM interface CJ<10pF, UART interface, PCM interface CJ<20pF, TVS diodes or varistors can be used for ESD protection.

- Antenna Interface: If TVS components are used in the antenna interface, RSE (Radiated Spurious Emissions) may exceed the values defined in EN301489. Therefore, it is not recommended to use TVS at the antenna port. It is suggested to connect a 47nH~82nH inductor for ESD protection.

6.5.2 ESD environmental control recommendations

(1) The processing equipment, testing instruments, tools, and equipment of electrostatic sensitive devices and components are all reliably grounded;

(2) The parts that come into contact with electrostatic sensitive components on equipment, instruments, tools, and fixtures, as well as the moving parts near electrostatic

sensitive components, are made of anti-static materials and have good grounding. The non-anti-static material parts are treated with anti-static measures.

(3) In the process of handling electrostatic sensitive devices such as ICs, single boards, modules, etc., employees correctly wear electrostatic wrist straps or gloves;

(4) Are there obvious anti-static labels and measures in the process of transporting and storing electrostatic sensitive devices?

Table 6-5 ESD performance parameters (Temperature: 25ºC, Humidity: 40%)

Pin name	Discharge phenomenon	Air discharge
VBAT,GND	±4kv	±8kv
Antenna Interface	±4kv	±8kv
Others	±0.5kv	±2kv

7 Mechanical dimensions

7.1 Mechanical dimensions

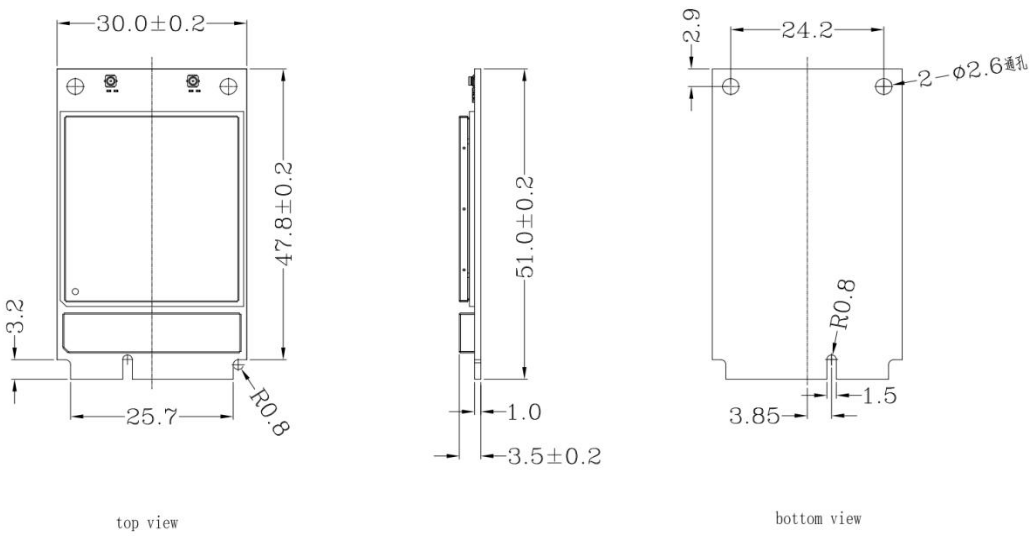


Figure 7.1 Module Mechanical Dimension Diagram (Unit: mm)

7.2 Module effect diagram

Figure 7.2 Module Rendering

The above is the design rendering of the module, please refer to the actual module for accuracy, especially the label content is for reference only.

7.3 MINIPCIE connector

The NR90-HCN Mini PCIe-A module uses a standard PCI Express Mini Card connector, such as the Molex 679105700 connector shown in the following diagram.

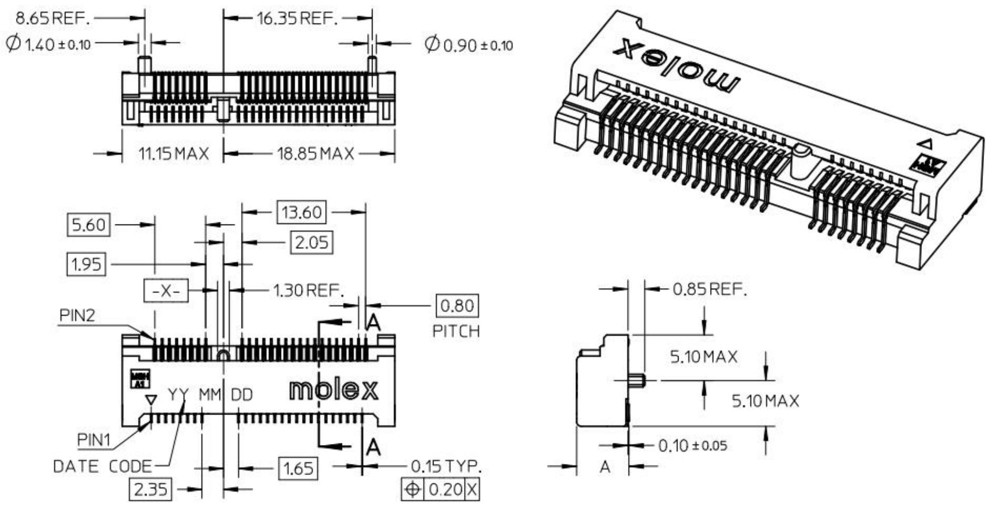


Figure 7.3 Molex 679105700 Mini PCI Express Connector (Unit: mm)

8 Packaging information

The NR90-HCN Mini PCIe-A module is packaged in a blister pack, the specific scheme is as follows.

8.1 Thermoformed tray

The vacuum-formed tray dimensions are as follows:

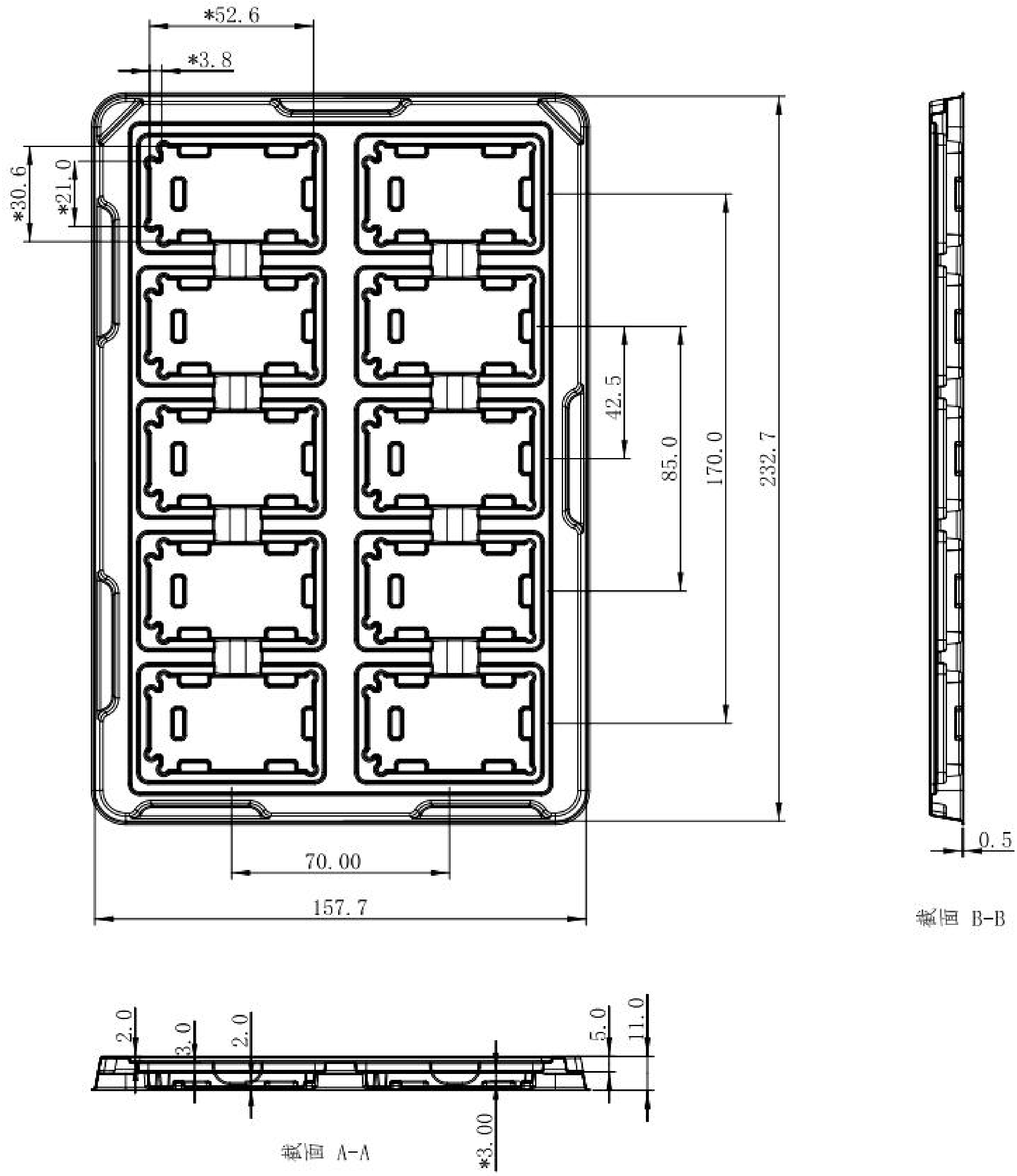
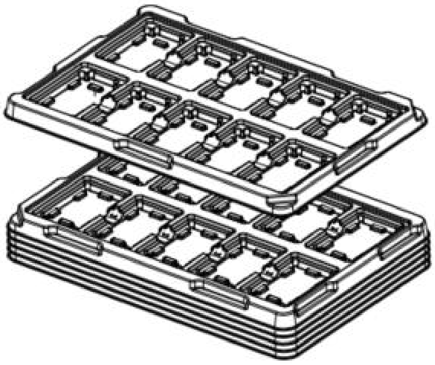
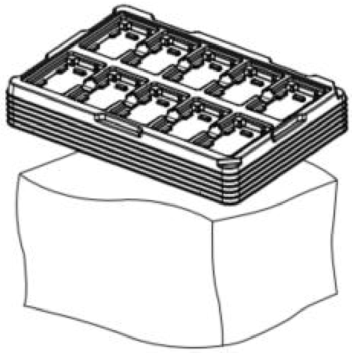


Figure 8.1 Thermoformed Tray Dimension Drawing (unit:mm)

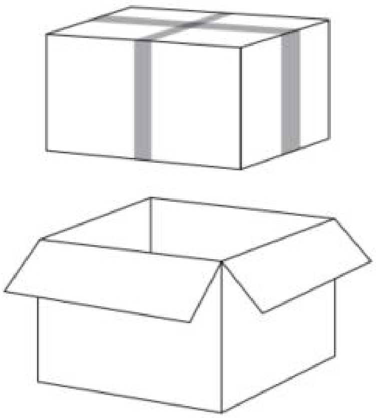
8.2 Packaging process



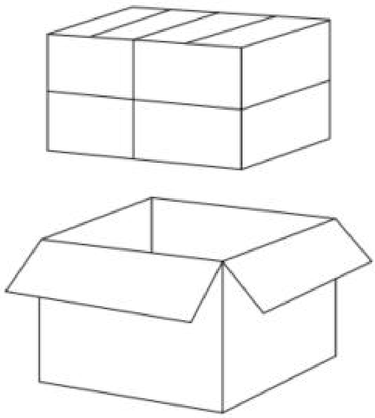
Each blister tray holds 10 modules, and then 5 of them are filled.
The modules' trays are stacked together, with one empty tray placed on top.
Tray.



Pack 6 vacuum-formed trays together, place a piece of cardboard on the top and bottom, add 10 grams of desiccant, then place the vacuum-formed trays in an aluminum foil bag, vacuum seal and pack.



Put the sealed vacuum-formed tray into a small box, one small box can contain
Install 50 modules.



Put 4 small boxes into one carton and seal it, one carton can pack 200 modules.

Figure 8.2 Packaging Process

9 Relevant documents and term abbreviations

Table 9-1 Related Documents

Serial number	Document name	Annotation
[1]	Lierda NR90-HCN AT Command Manual_Rev 1.2	AT command set

Table 9-2 Term Abbreviations

Abbreviation	English full name	Chinese full name
bps	bits per second	Per second
CPE	Customer-Premise Equipment	User resident equipment
FOTA	Firmware Over-The-Air	Firmware over-the-air differential upgrade
ESD	Electrostatic Discharge	Electrostatic discharge
FDD	Frequency Division Duplexing	Frequency Division Multiplexing
HSPA	High Speed Packet Access	High-speed data packet access
HSUPA	High Speed Uplink Packet Access	High-speed uplink data packet access
kbps	Kilo Bits Per Second	Thousand bits per second
LED	Light Emitting Diode	Light Emitting Diode
LTE	Long Term Evolution	Long-term evolution
Mbps	Mega Bits Per Second	Megabits per second
MIMO	Multiple-Input Multiple-Output	Multiple inputs, multiple

		outputs
NR	New Radio	New Air Interface
PCIe	Peripheral Component Interconnect Express	Peripheral component interconnect standard
PCM	Pulse Code Modulation	Pulse Code Modulation
PPP	Point-to-Point Protocol	Point-to-Point Protocol
QAM	Quadrature Amplitude Modulation	Orthogonal Amplitude Modulation
QPSK	Quadrature Phase Shift Keying	Orthogonal Frequency Division Multiplexing
RC	Root Complex	Root complex
RF	Radio Frequency	Radio Frequency
RFFE	RF Front-End	RF front end
Rx	Receive	Receive
SIMO	Single Input Multiple Output	Single Input Multiple Output
SMS	Short Message Service	Short Message Service
Tx	Transmit	Send
UART	Universal Asynchronous Receiver & Transmitter	General asynchronous transceiver
USB	Universal Serial Bus	Universal Serial Bus
(U)SIM	(Universal) Subscriber Identity Module	Global user identification module
VIH	Input High Voltage Level	Enter high voltage level
VIL	Input Low Voltage Level	Enter low voltage level
VOH	Output High Voltage Level	Output high voltage level
VOL	Output Low Voltage Level	Low voltage level output
WCDMA	Wideband Code Division Multiple Access	Broadband code division

		multiple access.