Lierda NE16U-CN 0F Module Hardware Design Manual

Version: Rev1.2

Date: 25/04/25

Status: Released

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Revision History of the Document

Document version	Change date	Reviser	Reviewer	Change content
Rev1.0	23-04-27	WPL	XL	Initial Version
Rev1.1	23-05-08	WPL	XL	1. Update some AT commands 2. Optimize part of the circuit
Rev1.2	25-04-25	WPL	XL	Standardization optimization of documents

Safety Instructions

Users are responsible for complying with the relevant regulations on wireless communication modules and devices in other countries and specific environmental regulations for use. By following the following safety principles, personal safety can be ensured and help protect products and work environments from potential damage. Our company is not responsible for any related losses caused by customers' failure to comply with these regulations.

	Safety first when driving! 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 in the airplane 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 devices 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 phone credit or the SIM card is invalid. In case of emergencies encountering the above situations, remember to use emergency calls, ensuring that your device is powered on and in an area with sufficient signal strength.
	Your mobile terminal device will receive and transmit radio frequency signals when it is powered on, which may cause radio frequency interference when it is near 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 the 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	Module introduction
1	NE16U-CN	0F	WCDMA/LTE/NR (Not support N5)	30 x 52 x 2.3mm	5G standard module

Content

1 Introduction

This document defines the hardware application specification of Lierda Group's NE16U-CN 0F 5G 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 corresponding documents, users can quickly master the application methods of the 5G module.

2 Product Overview

Lierda NE16U-CN 0F 5G Sub-6GHz module is based on the Unisoc V510 platform, supporting 5G standalone (SA) and non-standalone (NSA) networking, meeting the frequency band requirements of the four major domestic operators, and supporting LTE and WCDMA network standards.

NE16U-CN 0F module adopts the M.2 Key B standard interface, with dimensions of 30*52*2.3mm, making it easy to install.

NE16U-CN 0F module supports embedded systems such as Linux, Windows, and Android, and can provide voice functions to meet various application scenarios.

NE16U-CN 0F module is an industrial-grade module, only suitable for industrial and commercial applications.

2.1 Frequency bands and functions

Table 2-1 Description of frequency bands supported by the NE16U-CN 0F module

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
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
NRn1	1920MHz-1980MHz	2110MHz-2170MHz
NR n8	880MHz-915MHz	925MHz-960MHz
NR n28	703MHz-748MHz	758MHz-803MHz

NR n41	2496MHz-2690MHz	2496MHz-2690MHz
NR n77	3300MHz-4200MHz	3300MHz-4200MHz
NR n78	3300MHz-3800MHz	3300MHz-3800MHz
NR n79	4400MHz-5000MHz	4400MHz-5000MHz

NE16U-CN 0F module can be applied in the following terminal scenarios:

- Remote monitoring equipment
- Intelligent measuring equipment
- Wireless CPE
- Smart TV
- Wireless router and switch
- Outdoor live broadcasting equipment
- Other wireless terminal devices

2.2 Key Features

The following table shows the main features of the NE16U-CN 0F module.

Table 2-2 Main Features of Lierda NE16U-CN 0F Module

Type	Description
Encapsulation	M.2 Key B
Physical properties	Dimensions: 30 x 52 x 2.3mm Weight: 8.7g
Working frequency band	5G SA：n1/n8/n28/n41/n77/n78/n79 5G NSA：n41/n78/n79 LTE FDD：B1/B3/B5/B8 LTE TDD：B34/B38/B39/B40/B41 WCDMA：B1/B5/B8
Transmission rate (theoretical value)	SA DL：2Gbps；UL：1Gbps NSA DL：2.2Gbps；UL：575Mbps LTE DL：600Mbps；UL：150Mbps WCDMA DL：384kbps；UL：384kbps DC-HSPA+：DL 42.2Mbps HSUPA：UL 11Mbps
Transmission power	WCDMA Frequency Band: Class 3 (24dBm +1.7/-3.7dB) LTE band: Class 3 (23dBm ±2.7dB) 5G NR n1/n8/n41：Class 3(23dBm ±2.7dB)

Type	Description
	5G NR n28：Class 3(23dBm +2.7/-3.2dB) 5G NR n77/n78/n79：Class 3(23dBm +2.7/-3.7dB) 5G NR n41/n77/n78/n79 HPUE：Class 2 (26dBm +2.7/-3.7dB)
WCDMA features	Support 3GPP R9 DC-HSDPA, HSDPA, HSUPA, HSPA+, and WCDMA. Support QPSK, 16QAM, 64QAM modulation. Maximum transmission rate (theoretical value): DC-HSDPA: 42.2Mbps (downlink speed) HSUPA: 11Mbps (uplink speed) WCDMA: 384kbps (downlink speed) / up to 384kbps (uplink speed)
LTE features	Maximum support: 3CC downlink / 2CC uplink Downlink: Cat 12/Uplink: Cat 13 Support 1.4/3/5/10/15/20 MHz RF bandwidth. Support uplink QPSK, 16QAM, 64QAM modulation modes. Support QPSK, 16QAM, 64QAM, 256QAM modulation schemes. Support downlink 2×2 MIMO. Maximum transmission rate (theoretical value): LTE: 600Mbps (downlink speed) / 150 Mbps (uplink speed)
5G NR features	Support uplink 256QAM modulation scheme and downlink 256QAM modulation scheme. Support downlink 4×4 MIMO for n1/n28/n41/n77/n78/n79. N41/N77/N78/N79 support uplink 2×2 MIMO. Support 15kHz and 30kHz for SCS. Support the working modes of SA and NSA. Support Option 3x, 3a, 3 and Option 2. Maximum transmission rate (theoretical value, related to network configuration and heat dissipation environment): NSA: 2.2 Gbps (downlink average speed) / 575 Mbps (uplink average speed) SA: 2 Gbps (average downlink rate) / 1 Gbps (average uplink rate)
Operating voltage range	DC 3.3V ~ 4.4V (typical value 3.8V)
Application temperature range	Operating temperature: -30 ~ +75°C Operating Temperature: -40 ~ +85°C Storage Temperature: -40 ~ +90°C
AT command	Reference detailed design document for NE16U-CN AT command manual.
USB interface	USB2.0 (High Speed) interface, with a maximum speed of 480Mbps.

Type	Description
	USB3.0 interface, with a maximum transfer rate of up to 5Gbps
UART Interface	2-line UART
(U)SIM interface	2 standard SIM interfaces (Class B and Class C) Support dual SIM single standby.
PCM and SPI interfaces	Support SLIC
I2C interface	The maximum speed can reach 3.4Mbps.
PCIe interface	Compliant with PCI Express Base Specification Revision 2.0, with a transfer rate of up to 5Gbps.
B code output interface	B code output interface, used for external device timing synchronization.
Control interface	FULL_CARD_POWER_OFF# (high-level power on) RESET# (low-level reset) WAKEUP_IN (high-level wake-up module) W_DISABLE1# (Flight Mode Control) WWAN_LED# (RF status indicator) WAKE_ON_WAN# (Wake on WAN)
Antenna interface	ANT1/ANT2/ANT3/ANT4
Network Protocol	PPP/RNDIS/ECM TCP/IP HTTP/MQTT/FTP
Drive	Linux Windows XP/7/8/10 Andriod
AT	3GPP TS 27.007 CMIOT extended AT commands
FOTA	Support
OneNET	Support
CTWing	Support
Certification	CCC/SRRC/NAL/ROHS/Operator Certification* (Telecom/Unicom/Mobile)

Note

Under development

2.3 Function block diagram

The diagram illustrates the main functions of the NE16U-CN 0F module: power management, baseband section, memory, RF function block, peripheral interfaces.

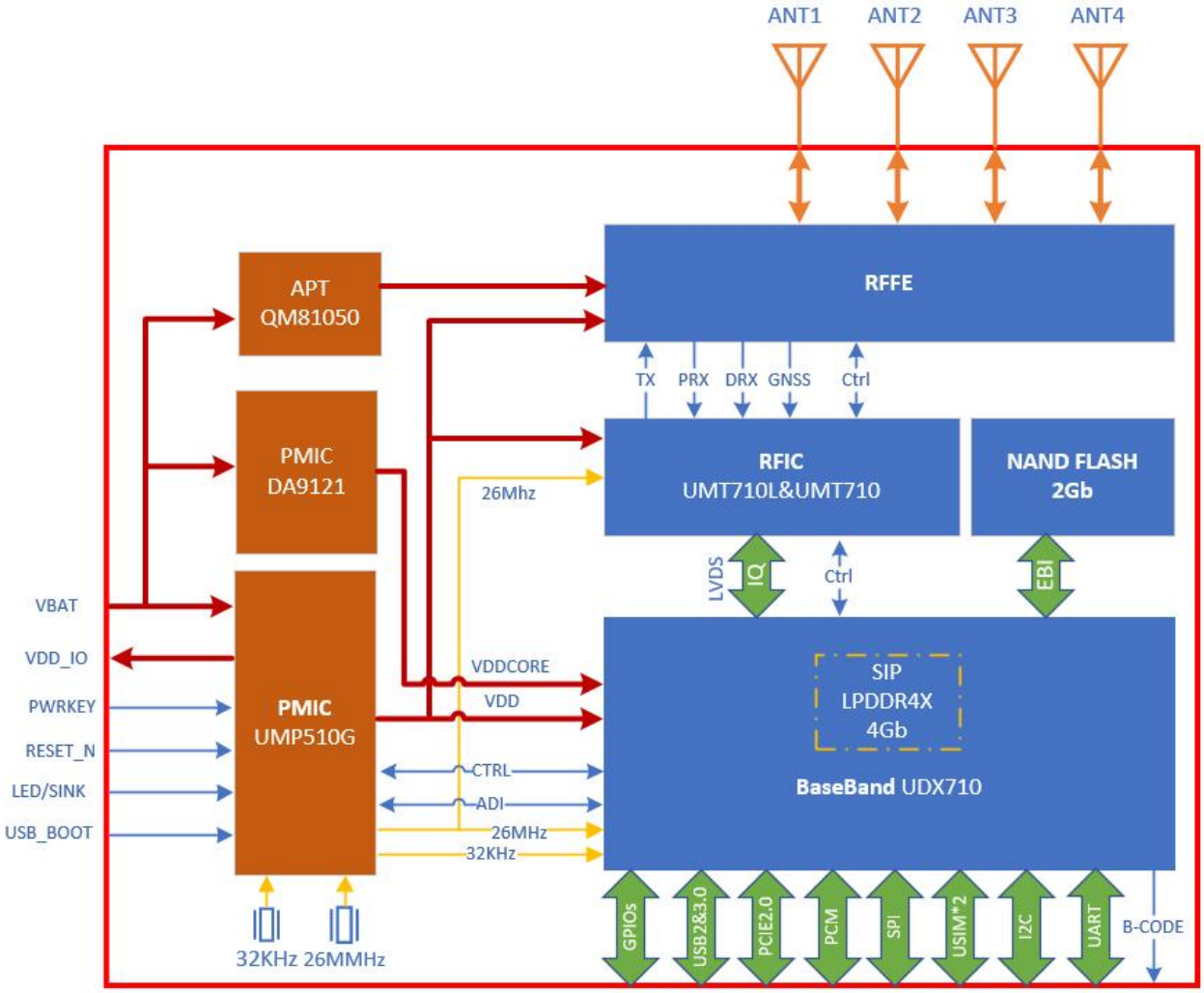
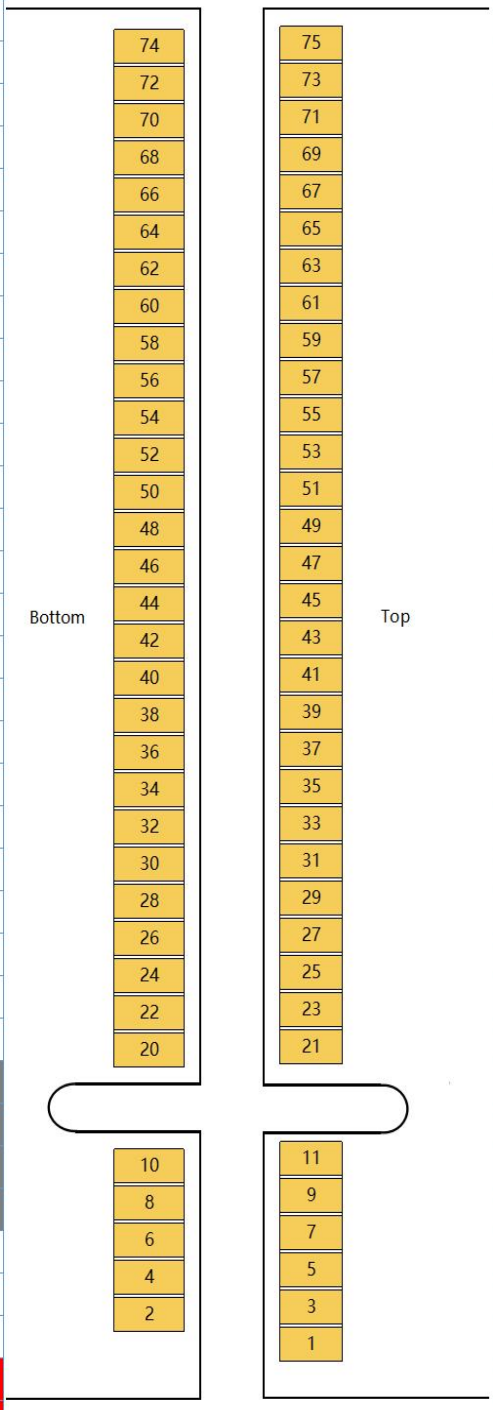


Figure 2.1 NE16U-CN 0F Module Hardware Diagram

2.4 Pinout diagram

The following is the pin assignment diagram for NE16U-CN 0F M.2 interface.

No.	Pin Name
74	VCC
72	VCC
70	VCC
68	I2C_SDA
66	USIM1_DET
64	UART_TXD
62	UART_RXD
60	SPI_DI
58	RFFE_DATA
56	RFFE_CLK
54	PCIE_WAKE_N
52	PCIE_CLKREQ_N
50	PCIE_RST_N
48	USIM2_VDD
46	USIM2_RST
44	USIM2_CLK
42	USIM2_DATA
40	USIM2_DET
38	WAKEUP_IN
36	USIM1_VDD
34	USIM1_DATA
32	USIM1_CLK
30	USIM1_RST
28	PCM_SYNC
26	B_CODE_OUT
24	PCM_DOUT
22	PCM_DIN
20	PCM_CLK
	Notch
	Notch
	Notch
	Notch
10	WWAN_LED#
8	W_DISABLE1#
6	FULL_CARD_POWER_OFF#
4	VCC
2	VCC



Pin Name	No.
CONFIG_2	75
GND	73
GND	71
CONFIG_1	69
RESET#	67
RFFE_VIO_1V8	65
SPI_DOUT	63
SPI_CLK	61
SPI_CS	59
GND	57
PCIE_REFCLK_P	55
PCIE_REFCLK_M	53
GND	51
PCIE_RX_P	49
PCIE_RX_M	47
GND	45
PCIE_TX_P	43
PCIE_TX_M	41
GND	39
USB_SS_RX_P	37
USB_SS_RX_M	35
GND	33
USB_SS_TX_P	31
USB_SS_TX_M	29
GND	27
I2C_CLK	25
WAKE_ON_WAN#	23
CONFIG_0	21
Notch	
Notch	
Notch	
Notch	
GND	11
USB_DM	9
USB_DP	7
GND	5
GND	3
CONFIG_3	1

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
DI	Digital input signal
DO	Digital output signal
AI	Simulated input signal
AO	Simulated output signal
DIO	Digital bidirectional input/output signal
OD	Leakage leads 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 numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
1	CONFIG_3	DO	The voltage value is determined by the host end for M.2 port type identification.					If not used, leave floating
2	VCC	PI	Module main power supply	-	3.3	3.8	4.4	
3	GND	G	GND					
4	VCC	PI	Module main power supply	-	3.3	3.8	4.4	
5	GND	G	GND					
6	FULL_CARD_POWER_OFF#	DI	Power On/Off Control	VIH	1.2	1.8	4.4	Power on with high level,

Pin numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
				VIL	-	-	0.2	
7	USB_DP	AIO	USB 2.0 differential data (+)					
8	W_DISABLE1#	DI	Flight mode control	Compatible with 1.8V and 3.3V voltage domains.				If not used, leave floating
9	USB_DM	AIO	USB 2.0 differential data (-)					
10	WWAN_LED#	OD	RF status indicator					Maximum sink current 20mA
11	GND	G	GND					
12	Groove	Groove						
13	Groove	Groove						
14	Groove	Groove						
15	Groove	Groove						
16	Groove	Groove						
17	Groove	Groove						
18	Groove	Groove						
19	Groove	Groove						
20	PCM_CLK	DIO	PCM clock	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
21	CONFIG_0	DO	The voltage value is determined by the host end for the M.2 port type identification.					If not used, leave floating
22	PCM_DIN	DI	PCM data input	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
23	WAKE_ON_WAN	DO	Wake up the	VOH	1.62	1.85	1.98	If not used,

Pin numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
				VOL	0	-	0.18	
24	PCM_DOUT	DO	PCM data output	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
25	I2C_SCL	OD	I2C clock	VIH	1.26	1.85	1.98	External pull-up is required. If not used, leave floating.
				VIL	0	-	0.54	
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
26	B_CODE_OUT	DO	B code time synchronization	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
27	GND	G	GND					
28	PCM_SYNC	DIO	PCM synchronous clock	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
29	USB_SS_TX_M	AO	USB3.0 transmission (-)					If not used, leave
30	USIM1_RST	DO	Reset (U)SIM1 card	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
31	USB_SS_TX_P	AO	USB3.0 transmission (+)					If not used, leave floating
32	USIM1_CLK	DO	SIM1 card clock	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
33	GND	G	GND					
34	USIM1_DATA	DIO	SIM1 card data	VIH	1.2/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VIL	0	-	0.54/	

Pin numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
							0.9	
				VOH	1.62/2.1	1.85/3.0	1.98/3.3	
				VOL	0	-	0.18/0.3	
35	USB_SS_RX_M	AI	USB3.0 receiving (-)					If not used, leave floating
36	USIM1_VDD	PO	(U)SIM1 card power supply	-	1.62	1.85/3.0	3.3	If not used, leave floating
37	USB_SS_RX_P	AI	USB 3.0 receiving (+)					If not used, leave floating
38	WAKEUP_IN	DI	Wake up the module	VIH	1.26	1.85	1.98	The module has passed the internal pull-up with a 100K resistor.
				VIL	0	-	0.54	
39	GND	G	GND					
40	USIM2_DET	DI	Detection of SIM2 card	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
41	PCIE_TX_M	AO	PCIe transmission (-)					If not used, leave floating
42	USIM2_DATA	DIO	(U)SIM2 card data	VIH	1.2/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VIL	0	-	0.54/0.9	
				VOH	1.62/2.1	1.85/3.0	1.98/3.3	
				VOL	0	-	0.18/	

Pin numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
							0.3	
43	PCIE_TX_P	AO	PCIe transmission (+)					If not used, leave floating
44	USIM2_CLK	DO	SIM2 card clock	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
45	GND	G	GND					
46	USIM2_RST	DO	Reset (U)SIM2 card	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
47	PCIE_RX_M	AI	PCIe receive (-)					If not used, leave floating
48	USIM2_VDD	PO	(U)SIM2 card power supply	-	1.62	1.85/3.0	3.3	If not used, leave floating
49	PCIE_RX_P	AI	PCIe receive (+)					If not used, leave floating
50	PCIE_RST_N	OD	PCIe reset	The leakage pole opens the way, and the voltage value is determined by the host				If not used, leave floating
51	GND	G	GND					
52	PCIE_CLKREQ_N	OD	PCIe clock request	The leakage pole opens the way, and the voltage value is determined by the host				If not used, leave floating
53	PCIE_REFCLK_M	AIO	PCIE reference clock (-)					If not used, leave floating
54	PCIE_WAKE_N	OD	PCIe Wakeup	The leakage pole opens the way, and the voltage value is determined by the host				If not used, leave floating

Pin numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
55	PCIE_REFCLK_P	PI	PCIe reference clock (+)					If not used, leave floating
56	RFFE_CLK	DO	MIPI RFFE Clock	VOH	1.62	1.85	1.98	Suggest reserving test points
				VOL	0	-	0.18	
57	GND	G	GND					
58	RFFE_DATA	DO	MIPI RFFE data	VOH	1.62	1.85	1.98	Suggest reserving test points.
				VOL	0	-	0.18	
59	SPI_CS	DO	SPI chip select	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
60	SPI_DI	DI	SPI input	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
61	SPI_CLK	DO	SPI clock	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
62	UART_RXD	DI	Main serial port reception	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
63	SPI_DOUT	DO	SPI output	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
64	UART_TXD	DO	Main serial port transmission	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
65	RFFE_VIO_1V8	PO	Antenna tuner power supply	-	1.2	1.85	2.2	If not used, leave floating
66	USIM1_DET	DI	Detection of SIM1 card	VIH	1.26	1.85	1.98	
				VIL	0	-	0.54	
67	RESET#	DI	Module reset	VIH	1.2	-	VCC	Internal pull-up to VCC
				VIL	0	-	0.5	
68	I2C_SDA	OD	I2C data	VIH	1.26	1.85	1.98	External

Pin numb	Pin names	Type	Description	Parameters	Minimum	Typical	Maximum	Note
				VIL	0	-	0.54	pull-up is needed, can be left floating if not used.
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
69	CONFIG_1	DO	The voltage value is determined by the host end for M.2 port type identification.					If not used, leave floating
70	VCC	PI	Module main power supply	-	3.3	3.8	4.4	
71	GND	G	GND					
72	VCC	PI	Module main	-	3.3	3.8	4.4	
73	GND	G	GND					
74	VCC	PI	Module main power supply	-	3.3	3.8	4.4	
75	CONFIG_2	DO	The voltage value is determined by the host end for M.2 port type identification.					If not used, leave floating

2.6 Evaluation suite

Lierda can provide a complete evaluation and development kit, including an ADP board for easy debugging of the minimum system, an EVB board with peripherals such as audio, RS485, SLIC, WIFI, and other accessories for development convenience.

3 Working characteristics

3.1 Working mode

Table 3-1 NE16U-CN 0F 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's power consumption depends on the network settings and data transmission rate.
Minimum Function Mode	Under uninterrupted power supply, using AT+CFUN=0 can set the module to minimal functional mode. In this mode, the RF does not work.	
Flight mode	AT+CFUN=4 or pull down the W_DISABLE1# pin can set the module to flight mode. In this mode, the RF does not work.	
Sleep mode	In this mode, the power consumption of the module will be reduced to a very low level, but the module can still receive paging, messages, calls, and TCP/UDP data.	
Shutdown mode	In this mode, the PMU stops supplying power to the baseband and RF sections, the software stops working, and the serial port is not accessible.	

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 relationship between the DRX operating time and the current consumption in sleep mode of the module is shown in the figure below. The longer the DRX cycle, the lower the power consumption.

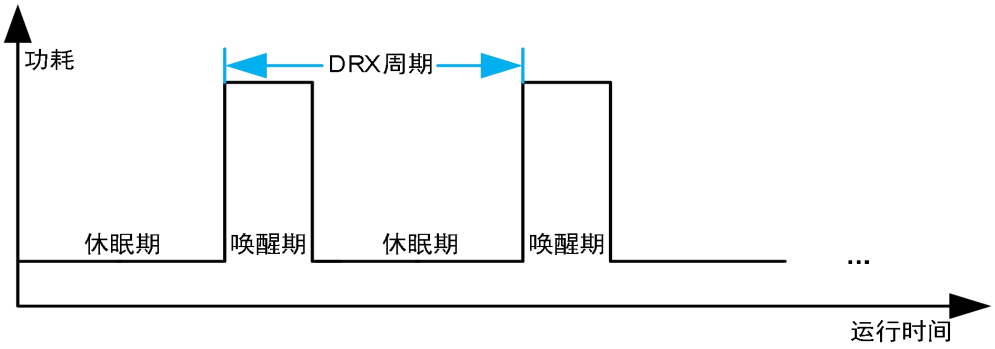


Figure 3.1 Relationship between DRX operation time and power consumption in sleep mode

NE16U-CN 0F module enters and exits sleep mode 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 maintain a low level continuously in sleep mode.
- When the module is in sleep mode, the host pulls the WAKEUP_IN pin high through a GPIO, and this GPIO can remain at a high level in the wake-up state.

The WAKEUP_IN interface reference design is as follows.

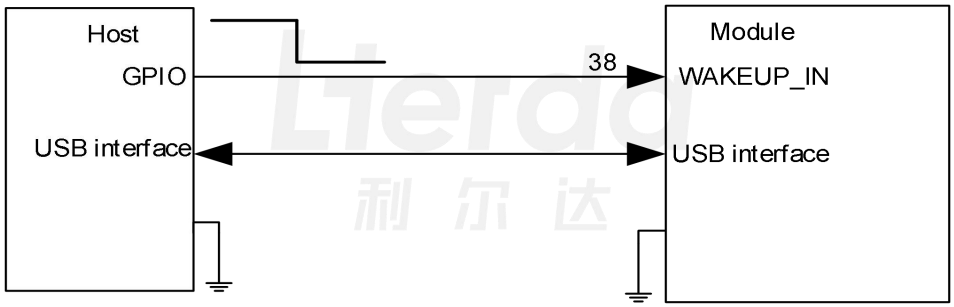


Figure 3.2 WAKEUP_IN Interface Reference Design Circuit

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	Describe	Minimum value	Typical value	Maximum value	Unit
2，4，70，72，74	PI	VCC	Module main power supply	3.3	3.8	4.4	V
3，5，11，27，33，39，45，51，57，71，73	G	GND	GND				

To ensure the normal operation of the NE16U-CN 0F module, the system power supply VCC 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 maintained above 3.3V, otherwise the module will not function properly.

External power supply LDO or DCDC selection advice: The component should be able to provide a current of 3A or more, and at least two 220uF storage capacitors should be connected in parallel on VCC. In addition, to reduce the impact of PCB traces on the power supply voltage, the VCC 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 VCC pin of the module with a power dissipation greater than 0.5W and a reverse voltage of 5.1V. Please refer to the circuit diagram shown below.

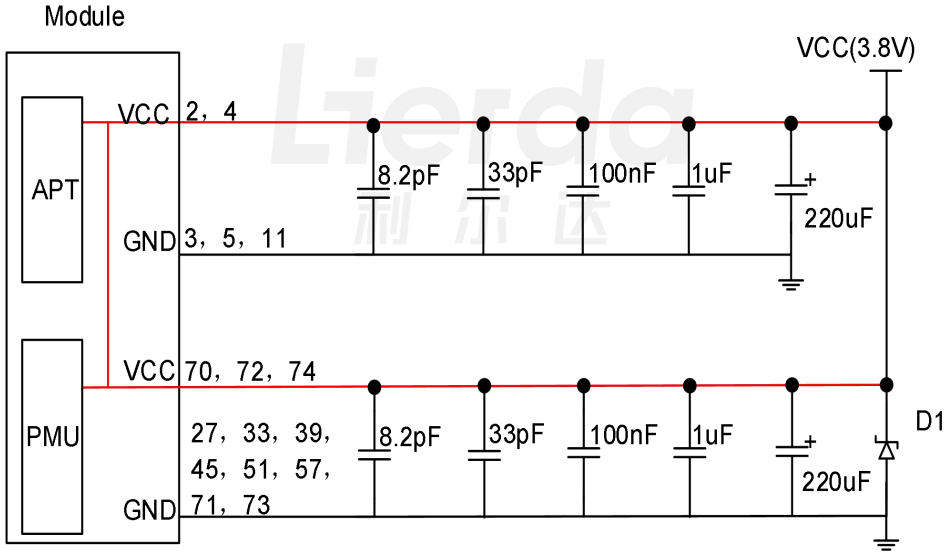


Figure 3.3 Power Supply Recommended Design

Table 3-3 Explanation of Capacitor Usage

Recommend capacitors	Application	Description
220uF×2	Stabilizing tantalum capacitor	Reduce power fluctuations during module operation, requiring the use of low ESR capacitors. (1) LDO or DCDC power supply requires a capacitance of not less

		than 440uF. (2) The battery power supply can be appropriately reduced to 100-220uF capacitance.
1uF，100nF	Digital signal noise	Filter out interference generated by clock and digital signals.
33pF	700, 850/900MHz frequency band	Filter out low-frequency RF interference.
8.2pF	1700/1800/1900, 2100/2300, 2500/2600MHz frequency bands	Filter out RF interference in the mid/high frequency range.

3.4 Power on/off.

NE16U-CN 0F module achieves power on and off through the FULL_CARD_POWER_OFF# pin.

Table 3-4 FULL_CARD_POWER_OFF# Interface Description

Pin numb	Pin Names	Type	Description	Parameter	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
6	FULL_CARD_POWER_OFF#	DI	Module power on/off control	VIH	1.2	1.8	4.4	Power on at high level, power off at low level,
				VIL	-	-	0.2	

3.4.1 Power on.

When the NE16U-CN 0F module is in the powered-off mode, it can be powered on by applying a high-level signal to FULL_CARD_POWER_OFF#. The input signal can be a 1.8V or 3.3V GPIO signal. Internally, this pin in the module is pulled down to GND through a 100K resistor, so the module is powered off by default after power-up.

The host powers on by pulling the FULL_CARD_POWER_OFF# pin high via GPIO, refer to the circuit diagram shown below.

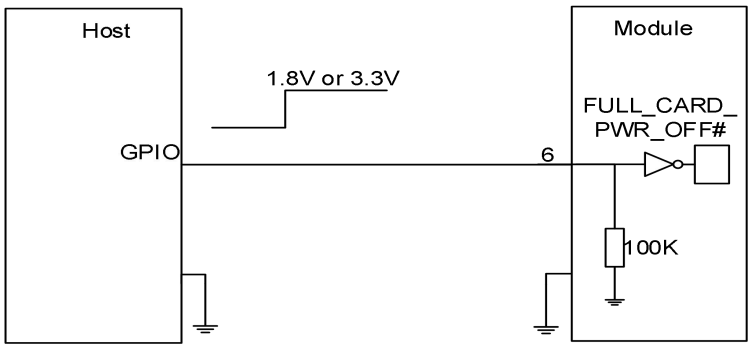


Figure 3.4 Powering on the module with GPIO control

The power-on sequence is as shown in the following figure.

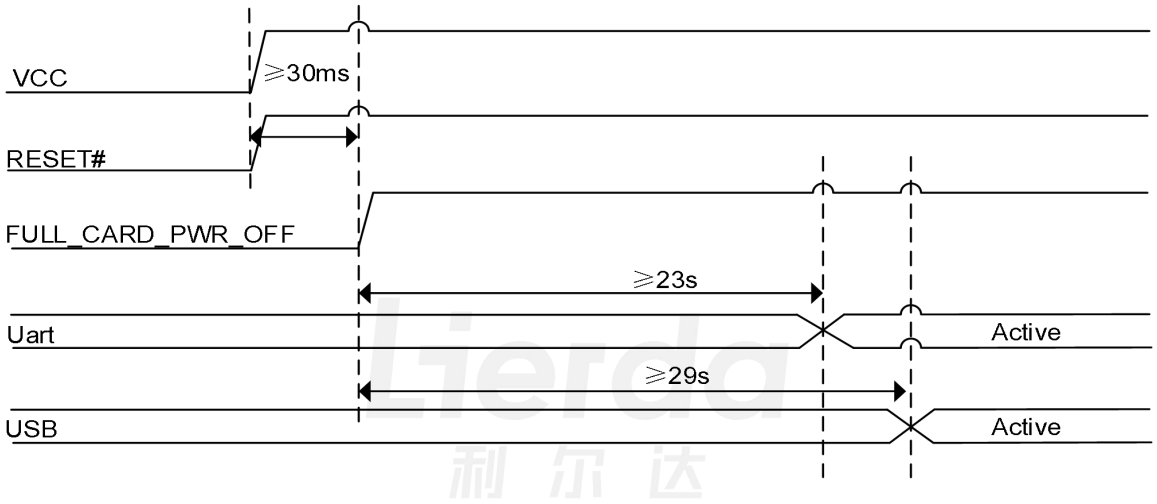


Figure 3.5 Power-on Timing Diagram

Note

Before pulling up the FULL_CARD_PWR_OFF# pin, ensure that the VCC voltage is stable. It is recommended to have a time interval of no less than 30 ms between powering up VCC and pulling up the FULL_CARD_PWR_OFF# pin. The timing here is related to the operations performed during UART and USB boot-up. In terms of the time required for AT commands, the difference between the two timings is not significant.

3.4.2 Shutdown

When the module is powered on, the host pulls down the FULL_CARD_PWR_OFF# pin through GPIO, and the module will execute the shutdown process. The following diagram shows the shutdown principle of the module. Additionally, shutdown can also be

initiated using the AT+LPOWD command.

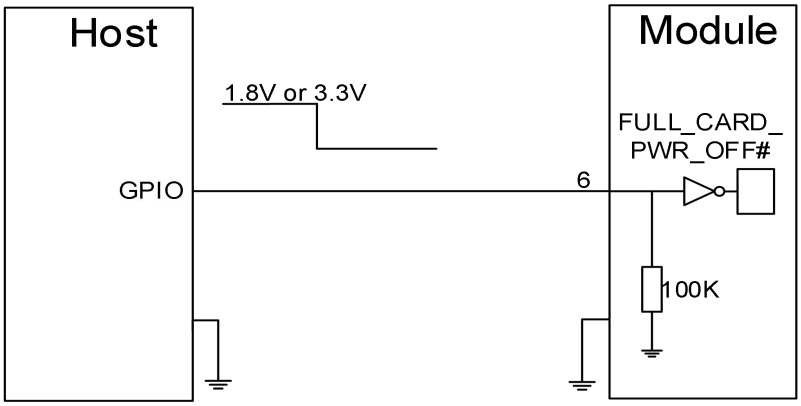


Figure 3.6 GPIO controls the shutdown of the module.

Shutdown timing sequence is as shown in the figure:

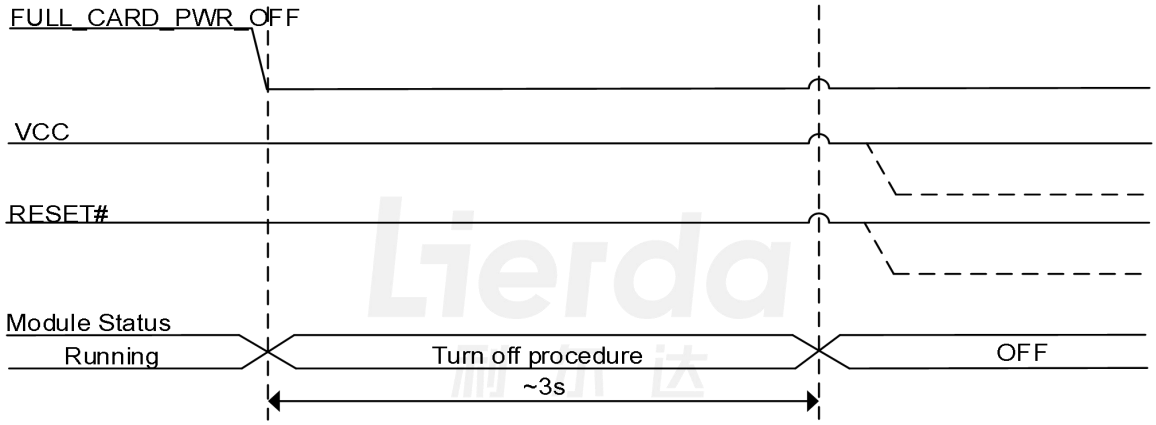


Figure 3.7 Shutdown Timing Diagram

Note

When the module is working normally, do not cut off the power supply immediately to avoid damaging the Flash inside the module. It is recommended to first turn off the module through FULL_CARD_PWR_OFF# or AT+LPOWD, and then disconnect the power supply.

After the AT command is executed successfully, it will return OK. Then the UE will activate the network and output POWERED DOWN to enter the shutdown state. The maximum duration for activating the network is 60 seconds, and the customer's design needs to consider the shutdown time. To avoid data loss, the module must not be powered off before outputting POWERED DOWN.

3.5 Reset

NE16U-CN 0F module can be reset by using the RESET# pin.

Table 3-5 RESET# Interface Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical Value (V)	Maximum value (V)	Note
67	RESET#	DI	Module reset	VIH	1.2	-	VCC	
				VIL	0	-	0.5	

When the module software stops responding, pull down the RESET# pin for 250ms 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 collector drive circuit or button to control the RESET# pin, refer to the circuit as shown in the following figure,

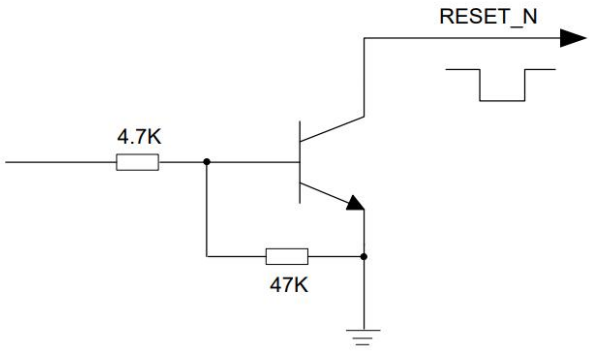


Figure 3.8 Open-Drain Driven Reset Reference Circuit

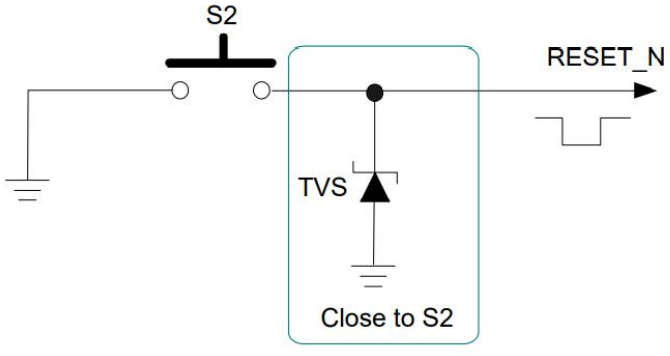


Figure 3.9 Key Reset Reference Circuit

The timing diagram for reset is as follows:

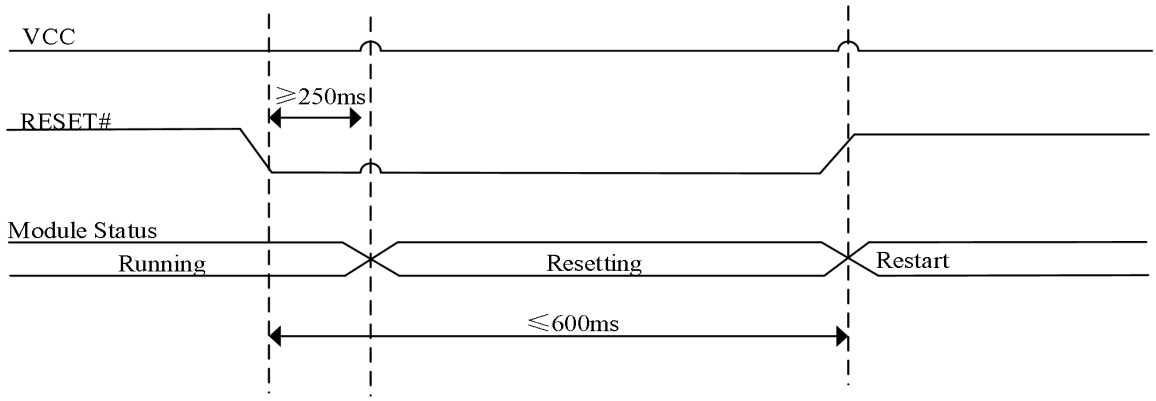


Figure 3.10 RESET# Timing Diagram

Note

- Ensure that the large load capacitance on the FULL_CARD_POWER_OFF# and RESET# pins does not exceed 47pF.
- The reset function should only be used after the AT+LPOWD command and FULL_CARD_PWR_OFF# shutdown fail.

4 Application Interface

The physical interface and electrical characteristics of the NE16U-CN 0F module comply with the PCI Express M.2 Specification. This chapter mainly introduces the definition of the interface and its related applications.

- UART interface
- USB interface
- PCIe interface
- (U)SIM interface
- I2C interface
- PCM and SPI interfaces
- Control and status indicator interface
- B Code time synchronization interface
- MIPI RFFE interface.
- Configure pins
- Antenna interface

4.1 UART interface

NE16U-CN 0F module has one serial port, with a maximum transmission rate of 961200bps, which can be used for AT command sending and data transmission, with a default baud rate of 115200bps.

Table 4-1 UART Interface Pin Description

Pin number	Pin name	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
62	UART_RXD	DI	Main serial port reception	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
64	UART_TXD	DO	Main serial port transmission	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	

When using the serial port interface, be sure to pay attention to the issue of level consistency.

(1) Transistor Level Conversion Reference Circuit

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

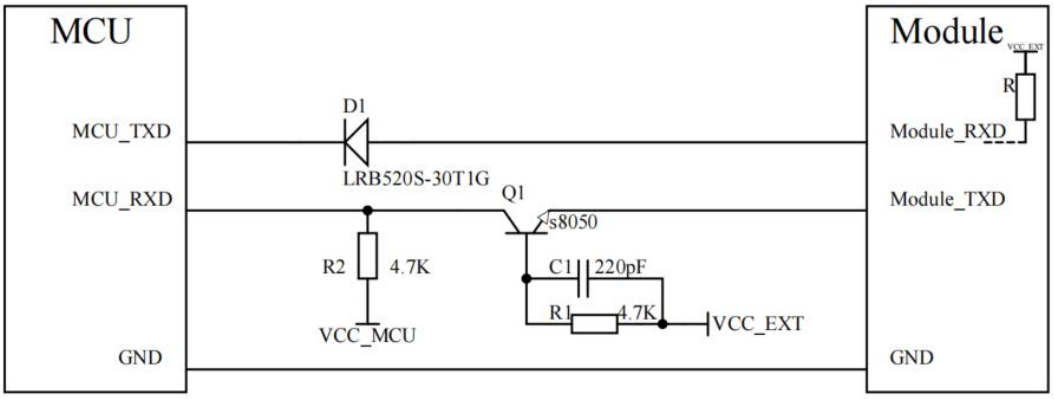


Figure 4.1 Transistor Level Conversion Reference Circuit

Note

- If the module has no internal pull-up, the diode conversion circuit user needs an external pull-up. NE16U-CN 0F internally pulls up through a 20K resistor to a 1.8V voltage domain.
- In this circuit, MCU_TXD defaults to outputting 3.3V, and VCC_EXT (RFFE_VIO_1V8) defaults to 1.85V. 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 circuit function 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, capable of meeting the requirement of serial port baud rate 921600bps. The reference design is as follows, pay attention to the direction of level conversion.

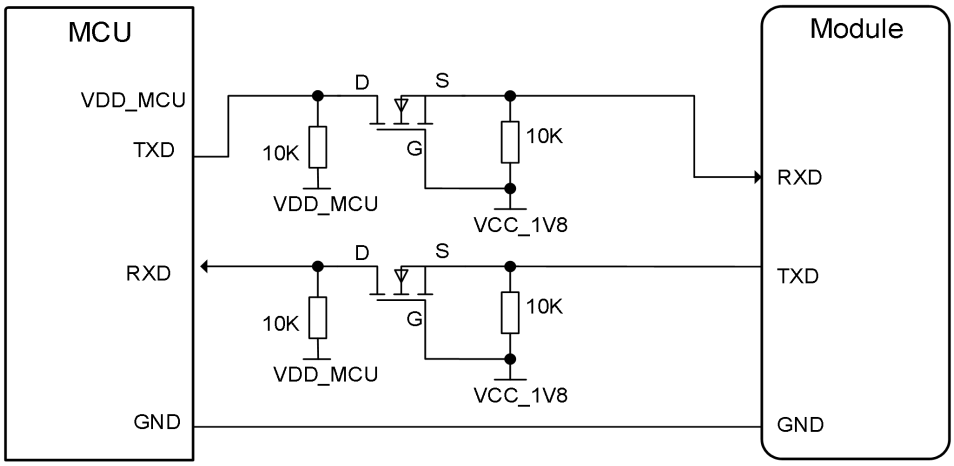


Figure 4.2 MOSFET level conversion reference circuit

Recommend MOSFET for reference:

Brand: LRC; Specifications: L2N7002LT1G, the corresponding internal principle is as follows:

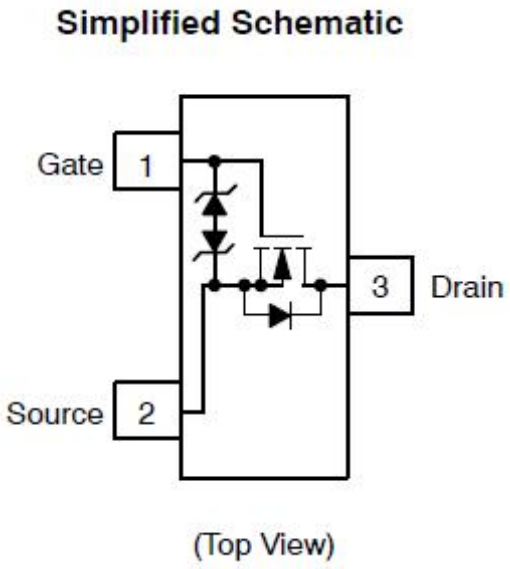


Figure 4.3 MOSFET device diagram

4.2 USB interface

NE16U-CN 0F module complies with USB 2.0 and 3.0 specifications, and supports USB 2.0 high-speed (480Mbps) and full-speed (12Mbps) modes, as well as USB 3.0 super-speed (5Gbps) mode. 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 4-2 USB Interface Pin Description

Pin number	Pin names	Type	Description	Note
7	USB_DP	AIO	USB differential data (+)	90Ω differential impedance
9	USB_DM	AIO	USB differential data (-)	
29	USB_SS_TX_M	AO	USB3.0 transmission (-)	
31	USB_SS_TX_P	AO	USB3.0 transmission (+)	
35	USB_SS_RX_M	AI	USB3.0 receiving (-)	
37	USB_SS_RX_P	AI	USB3.0 reception(+)	

It is recommended that the customer design to reserve the USB2.0 interface for firmware upgrade while also reserving test points. The reference circuits for USB2.0 and USB3.0 are as follows:

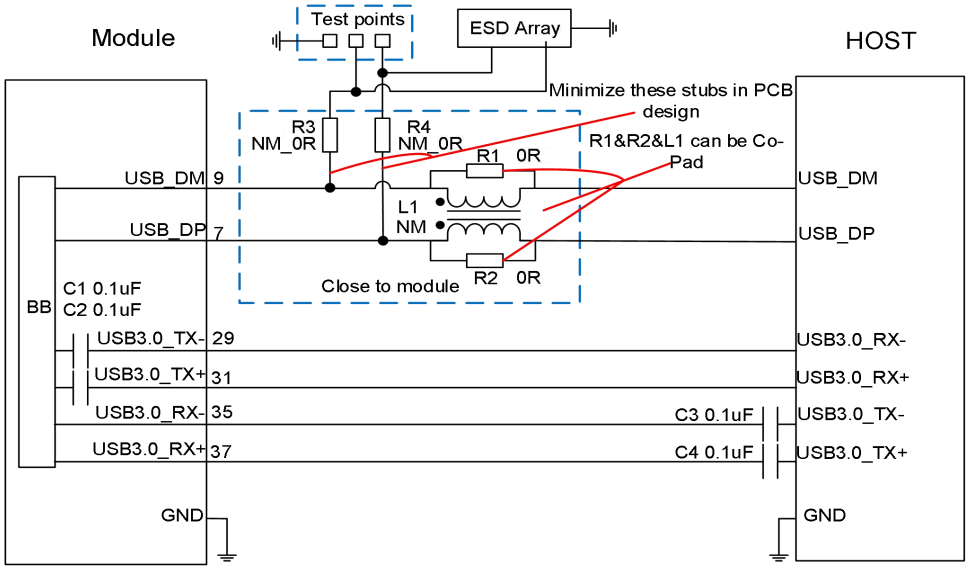


Figure 4.4 USB reference design diagram

Coupling capacitors C3 and C4 must be placed near the TX end of the host USB 3.0 interface, and the two capacitors should be positioned close to each other. Coupling capacitors C1 and C2 are already integrated inside the module, so there is no need to add them externally during the original design.

Note

- It is recommended to connect a common mode inductor L1 between the host and the module to prevent USB signal EMI interference, or use a 0Ω resistor for direct connection, designed with a common pad with L1 for debugging purposes. Depending on the debugging situation, either a common mode inductor or a resistor can be used. Additionally, it is suggested to connect resistors R3 and R4 to test points for debugging purposes, with the resistors not populated by default. To meet the USB data line signal integrity requirements, L1, R1, R2, R3, and R4 need to be placed close to the module, with R3 and R4 placed close to each other, and the routing of the connections to 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 traces need to be surrounded by GND, using 90Ω differential impedance lines. Do not route 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 ensuring that the parasitic capacitance for USB 2.0 does not exceed 1pF and for USB 3.0 does not exceed 0.5pF. Place the ESD protection devices as close to the USB interface as possible and ensure that the signals pass through the ESD protection devices first.

- For USB3.0 signals, the differential pair traces should be kept as short as possible. When connecting type A/B connectors, the length should not exceed 100mm. When connecting microAB/micro B/type C connectors, the length should not exceed 220mm. For TXP/TXN and RXP/RXN differential pairs, the intra-pair skew should not exceed 0.15mm.

4.3 PCIe interface

NE16U-CN 0F module includes a PCIe interface that complies with the PCIe 2.0 specification. It supports EP and RC modes, and the PCIe operating mode can be configured through AT+LCFG="pcie/mode",1 (0 for EP, 1 for RC, effective after reboot). The default mode is RC mode. For more details on related AT commands, please refer to the AT+LCFG="pcie/mode" section in the NE16U_CN AT Command Manual. The main features of the PCIe interface are as follows:

- Support PCIe Gen2 (5Gbps max), backward compatible
- Support PCIe to Ethernet conversion.
- Support RC and EP modes.

Table 4-3 PCIe Interface Pin Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical Value (V)	Maximum value (V)	Note
41	PCIE_TX_M	AO	PCIe transmits data (-)					
43	PCIE_TX_P	AO	PCIe sends data (+)					

47	PCIE_RX_M	AI	PCIe receive data (-)		
49	PCIE_RX_P	AI	PCIe receive data (+)		
53	PCIE_REFCLK_M	AIO	PCIe reference clock (-)		RC mode: Output (default) EP Mode: Input
55	PCIE_REFCLK_P	AIO	PCIE reference clock (+)		
50	PCIE_RST_N	OD	PCIe reset	The leakage pole opens the way, and the voltage value is determined by the host	RC mode: Output (default) EP Mode: Input
52	PCIE_CLKREQ_N	OD	PCIe clock request	The leakage pole opens the way, and the voltage value is determined by the host end.	RC mode: Input (default) EP Mode: Output
54	PCIE_WAKE_N	OD	PCIe wake-up	The leakage pole opens the way, and the voltage value is determined by the host	RC mode: Input (default) EP Mode: Output

NE16U-CN 0F PCIe interface has slight hardware circuit differences when operating in RC mode and EP mode. The following diagram shows the reference circuit of NE16U-CN 0F using PCIe interface to connect PCIe devices and hosts:

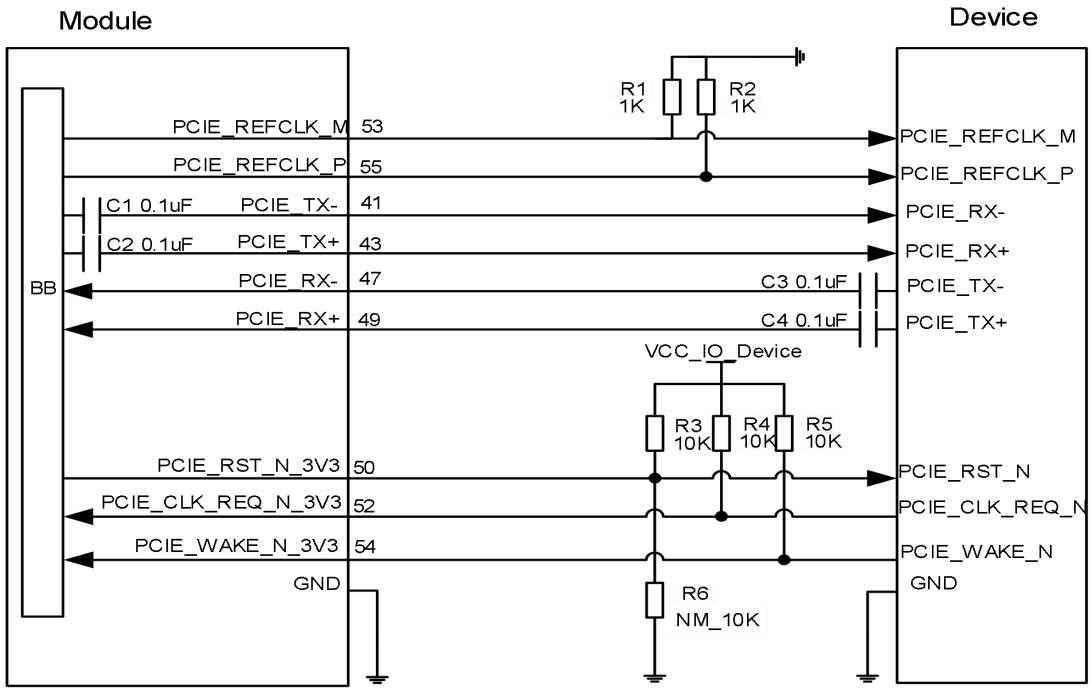


Figure 4.5 Reference Design for Module Connection to PCIe Devices (RC Mode)

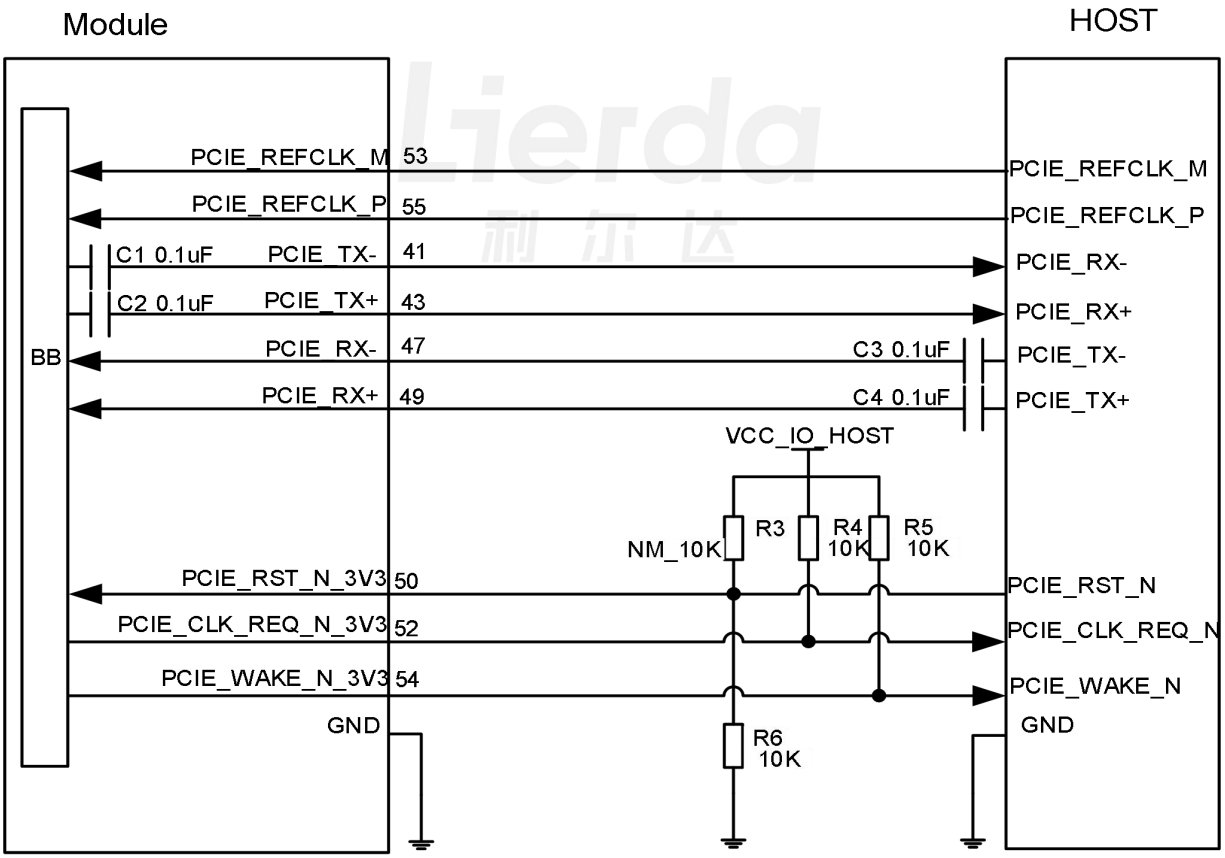


Figure 4.6 Reference Design of Module Connected to PCIe Host (EP Mode)

Note

- C3 and C4, the decoupling capacitors, should be placed close to the Tx PIN. It is recommended to use 0.1uF, +/-10%, X5R or X7R capacitors. C1 and C2 have already been integrated into the module, so there is no need to add these two capacitors when designing the terminal equipment.
- R1 and R2 are recommended to be 1K resistors when connected at the two ends.
- CLK, TX, and RX need to be routed with three pairs of differential signal lines following 100Ω +/-10% differential impedance control.
- When routing PCIe, stay away from sensitive signal sources such as RF, audio, and crystal oscillators.
- PCIe traces cannot be routed under components, and crossing traces with other signals is prohibited.
- CLK, TX, and RX three pairs of differential signal lines should be routed as short as possible, preferably within 350mm, and maintain a 3W line width between differential pairs and other signals.
- CLK, TX, and RX should be routed in a three-dimensional manner with top, bottom, left, right, and ground plane.

4.4 (U)SIM card interface

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

Pin num	Pin names	Type	Description	Parameter	Minimum	Typical Value	Maximum value	Note
30	USIM1_RST	DO	Reset (U)SIM1 card	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
32	USIM1_CLK	DO	Clock of SIM1 card	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	

34	USIM1_DATA	DIO	SIM1 card data	VIH	1.2/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VIL	0	-	0.54/0.9	
				VOH	1.62/2.1	1.85/3.0	1.98/3.3	
				VOL	0	-	0.18/0.3	
36	USIM1_VDD	DO	SIM1 card power	-	1.62	1.85/3.0	3.3	If not used, leave floating
66	USIM1_DET	DI	Detection of SIM1 card	VIH	1.26	1.85	1.98	Ensure logical consistency in the design of software and hardware.
				VIL	0	-	0.54	
40	USIM2_DET	DI	Detection of (U)SIM2 card	VIH	1.26	1.85	1.98	
				VIL	0	-	0.54	
42	USIM2_DATA	DIO	(U)SIM2 card data	VIH	1.2/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VIL	0	-	0.54/0.9	
				VOH	1.62/2.1	1.85/3.0	1.98/3.3	
				VOL	0	-	0.18/0.3	
44	USIM2_CLK	DO	SIM2 card clock	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
46	USIM2_RST	DO	Reset (U)SIM2 card	VOH	1.62/2.1	1.85/3.0	1.98/3.3	If not used, leave floating
				VOL	0	-	0.18/0.3	
48	USIM2_VDD	PO	SIM2 card power	-	1.62	1.85/3.0	3.3	If not used, leave floating

Table 4-4 (U)SIM Card Interface Definition

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

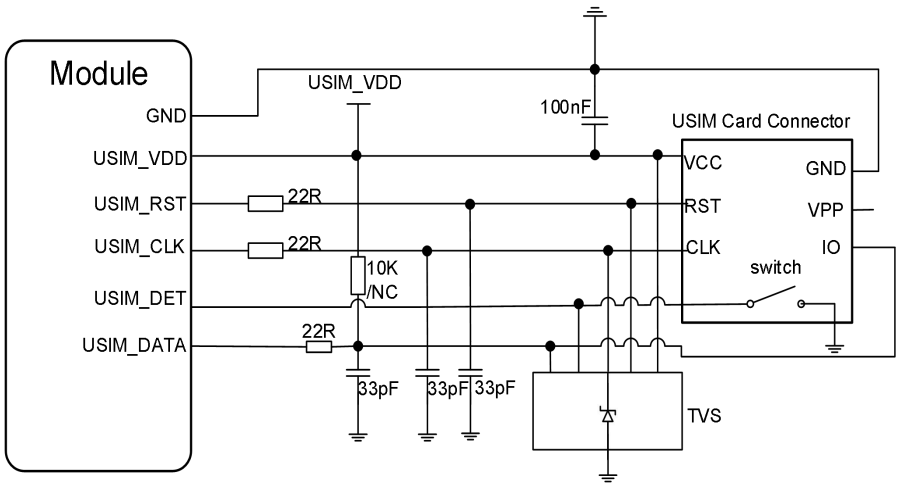


Figure 4.7 8-pin (U)SIM interface reference circuit diagram

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 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

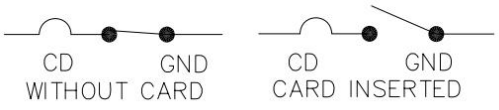


Figure 4.8 SIM card connector Detect Switch operation schematic

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:

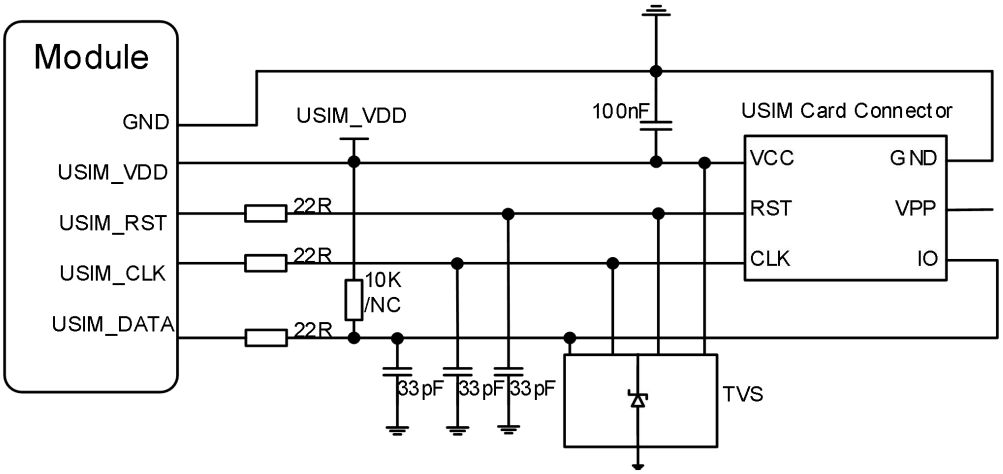


Figure 4.9 6-pin (U)SIM interface reference circuit diagram

4.4.1 Hot-swappable (U)SIM

NE16U-CN 0F 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, thereby supporting (U)SIM card hot plug function. The (U)SIM card hot plug function can be configured via the AT+LSIMDET command.

This command is used to query/enable/disable the card detection of the (U)SIM card. GPIO interrupt is used for (U)SIM card detection, and the detection pin level needs to be set when inserting the (U)SIM card.

Test command AT+LSIMDET=?	Response +LSIMDET: (Supported <enable> list), (Supported <insert_level> List OK

Query command AT+LSIMDET?	Response +LSIMDET:<enable>,<insert_level> OK
Set command AT+LSIMDET=<enable>,<insert_level>	Response OK Or ERROR
Maximum response time	3 seconds
Feature Description	The command will take effect after a restart; Automatic saving after parameter configuration.

Parameters

Integer. Enable/disable (U)SIM card detection function.

0 Disable

1 Enable

<insert_level> integer. Detect the level of the pins when inserting the (U)SIM card.

0 Low Level

1 High Level

Table 4-5 USIM_DET Control Voltage Description

AT format	AT command	SIM card hot plug detection	Function Description
Read Command AT+LSIMSTAT? Write Command AT+LSIMSTAT=<enable>,<insert_level>	AT+LSIMDET=1,0	Start	(USIM) SIM card hot plug detection function enabled, the module detects whether the (U)SIM card is inserted

			through the USIM_DET pin status detection, low-level detection.
	AT+LSIMDET=1,1	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, high level detection.
	AT+LSIMDET=0,0 AT+LSIMDET=0,1	Shut down	SIM card hot plug detection function disabled, module reads (U)SIM card at power on, does not detect USIM_DET status

Note

- NE16U-CN 0F module (U) SIM card hot swap function is enabled by default, and AT+LSIMDET=1,1.
- The <insert_level> value needs to be consistent with the insertion level of the hardware design, otherwise the hot-swappable function will be invalid.
- If a (U)SIM card has been successfully detected, the command to control the (U)SIM card detection function is no longer supported. The module needs to be restarted or the (U)SIM card needs to be hot-swapped before the command to control the (U)SIM card detection function can be used again.

4.4.2 (U)SIM card interface design requirements

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 bracket 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 lines should be routed away from RF lines and VCC 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 needed for the USIM_RST signal.
- To ensure good ESD protection, it is recommended to add TVS diodes placed close to 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 (U)SIM card for debugging purposes. 33pF capacitors should 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.
- Adding a pull-up resistor to USIM_DATA helps to increase the anti-interference ability of the (U)SIM card. It is recommended to reserve a pull-up resistor near the (U)SIM card slot when the (U)SIM card traces are too long or when they are close to the interference source.

4.5 I2C interface

NE16U-CN 0F module provides a set of I2C interfaces, with a maximum speed of up to 3.4Mbps.

Table 4-6 I2C Interface Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
25	I2C_SCL	OD	I2C clock signal	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	

				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
68	I2C_SDA	OD	I2C data signal	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	

The I2C interface schematic diagram is as shown in the following figure, pay attention to level matching when designing the principle:

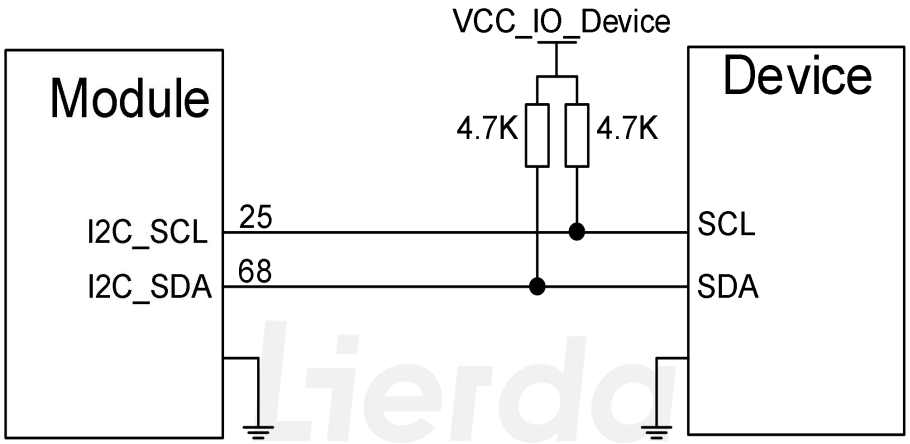


Figure 4-10 I2C Reference Design

4.6 PCM and SPI interfaces

NE16U-CN 0F module supports external connection of LE9643 SLIC through PCM and SPI interfaces.

Table 4-7 PCM and SPI Interface Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
22	PCM_DIN	DI	PCM data input	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
24	PCM_DOUT	DO	PCM data output	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
28	PCM_	DI	PCM	VIH	1.26	1.85	1.98	If not used,

	SYNC	O	synchronous output	VIL	0	-	0.54	leave floating
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
20	PCM_CLK	DIO	PCM clock output	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
				VOH	1.62	1.85	1.98	
				VOL	0	-	0.18	
59	SPI_CS	DO	SPI chip select	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
60	SPI_DI	DI	SPI input	VIH	1.26	1.85	1.98	If not used, leave floating
				VIL	0	-	0.54	
61	SPI_CLK	DO	SPI clock	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
63	SPI_DOUT	DO	SPI output	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	

The external diagram of the LE9643 miSLIC device is as shown in the following figure, please refer to the user manual of LE9643 for detailed design:

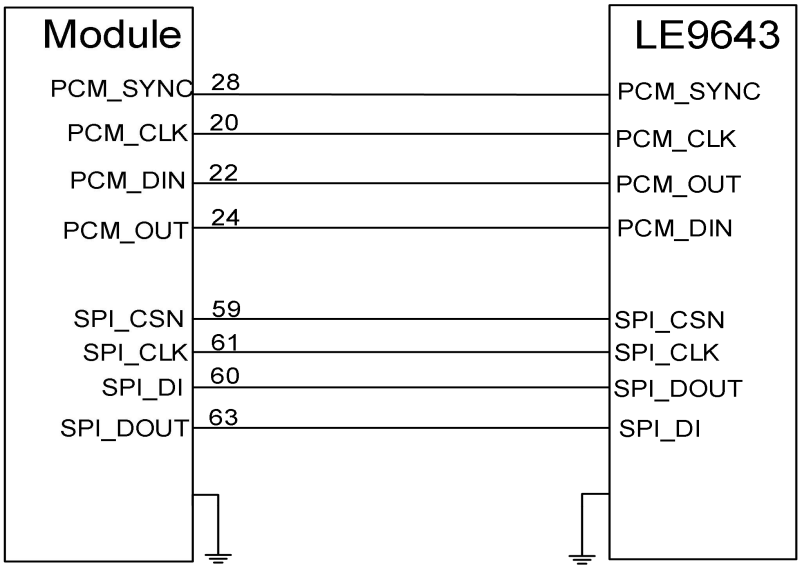


Figure 4-11 PCM and SPI reference design

4.7 Control and status indicator interface

4.7.1 RF status indicator

NE16U-CN 0F module drives the LED through the WWAN_LED# pin, which allows a maximum input current of 20mA.

Table 4-8 WWAN_LED# Interface Description

Pin number	Pin names	Type	Description	Parameters	Note
10	WWAN_LED#	OD	RF status indicator	Maximum sink current 20mA	

Table 4-9 NE16U-CN 0F Module Network Indicator Light Description

Pin names	Pin working status	Network status
WWAN_LED#	High (indicator light off)	If any of the following conditions are met, the RF function will be turned off: ● (U)SIM card not powered on or (U)SIM card not inserted ● Enable airplane mode (W_DISABLE1# is low level). ● Disable RF function (AT+CFUN=0)
	Low (indicator light on)	RF turned on successfully

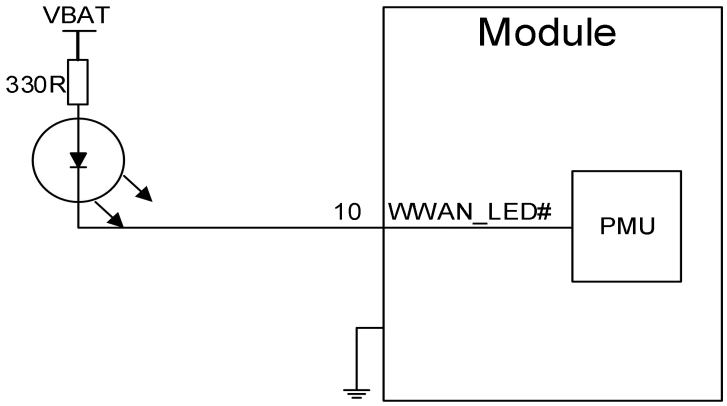


Figure 4.12 RF status indicator light interface reference circuit for NE16U-CN 0F module

4.7.2 Flight mode

NE16U-CN 0F module controls the activation or deactivation of flight mode through the W_DISABLE1# pin. This pin is compatible with two voltage domains: 1.8V and 3.3V. Apart from this method, flight mode can also be activated or deactivated through AT commands.

Table 4-10 NE16U-CN 0F W_DISABLE1# Pin Description

Pin number	Pin names	Type	Description	Parameters	Note
8	W_DISAB	DI	Module flight	Compatible with 1.8V and 3.3V	If not used,

Table 4-11 NE16U-CN 0F 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 to pull up) W_DISABLE1# is normal mode, pull down is flight mode.
2	AT command control	AT+CFUN=4--Enter flight mode AT+CFUN=0--Minimum functionality mode (RF and SIM card turned off) AT+CFUN=1--Full functionality mode

The reference design of the W_DISABLE1# interface is shown in the figure below, where the typical value of VCC_IO_HOST can be 1.8V or 3.3V.

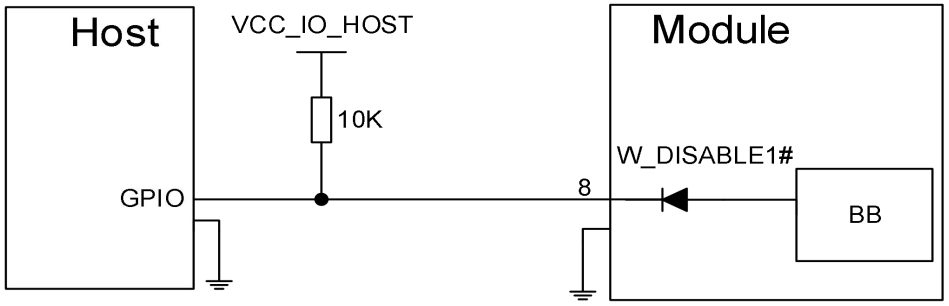


Figure 4.13 Reference circuit for the W_DISABLE1# interface of the NE16U-CN 0F module.

4.7.3 Wake up the host

NE16U-CN 0F module wakes up the host via the WAKE_ON_WAN# pin.

Table 4-12 NE16U-CN 0F Wake-up Host Interface Description

Pin number	Pin names	Type	Description	Parameters	Note
23	WAKE_ON_WA	DO	Wake up the	Low level	If not used, leave

Table 4-13 NE16U-CN 0F Signal Status

Pin status	Module operating status
Output a low-level pulse signal of 1s.	Incoming calls/text messages/data wake up the host.
Always at a high level.	Idle State / Sleep Mode

WAKE_ON_WAN#The interface reference design is as shown in the figure below.

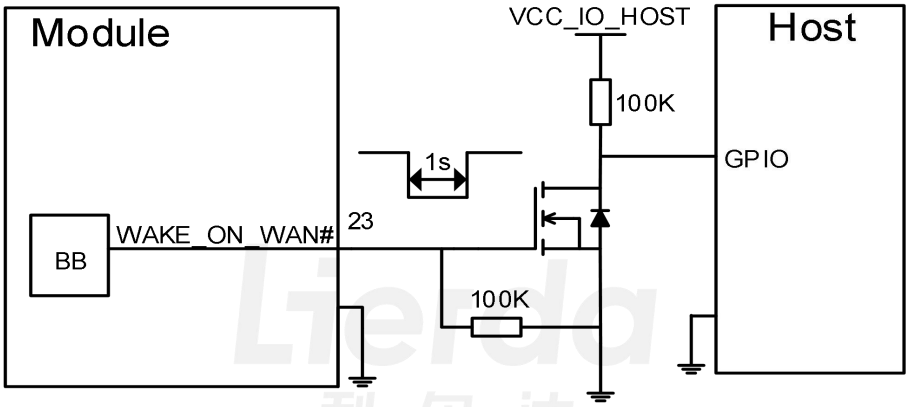


Figure 4.14 WAKE_ON_WAN# Interface Reference Circuit

4.8 B code time synchronization interface

NE16U-CN 0F module provides a B-code output interface for external device timing synchronization.

Table 4-14 NE16U-CN 0F Wake-up Host Interface Description

Pin numb	Pin names	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
26	B_CODE_OUT	DO	B code time synchronization	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	

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

Figure 4.15 B-code output interface reference circuit

4.9 Pin configuration

NE16U-CN 0F module has four configuration pins, defined as in the following table.

Table 4-15 NE16U-CN 0F Module Configuration Pin Description

Pin number	Pin names	Type	Description	Parameters	Note
21	CONFIG_0	DO	The module is suspended	The voltage value is determined by the host end for M.2 port type	If not used,
69	CONFIG_1	DO	Module internal GND	The voltage value is determined by the host end for M.2 port type	If not used,
75	CONFIG_2	DO	The module is suspended	The voltage value is determined by the host end for M.2 port type	If not used,
1	CONFIG_3	DO	The module is suspended	The voltage value is determined by the host end for M.2 port type	If not used,

The following is a reference circuit diagram for four configuration pins:

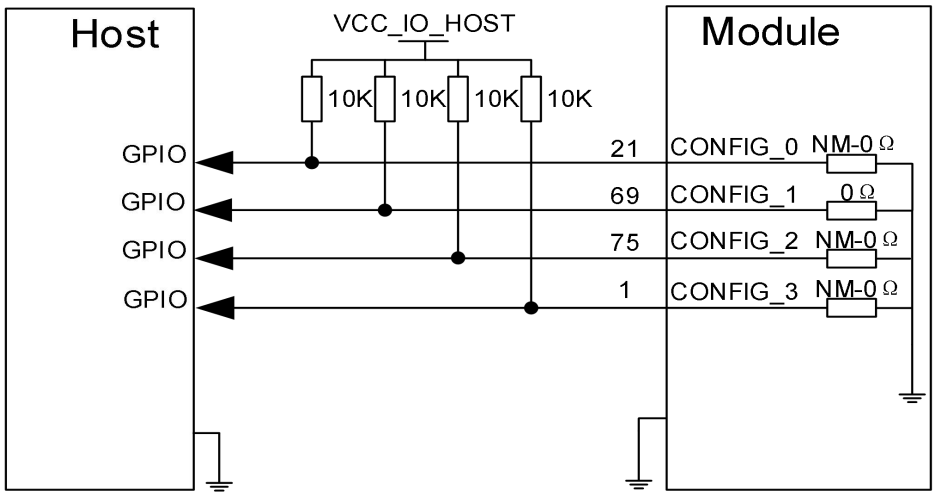


Figure 4.16 CONFIG Configuration Pin Reference Circuit

Table 4-16 Pin Configuration List of the M.2 Specification

CONFIG_0 （Pin 21）	CONFIG_1 (Pin 69)	CONFIG_2 （Pin75）	CONFIG_3 (Pin 1)	Module types and host interfaces.	Port configuration
NC	GND	NC	NC	Defined by Lierda.	N/A

4.10 MIPI RFFE interface.

NE16U-CN 0F module provides a MIPI RFFE interface for antenna tuning switch, defined as the table below.

Table 4-17 NE16U-CN 0F MIPI RFFE Pin Description

Pin number	Pin names	Type	Description	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Note
56	RFFE_CLK	DO	MIPI RFFE Clock	VOH	1.62	1.85	1.98	If not used,
				VOL	0	-	0.18	
58	RFFE_DATA	DO	MIPI RFFE data	VOH	1.62	1.85	1.98	If not used, leave floating
				VOL	0	-	0.18	
65	RFFE_VIO_1V8	PO	Antenna tuner power supply	-	1.2	1.85	2.2	If not used,

Note

* indicates that the interface function is under development and is not supported at the moment.

4.11 Antenna interface

4.11.1 Antenna interface

NE16U-CN 0F module provides four IPEX4 generation antenna interfaces, the positions and interface definitions are as follows:

Figure 4.17 Antenna Interface Position Diagram

Table 4-18 NE16U-CN 0F Antenna Interface Definition

Antenna	LTE/WCDMA	5G NR			Frequency Range
		n8	n1/28	n41/77/78/79	
ANT1	LMHB TRX	TRX	TRX	TRX Second	703～5000
ANT2	LMHB DIV	DRX	DRX	MIMO4	703～5000
ANT3	—	—	MIMO3	TRX Primary	703～5000
ANT4	—	—	MIMO4	MIMO3	703～5000

When in use, the antenna can be directly led out from the antenna interface of the module, or it can be connected through the PCB board. When connecting, the RF traces on the board should be kept as short as possible, and a Π-type matching circuit should be reserved for debugging to ensure that the trace impedance is 50Ω.

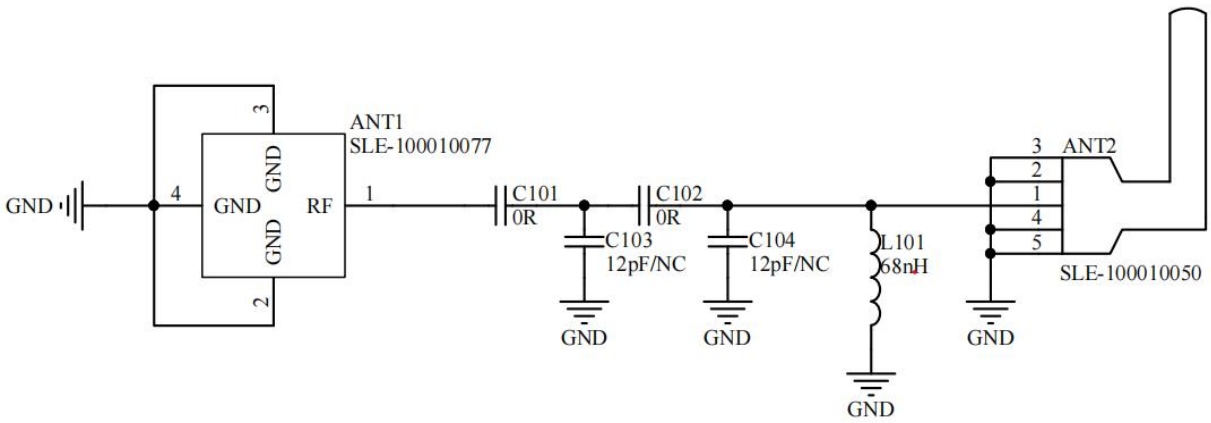


Figure 4.18 Antenna Matching Circuit

4.11.2 RF connector dimensions

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

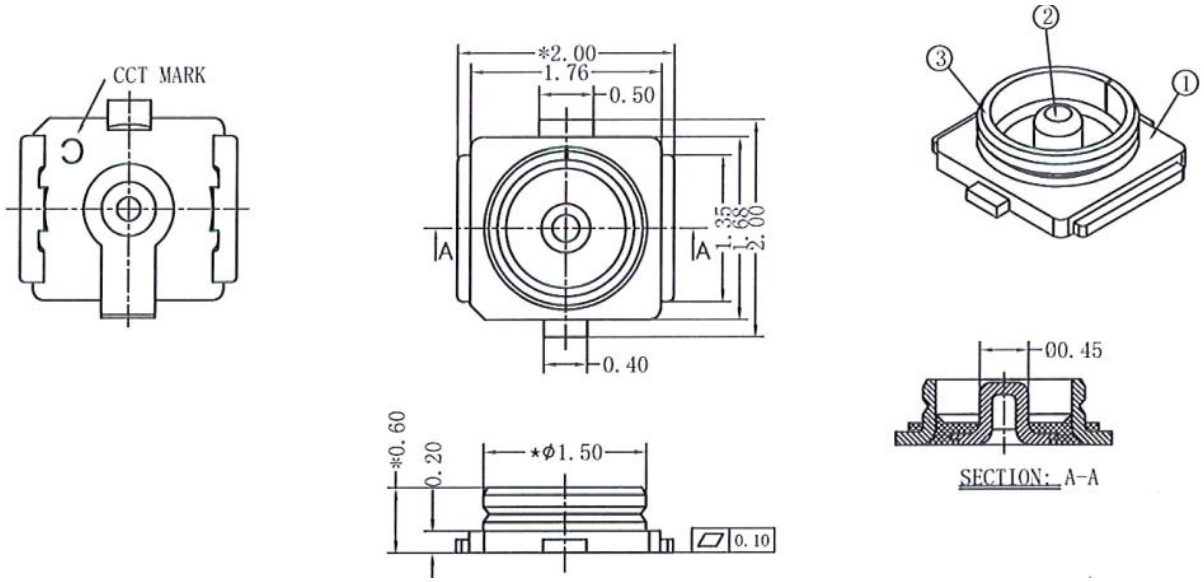


Figure 4.19 Motherboard RF connector dimension diagram (unit: mm)

Table 4-19 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)

4.11.3 RF coaxial cable requirements

Select the coaxial cable that matches the RF connector according to the following specifications.

Table 4-20 RF Coaxial Cable Characteristics

Parameters	Standard
Nominal frequency range	DC~6GHz
Line Losses	0.1dBm/V@100MHz
Characteristic impedance	50Ω
Temperature range	-40~85℃

Voltage Standing Wave Ratio (VSWR)	Maximum 1.5 (3-6 GHz)

The figure shows the post-coupling states of Lierda 0.81 fourth-generation and Lierda 1.13 fourth-generation.

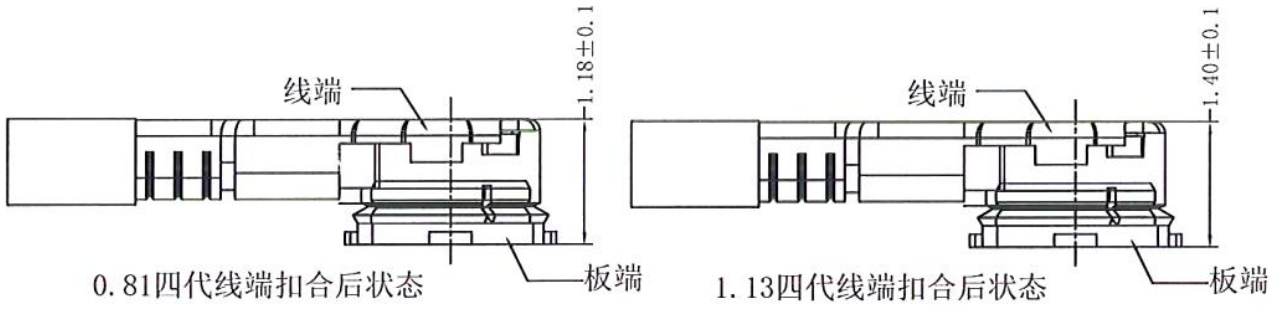


Figure 4.20 The status after the cable connectors are fastened.

4.11.4 Antenna selection requirements

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

Table 4-21 Lierda NE16U-CN 0F 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 transmission power

5.1 Conduction test data

5.1.1 Test environment

Test instruments: Lierda CMW500, MT8000A

Power: 66319D

5.1.2 Conduction reception sensitivity

The reception sensitivity index is an important parameter for evaluating the performance of the NE16U-CN 0F module, and the test results are shown in the table below.

Table 5-1 Description of the receiving sensitivity of Lierda NE16U-CN 0F

Frequency band	Test value (unit: dBm)			3GPP(SIMO)
	Main Collection	Episodes	SIMO[1]	
WCDMA Band 1	-110	-110.5	-113	-106.7
WCDMA Band 5	-108	-111	-112	-104.7
WCDMA Band 8	-108	-110.5	-111.8	-103.8
LTE Band 1(10 MHz)	-98	-99.2	-101.2	-96.3
LTE Band 3(10 MHz)	-96.1	-96.8	-99.5	-93.3
LTE Band 5(10 MHz)	-97.8	-99	-101	-94.3
LTE Band 8(10 MHz)	-97.5	-98.9	-100.5	-93.3
LTE Band 34(10 MHz)	-96.9	-97.2	-100	-96.3

[1] 对于 SIMO 灵敏度测试值，WCDMA、LTE、NR n8 是在 2RX 天线下测量得到，NR n1/n28/n41/n77/n78/n79 是在 4RX 天线下测量得到。

Frequency band	Test value (unit: dBm)			3GPP(SIMO)
	Main Collection	Episodes	SIMO[1]	
LTE Band 38(10 MHz)	-98.2	-98.3	-101.2	-96.3
LTE Band 39(10 MHz)	-97	-98.5	-100.4	-96.3
LTE Band 40(10 MHz)	-98	-97	-100.5	-96.3
LTE Band 41(10 MHz)	-97.8	-98	-100.8	-94.3
NRn1(20 MHz)	/	/	-101.2	-93.8
NR n8(20 MHz)	/	/	-97.2	-85.8
NR n28(20 MHz)	/	/	-100.5	-90.8
NR n41(100 MHz)	/	/	-92.8	-86.7
NR n77(100 MHz)	/	/	-93.8	-86.8
NR n78(100 MHz)	/	/	-93.6	-87.3
NR n79(100 MHz)	/	/	-94.2	-86.8

5.1.3 Transmitting power

The conducted transmit power is an important indicator to measure the performance of the NE16U-CN 0F module, and the test results are shown in the table below.

Table 5-2 Lierda NE16U-CN 0F Transmit Power Description

Frequency band	Maximum value of transmission power	Minimum value of transmission power
WCDMA B1/B5/B8	24dBm +1.7/-3.7dB	< -49dBm
LTE B1/B3/B5/B8/B34/B39/B38/B	23dBm ±2.7dB	< -39dBm
NR n1/n8/n41	23dBm ±2.7dB(Class 3)	< -40dBm
NR n28	23dBm +2.7/-3.2dB(Class 3)	< -40dBm
NR n77/n78/n79	23dBm +2.7/-3.7dB(Class3)	< -40dBm
NR n41/n77/n78/n79	26dBm +2.7/-3.7dB(Class2)	< -40dBm

6 Electrical performance and reliability

This chapter mainly introduces the electrical characteristics and reliability characteristics of the NE16U-CN 0F module interface.

6.1 Work and storage environment

The operating and storage temperature ranges of the NE16U-CN 0F module are shown in the table below.

Table 6-1 NE16U-CN 0F operating and storage temperatures

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

6.2 Power Characteristics

The input voltage requirements for the NE16U-CN 0F module are as shown in the table below.

Table 6-2 NE16U-CN 0F Operating Voltage

Symbols	Parameters	Minimum value (V)	Typical value (V)	Maximum value (V)	Ripple (V)
VCC	External power supply voltage	3.3	3.8	4.4	0.1

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

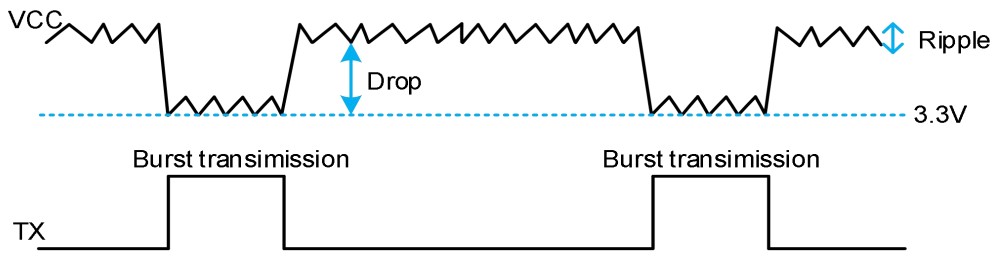


Figure 6.1 Power Requirements for RF Transmission

6.3 Absolute maximum rated value

Table 6-3 Absolute Maximum Ratings

Symbol	Minimum value	Maximum value	Unit
VCC	-0.3	6.0	V
Digital interface voltage	-0.3	2.1	V

6.4 Power consumption characteristics

Table 6-4 Power Consumption of Lierda NE16U-CN 0F Module

Module status	Condition	Average Typ.Current(mA)@ 3.8V
Shutdown mode	Module power off	0.076
Sleep mode	Idle(AT+cfun=0)	3.7
Maximum transmission power of WCDMA	WCDMA B1 HSDPA CH9750 @ 23.36 dBm	744
	WCDMA B1 HSUPA CH9750 @ 21.21 dBm	583
	WCDMA B5 HSDPA CH4182 @ 23.57dBm	673
	WCDMA B5 HSUPA CH4182 @ 21.55 dBm	581
	WCDMA B8 HSDPA CH2788 @ 23.59 dBm	638
	WCDMA B8 HSUPA CH2788 @ 20.08 dBm	518
Maximum transmission power of LTE	LTE-FDD B1 CH18300@23.15dBm	674
	LTE-FDD B3 CH19575@22.1dBm	588
	LTE-FDD B5 CH20525@22.85dBm	660
	LTE-FDD B8 CH21625@23dBm	637
	LTE-TDD B34 CH36275@23.2dBm	350
	LTE-TDD B38 CH38000@21.74dBm	423
	LTE-TDD B39 CH38450@22.1dBm	336
	LTE-TDD B40 CH39150@22.84dBm	373
	LTE-TDD B41 CH40620@22.81dBm	462
Maximum transmission power of 5G	5G NR-FDD n1 CH389000@23.46dBm	1074
	5G NR-FDD n1 CH390000@23.37dBm	1072
	5G NR-FDD n1 CH391000@23.48dBm	1070

Module status	Condition	Average Typ.Current(mA)@ 3.8V
NR	5G NR-FDD n8 CH178000@23.95dBm	968
	5G NR-FDD n8 CH179500@23.82dBm	933
	5G NR-FDD n8 CH181000@24.02dBm	1010
	5G NR-FDD n28 CH143600@22.02dBm	937
	5G NR-FDD n28 CH145100@21.17dBm	910
	5G NR-FDD n28 CH146600@22.03dBm	922
	5G NR-TDD n41 CH509202@25.05dBm	626
	5G NR-TDD n41 CH518600@25.53dBm	604
	5G NR-TDD n41 CH527997@25.16dBm	681
	5G NR-TDD n77 CH623334@25.79dBm	710
	5G NR-TDD n77 CH650000@26.39dBm	754
	5G NR-TDD n77 CH676666@26.78dBm	789
	5G NR-TDD n78 CH623334@24.65dBm	684
	5G NR-TDD n78 CH636667@25.27dBm	724
	5G NR-TDD n78 CH649999@25.25dBm	716
	5G NR-TDD n79 CH696668@25.91dBm	709
	5G NR-TDD n79 CH713334@25.83dBm	729
	5G NR-TDD n79 CH729999@25.53dBm	743
WCDMA voice call	WCDMA B1 CH9750@23.97dBm	665
	WCDMA B5 CH4182@23.23dBm	588
	WCDMA B8 CH2788@24.03dBm	614

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 noticeable 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, CJ<0.5pF for USB3.0 interface

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

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

6.5.2 ESD environment control recommendations

(1) The processing equipment, testing instruments, tools, and equipment of electrostatic sensitive devices and components should all be reliably grounded.

(2) The parts that come into contact with electrostatic sensitive components on equipment, instruments, tools, and fixtures, as well as moving parts near electrostatic sensitive components, are made of anti-static materials and have good grounding. Non-antistatic material parts are treated for electrostatic protection.

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

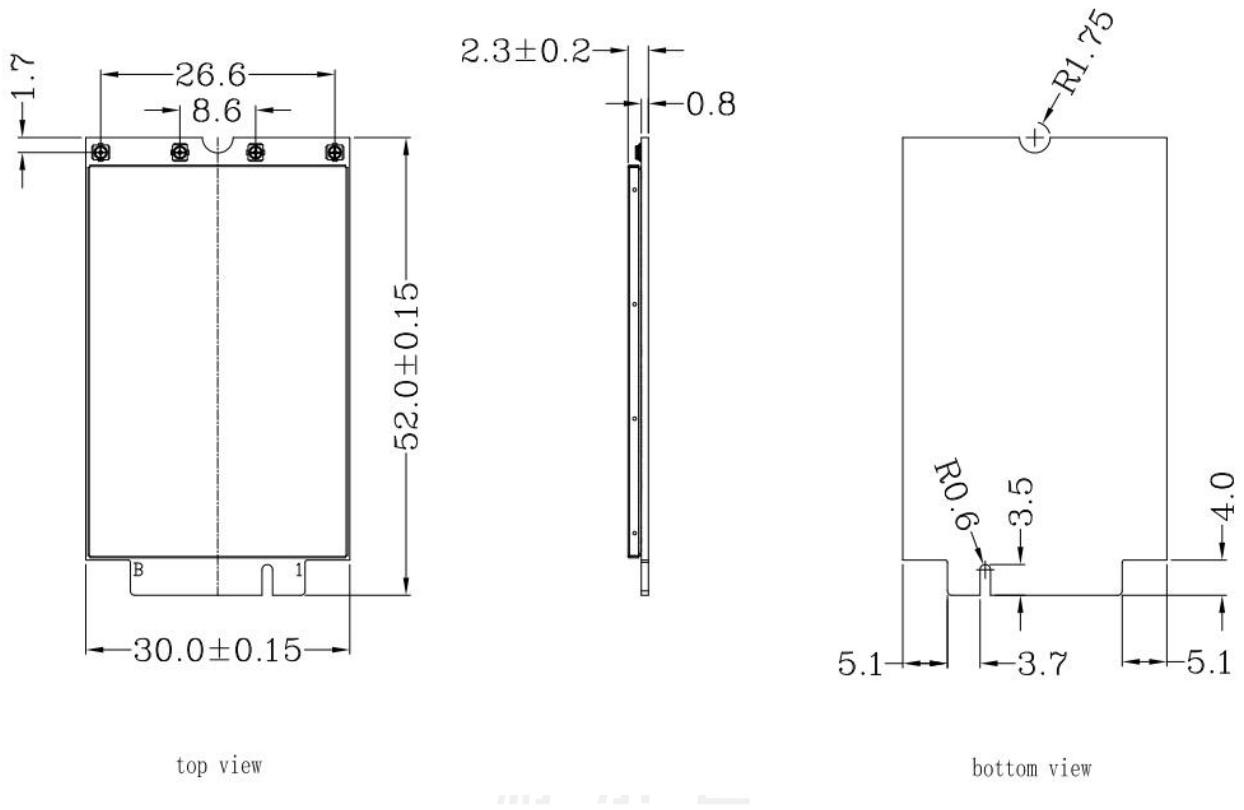
(4) Are there obvious anti-static signs and anti-static measures in the process of transporting and storing electrostatic sensitive devices?

Table 6-5 ESD Performance Parameters (Temperature: 25ºC, Humidity: 40%)

Pin name	Discharge.	Air discharge
VCC,GND	+/-6kV	+/-10kV
Antenna interface	+/-6kV	+/-10kV
Others	+/-0.5kV	+/-2kV

7 Mechanical dimensions

7.1 Mechanical dimensions



UNIT:mm

Figure 7-1 Module Mechanical Dimension Diagram

7.2 Module top view / bottom view

Top View Bottom View

Figure 7.2 Top/Bottom View of the Module

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 M.2 connector

The NE16U-CN 0F module uses a standard PCI Express M.2 connector. For more information, please refer to PCI Express M.2 Specification Revision 3.0, Version 1.2.

8 Packaging information

NE16U-CN 0F module is packaged in a blister pack, the specific solution is as follows.

8.1 Thermoformed tray

The size of the vacuum-formed tray is as follows:

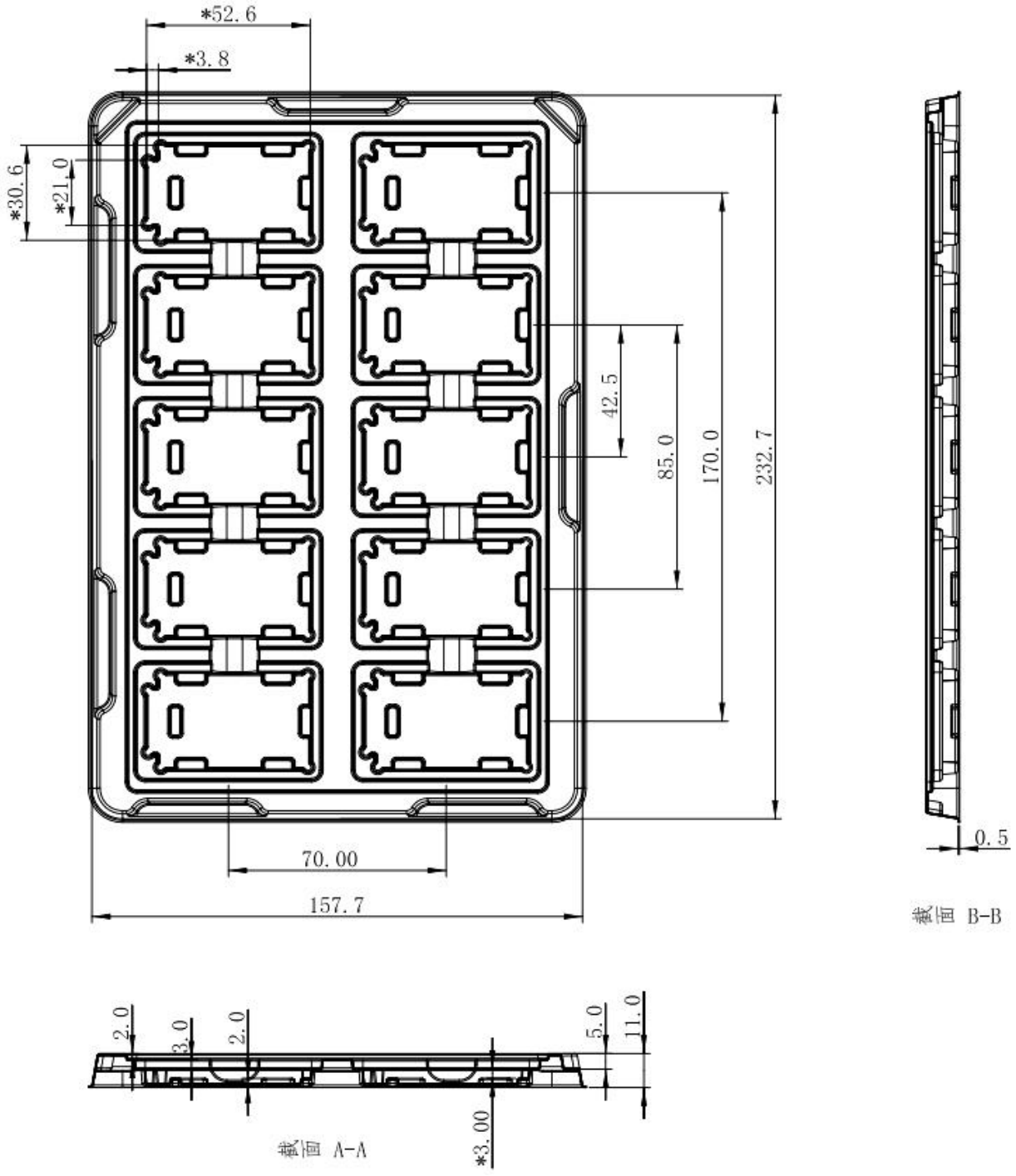
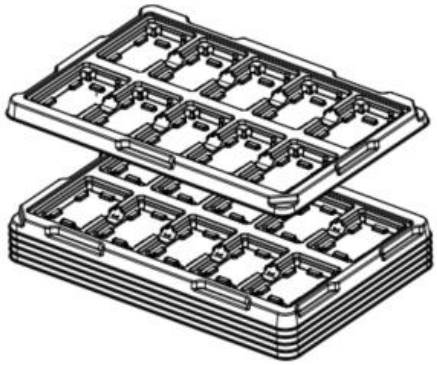


Figure 8.1 Vacuum-formed tray dimensional drawing (unit:mm)

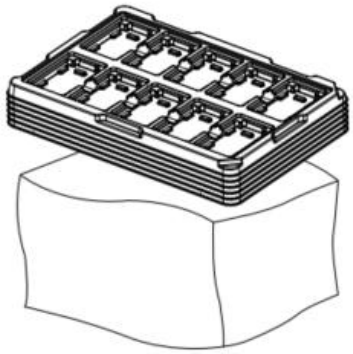
8.2 Packaging process



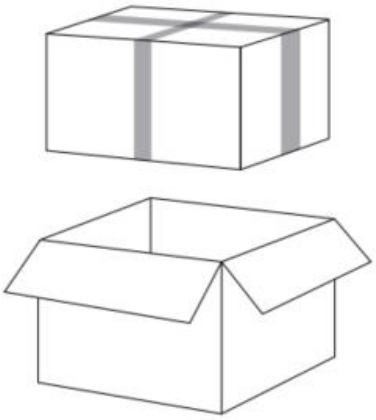
Each blister tray holds 10 modules, then 5 are filled.

The modules' trays are stacked together, with an empty one placed on top.

Tray.

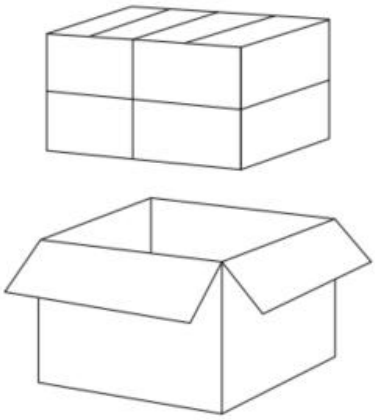


Pack 6 vacuum-formed trays together, place a piece of cardboard on top and bottom, add 10g desiccant, then put the vacuum-formed trays into an aluminum foil bag, vacuum seal and pack.



Put the sealed vacuum-formed tray into a small box, one small box can accommodate

Install 50 modules.



Put 4 small boxes into one cardboard box and seal the box. One cardboard box can pack 200 modules.

Figure 8.2 Packaging Process

9 Related documents and terminology abbreviations

Table 9-1 Related Documents

Serial number	Document name	Annotation
[1]	NE16U-CN AT Command Manual V2.0	AT command set

Table 9-2 Term Abbreviations

Abbreviation	Full English name	Chinese full name
bps	bits per second	Per second
CPE	Customer-Premise Equipment	User residence 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	Many inputs, many outputs
NR	New Radio	New air interface
PCIe	Peripheral Component Interconnect	Peripheral component

	Express	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 Phase Shift Keying
RC	Root Complex	Root complex
RF	Radio Frequency	Radio frequency
RFFE	RF Front-End	RF front end
Rx	Receive	Receive
SCS	Subcarrier Spacing	Carrier spacing
SIMO	Single Input Multiple Output	Single Input Multiple Output
SMS	Short Message Service	Short Message Service
Tx	Transmit	Send
UART	Universal Asynchronous Receiver & Transmitter	Universal asynchronous receiver-transmitter
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	Input low voltage level
VOH	Output High Voltage Level	Output high voltage level
VOL	Output Low Voltage Level	Output low voltage level
WCDMA	Wideband Code Division Multiple Access	Broadband code division multiple access