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FIBOCOM NL668-AM Hardware User Manual

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Date: 2018-11-13

Applicability type

No.	Product model	Description
1	NL668-AM-00	MCP is 4+2, and supports MAIN_ANT, DIV_ANT, GNSS_ANT
2	NL668-AM-01	Based on NL668-AM-00 delete Band 71

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Versions

Version	Author	Assessor	Approver	Update Date	Description
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1 Foreword

1.1 Introduction

This document describes the electrical characteristics, RF performance, structure size, application environment, etc. of NL668-AM module. With the assistance of the document and other instructions, the developers can quickly understand the hardware functions of the NL668-AM module and develop products.

1.2 Safety Instruction

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

Road safety first! When you drive, do not use the handheld devices even if it has a hand-free feature. Please stop and call.

Please turn off the mobile device before boarding. The wireless feature of the mobile device is not allowed on the aircraft to prevent interference with the aircraft communication system. Ignoring this note may result in flight safety issue or even breaking the law.

When in a hospital or health care facility, please be aware of restrictions on the use of mobile devices. Radio frequency interference may cause medical equipment to malfunction, so it may be necessary to turn off the mobile device.

The mobile device does not guarantee that an effective connection can be made under any circumstances, for example, when there is no prepayment for the mobile device or the SIM is invalid. When you encounter the above situation in an emergency, remember to use an emergency call, while keeping your device turned on and in areas where signal is strong.

Your mobile device receives and transmits RF signals when it is powered on. Radio interference occurs when it is near televisions, radios, computers, or other electronic devices.

Keep the mobile device away from flammable gases. Turn off the mobile device when near gas stations, oil depots, chemical plants or explosive workplaces. There is a safety hazard in operating electronic equipment in any potentially explosive environment.

1.3 Reference Standards

This design of the product complies with the following standards:

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

1.4 Related Document

- FIBOCOM_RF Antenna Application Design Instruction
- FIBOCOM_ADP-NL668 Evaluation board instruction
- FIBOCOM_NL668 AT Command Manual
- FIBOCOM_EVK-GT8230-NL User Manual
- FIBOCOM_ NL668 LCC SMT Application Design Instruction

1.5 Federal Communication Commission Interference Statement

FCC Regulations:

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

This device has been tested and found to comply with the limits for a Class B digital device , pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiated radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

-Reorient or relocate the receiving antenna.
-Increase the separation between the equipment and receiver.
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
-Consult the dealer or an experienced radio/TV technician for help.

Caution: Changes or modifications not expressly approved by the party responsible for compliance could void the user‘s authority to operate the equipment.

RF Exposure Information:

This device complies with FCC radiation exposure limits set forth for an uncontrolled environment. In order to avoid the possibility of exceeding the FCC radio frequency exposure limits, human proximity to the antenna shall not be less than 20cm (8 inches) during normal operation.

IMPORTANT NOTE :

This module is intended for OEM integrator. The OEM integrator is still responsible for the FCC compliance requirement of the end product, which integrates this module. 20cm minimum distance has to be able to be maintained between the antenna and the users for the host this module is integrated into. Under such configuration, the FCC radiation exposure limits set forth for an population/uncontrolled environment can be satisfied.

Any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment.

USERS MANUAL OF THE END PRODUCT :

In the user manual of the end product, the end user has to be informed to keep at least 20cm separation with the antenna while this end product is installed and operated. The end user has to be informed that the FCC radio-frequency exposure guidelines for an uncontrolled environment can be satisfied. The end user has to also be informed that any changes or modifications not expressly approved by the manufacturer could void the user's authority to operate this equipment. If the size of the end product is smaller than 8x10cm, then additional FCC part 15.19 statement is required to be available in the users manual: This device complies with Part 15 of FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

LABEL OF THE END PRODUCT :

The final end product must be labeled in a visible area with the following " Contains Transmitter Module FCC ID: ZMONL668AM01". If the size of the end product is larger than 8x10cm, then the following FCC part 15.19 statement has to also be available on the label: This device complies with Part 15 of FCC rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference and (2) this device must accept any interference received, including interference that may cause undesired operation.

2 Product Overview

2.1 Product Introduction

The NL668-AM wireless module is a wideband wireless terminal product applicable to various network formats and multi-bands including FDD-LTE/UMTS.

2.2 Product Specifications

Specification		
Operating frequency	NL668-AM-00	LTE FDD: Band 2,4,5,12,13,17,66,71
		WCDMA: Band 2,4,5
	NL668-AM-01	LTE FDD: Band 2,4,5,12,13,17,66
		WCDMA: Band 2,4,5
Data transmission	LTE FDD Rel.9	150Mbps DL/50Mbps UL(Cat 4); LTE Downlink MIMO 2x2, 4x2
	WCDMA Rel.8	WCDMA:384 kbps DL/384 kbps UL
		DC-HSDPA+:42Mbps (Cat 24)/HSUPA:5.76Mbps (Cat 6)
Power	3.3V～4.3V (3.8V recommended)	
Temperature	Normal: -30°C～+75°C	
	Extended: -40°C～+85°C	
	Storage: -40°C～+85°C	
Power consumption	Base current: <1.5mA	
	Sleep mode: ≤3mA	
	Idle mode: <20mA	
Physical characteristics	Package: LCC 144PIN	
	Size: 32.0×29.0×2.4 mm	
	Weight: About 5.5g	
Interface		
Antenna	Antenna: Main x 1, GNSS x 1, DIV x 1	
Functional	USIM 3.0V/1.8V	

Interface	USB 2.0 x 1
	UART, PCM, I2C, SGMII, SDIO, GPIO, SPI
	System Indicator
	ADC
Software	
Protocol Stack	Embedded TCP/IP and UDP/IP protocol stack
AT Command	3GPP TS 27.007 and 27.005, and proprietary FIBOCOM AT
Firmware update	USB(UART does not support DOWNLOAD)
Voice service	VoLTE, HR, FR, EFR, AMR, DTMF, Caller ID, Call Transfer, Call Hold, Call Waiting and Multi-Talk, etc.
SMS	point-to-point MO, MT; cell broadcast; support Text and PDU modes
MMS service	Need AP to realize MMS protocol

Table 2-1 Product Specifications

Note:
When the temperature is beyond the normal operating temperature range (-30 °C to + 75 °C), the RF performance of the module may slightly exceed the 3GPP specifications.

2.3 Hardware Diagram

Figure 2-2 hardware diagram shows the main hardware features of the NL668-AM module, including baseband and RF features.

Baseband includes:

- UMTS/ LTE FDD controller
- PMIC
- MCP
- UART、USB、SIM、PCM、I2C、SPI、SGMII、SDIO、ADC

RF includes:

- RF Transceiver
- RF PA
- RF filter
- Antenna

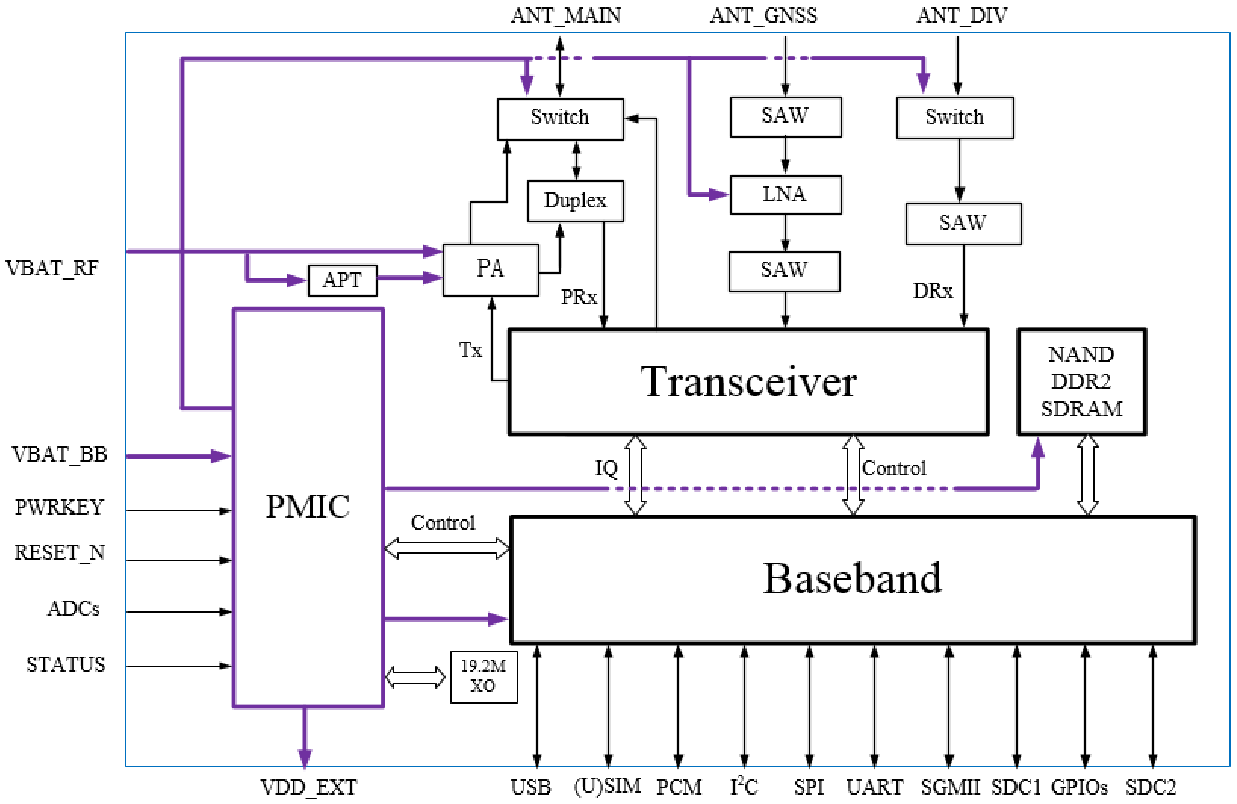

ANT_MAIN
ANT_GNSS
ANT_DIV
Switch
SAW
Switch
Duplex
LNA
SAW
VBAT_RF
APT
PA
SAW
PRx
DRx
Tx
Transceiver
NAND
DDR2
SDRAM
VBAT_BB
IQ
Control
PWRKEY
PMIC
Control
RESET_N
Baseband
ADCs
STATUS
19.2M
XO
VDD_EXT
USB
(U)SIM
PCM
I2C
SPI
UART
SGMII
SDC1
GPIOs
SDC2

Figure 2-1 Hardware Diagram

3 Application Interface

3.1 LCC Interface

NL668-AM module adopts LCC packaging, with a total of 144 pins.

3.1.1 Pin distribution

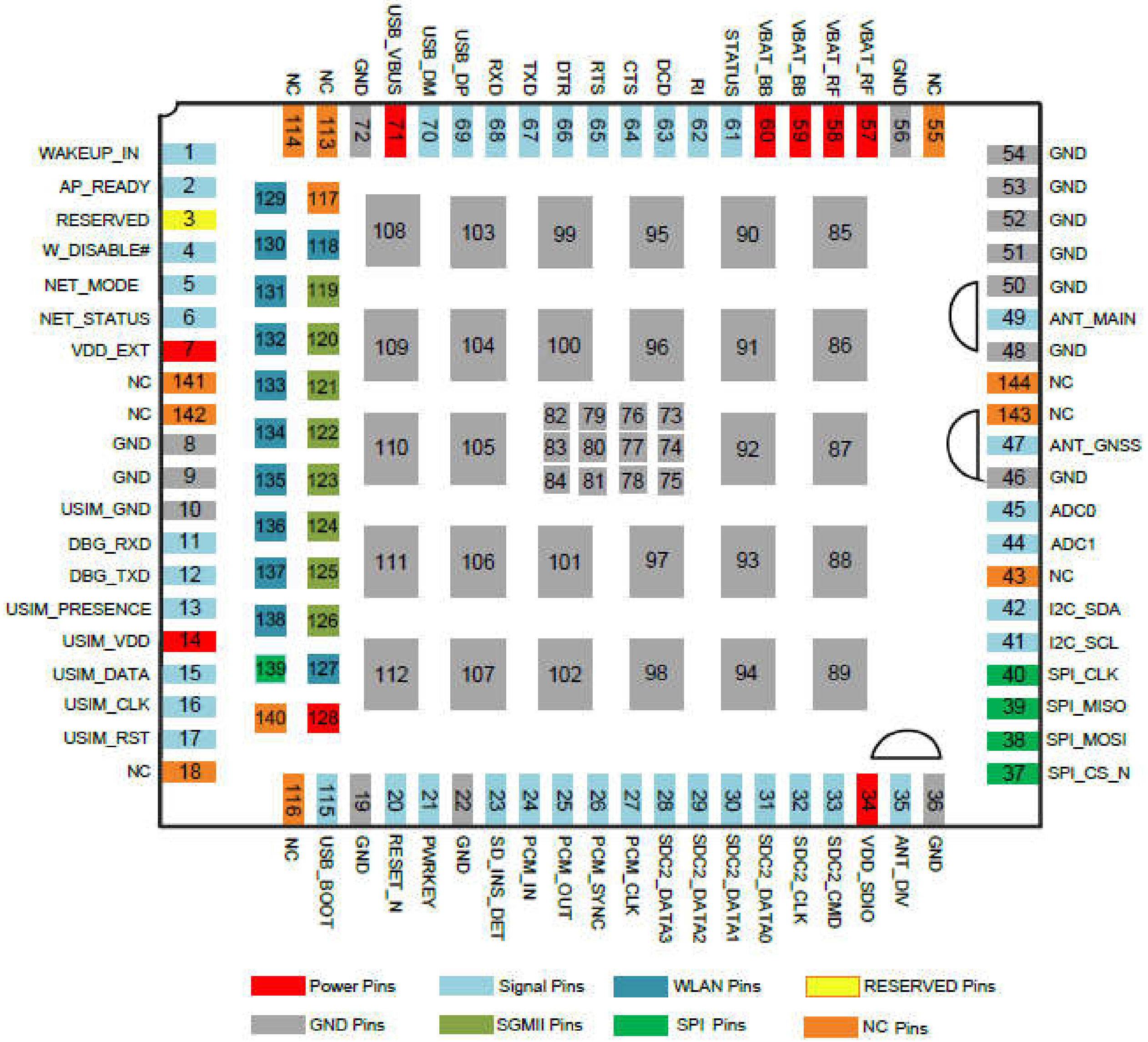

NC 114
NC 113
GND 72
USB_VBUS 71
USB_DM 70
USB_DP 69
RXD 68
TXD 67
DTR 66
RTS 65
CTS 64
DCD 63
RI 62
STATUS 61
VBAT_BB 60
VBAT_BB 59
VBAT_RF 58
VBAT_RF 57
GND 56
NC 55
WAKEUP_IN 1
AP_READY 2
RESERVED 3
W_DISABLE# 4
NET_MODE 5
NET_STATUS 6
VDD_EXT 7
NC 141
NC 142
GND 8
GND 9
USIM_GND 10
DBG_RXD 11
DBG_TXD 12
USIM_PRESENCE 13
USIM_VDD 14
USIM_DATA 15
USIM_CLK 16
USIM_RST 17
NC 18
129 117
130 118
131 119
132 120
133 121
134 122
135 123
136 124
137 125
138 126
139 127
140 128
108 103 99 95 90 85
109 104 100 96 91 86
82 79 76 73
83 80 77 74
84 81 78 75
110 105 92 87
111 106 101 97 93 88
112 107 102 98 94 89
54 GND
53 GND
52 GND
51 GND
50 GND
49 ANT_MAIN
48 GND
144 NC
143 NC
47 ANT_GNSS
46 GND
45 ADC0
44 ADC1
43 NC
42 I2C_SDA
41 I2C_SCL
40 SPI_CLK
39 SPI_MISO
38 SPI_MOSI
37 SPI_CS_N
116 NC
115 USB_BOOT
19 GND
20 RESET_N
21 PWRKEY
22 GND
23 SD_INS_DET
24 PCM_IN
25 PCM_OUT
26 PCM_SYNC
27 PCM_CLK
28 SDC2_DATA3
29 SDC2_DATA2
30 SDC2_DATA1
31 SDC2_DATA0
32 SDC2_CLK
33 SDC2_CMD
34 VDD_SDIO
35 ANT_DIV
36 GND
Power Pins
Signal Pins
WLAN Pins
RESERVED Pins
GND Pins
SGMII Pins
SPI Pins
NC Pins

Figure 3-1 Pin Distribution Diagram(TOP plan perspective diagram)

Note:

“73 ~ 112” is the thermal pin, and the module is grounded internally. It is recommended that the heat sink pad is reserved for PCB packaging and welded.

3.1.2 Pin definition

The pin definitions are shown in the following table:

Pin	Pin Name	I/O	Level	Description
1	WAKEUP_IN	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	External device wake-up module
2	AP_READY	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	Reserved
3	RESERVED		-	Reserved
4	W_DISABLE#	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	Module flight mode control
5	NET_MODE	O	V_{OH}min=1.35V V_{OL}max=0.45V	Module state indicate
6	NET_STATUS	O	V_{OH}min=1.35V V_{OL}max=0.45V	Reserved
7	VDD_EXT	PO	1.8V	Module digital level, 1.8V output, 80mA
8	GND	G	-	Ground
9	GND	G	-	Ground
10	GND	G	-	Ground
11	DBG_RXD	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	DEBUG serial port Receive data
12	DBG_TXD	O	V_{OL}max=0.45V V_{OH}min=1.35V	DEBUG serial port Transmit data
13	USIM_PRESENCE	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	USIM card hot plug detection
14	USIM _VDD	O	For 1.8V USIM: Vmax=1.9V Vmin=1.7V	USIM power

Pin	Pin Name	I/O	Level	Description
			For 3.0V USIM: Vmax=3.05V Vmin=2.7V $I_O$max=150mA	
15	USIM _DATA	O	For 1.8V USIM: V_{IL}max=0.6V V_{IH}min=1.2V V_{OL}max=0.45V V_{OH}min=1.35V For 3.0V USIM: V_{IL}max=1.0V V_{IH}min=1.95V V_{OL}max=0.45V V_{OH}min=2.55V	USIM data signal cable
16	USIM _CLK	O	For 1.8V USIM: V_{OL}max=0.45V V_{OH}min=1.35V For3.0V USIM: V_{OL}max=0.45V V_{OH}min=2.55V	USIM clock signal cable
17	USIM _RST	O	For 1.8V USIM: V_{OL}max=0.45V V_{OH}min=1.35V For 3.0V USIM: V_{OL}max=0.45V V_{OH}min=2.55V	USIM reset signal cable
18	NC	-	-	NC
19	GND	G	-	Ground
20	RESET_N	I	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	Module reset signal, active low, no need pull up externally
21	PWRKEY	I	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	Turn on/off the module, active low, no need pull up externally
22	GND	G	-	Ground
23	SD_INS_DET	I	-	Reserved
24	PCM_IN	I	V_{IL}min=-0.3V	PCM input signal

Pin	Pin Name	I/O	Level	Description
			V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	
25	PCM_OUT	O	V_{OL}max=0.45V V_{OH}min=1.35V	PCM output signal
26	PCM_SYNC	I/O	V_{OL}max=0.45V V_{OH}min=1.35V V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	PCM synchronization signal
27	PCM_CLK	I/O	V_{OL}max=0.45V V_{OH}min=1.35V V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	PCM clock signal
28	SDC2_DATA3	I/O	-	Reserved
29	SDC2_DATA2	I/O	-	Reserved
30	SDC2_DATA1	I/O	-	Reserved
31	SDC2_DATA0	I/O	-	Reserved
32	SDC2_CLK	O	-	Reserved
33	SDC2_CMD	I/O	-	Reserved
34	VDD_SDIO	PO	-	Reserved
35	ANT_DIV	I	-	Diversity antenna
36	GND	G	-	Ground
37	SPI_CS_N	I	-	Reserved
38	SPI_MOSI	I	-	Reserved
39	SPI_MISO	O	-	Reserved
40	SPI_CLK	O	-	Reserved
41	I2C_SCL	OD	-	I2C interface clock signal
42	I2C_SDA	OD	-	I2C interface data signal
43	NC	-	-	NC
44	ADC1	I	-	Analog to digital converter interface
45	ADC0	I	-	Analog to digital converter interface 0
46	GND	G	-	Ground

Pin	Pin Name	I/O	Level	Description
47	ANT_GNSS	I	-	GNSS antenna
48	GND	G	-	Ground
49	ANT_MAIN	I/O	-	Main antenna
50	GND	G	-	Ground
51	GND	G	-	Ground
52	GND	G	-	Ground
53	GND	G	-	Ground
54	GND	G	-	Ground
55	NC	-	-	NC
56	GND	G	-	Ground
57	VBAT_RF	I	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	RF power input (3.3V~4.3V)
58	VBAT_RF	I	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	RF power input (3.3V~4.3V)
59	VBAT_BB	I	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	Baseband power input（3.3V~4.3V）
60	VBAT_BB	I	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	Baseband Power Input (3.3V~4.3V)
61	STATUS	O	V_{OH}min=1.35V V_{OL}max=0.45V	Reserved
62	RI	O	V_{OL}max=0.45V V_{OH}min=1.35V	Module output ring indicator
63	DCD	O	V_{OL}max=0.45V V_{OH}min=1.35V	Module output data carrier detection
64	CTS	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	Clear to send
65	RTS	O	V_{OL}max=0.45V V_{OH}min=1.35V	Request to send
66	DTR	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V	Data ready

Pin	Pin Name	I/O	Level	Description
			V_{IH}max=2.0V	
67	TXD	O	V_{OL}max=0.45V V_{OH}min=1.35V	Transmit data
68	RXD	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	Receive data
69	USB_DP	I/O	Conform to USB2.0 standard specification	USB differential data bus (+)
70	USB_DM	I/O	Conform to USB2.0 standard specification	USB differential data bus (-)
71	USB_VBUS	I	Vmax=5.25V Vmin=3.0V Vnorm=5.0V	USB plug detection
72	GND	G	-	Ground
73-112	GND	G	-	Ground
113	NC	-	-	NC
114	NC	-	-	NC
115	USB_BOOT	I	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	Emergency download high level active recommended to reserve test point
116	NC	-	-	NC
117	NC	-	-	NC
118	WLAN&SDIO	I/O		Reserved
119	EPHY_RST_N	O		Reserved
120	EPHY_INT_N	I		Reserved
121	SGMII_MDATA	I/O		Reserved
122	SGMII_MCLK	O		Reserved
123	SGMII_TX_M	O		Reserved
124	SGMII_TX_P	O		Reserved
125	SGMII_RX_P	I		Reserved
126	SGMII_RX_M	I		Reserved
127	PM_ENABLE	I		Reserved
128	VREG_L5_UIM2	PO		Reserved
129	SDC1_DATA_3	I/O		Reserved

Pin	Pin Name	I/O	Level	Description
130	SDC1_DATA_2	I/O		Reserved
131	SDC1_DATA_1	I/O		Reserved
132	SDC1_DATA_0	I/O		Reserved
133	SDC1_CLK	O		Reserved
134	SDC1_CMD	I/O		Reserved
135	WAKE_WLAN	I		Reserved
136	WLAN_EN	I		Reserved
137	COEX_UART_RXD	I		Reserved
138	COEX_UART_TXD	I/O		Reserved
139	BT_EN	I		Reserved
140	NC	-	-	NC
141	NC	-	-	NC
142	NC	-	-	NC
143	NC	-	-	NC
144	NC	-	-	NC

Table 3-1 Pin Definitions

Note:

Keep the unused pins floating.

Pin73~Pin112 is the module thermal pad, and the corresponding ground pad is reserved for PCB packaging and welded.

3.2 Power Supply

The power interfaces of NL668-AM module are shown in the following table:

Pin Name	I/O	Pin	Description
VBAT_RF	I	57,58	Module power supply, 3.3~4.3V, typical value 3.8V
VBAT_BB	I	59,60	Module power supply, 3.3~4.3V, typical value 3.8V
VDD_EXT	O	7	Voltage Output, 1.8V, 80mA
GND	-	8,9,10,19,22,36,46,48,50-54,56,72-112	Ground

Table 3-2 Power Interfaces

Note:

In the rest of the document, VBAT_BB, VBAT_RF will be replaced with VBAT.

3.2.1 Power supply

The NL668-AM module needs to be powered by the VBAT pin. The power design is shown in Figure 3-2:

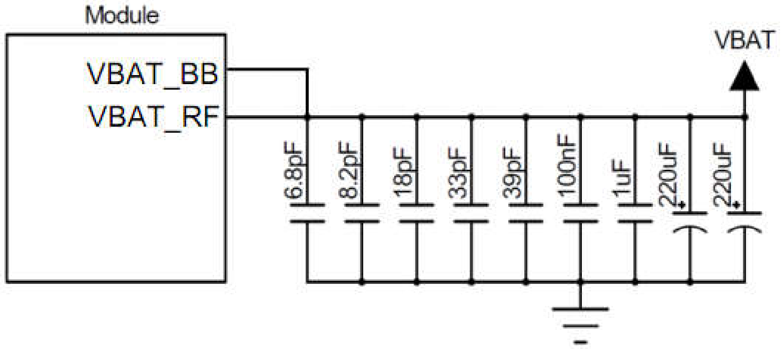


Figure 3-2 Power Design

Power filter capacitor design is shown in the following table:

Recommended capacitor	Application	Description
220uF x 2	Regulating capacitor	Reduce power fluctuations during module operation, requiring low ESR Capacitor ● LDO or DCDC power requires not less than 440uF capacitor ● Battery power can be properly reduced to 100 ~ 220uF capacitor
1uF,100nF	Digital signal noise	Filter clock and digital signal interference
39pF,33pF	700, 850/900 MHz bands	Filter low band RF interference
18pF,8.2pF,6.8pF	1700/1800/1900,2100/2300,2500/2600MHz bands	Filter middle/high band RF interference

Table 3-3 Power Filter Capacitor Design

The power stability ensures the normal operation of NL668-AM module. The design requires special attention to the power ripple below 300mV(The circuit ESR < 100mΩ). When the module is operating in WCDMA/LTE mode (Burst transmit), the maximum operating current can reach 2A, and the power voltage needs to be at least 3.3V. Otherwise, the module may power off or restart. The power limit is shown in Figure 3-3:

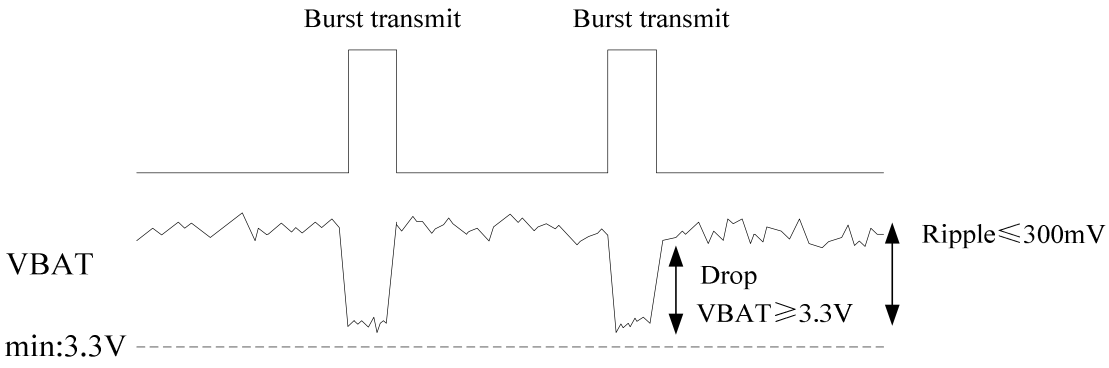


Figure 3-3 Power Limit

3.2.2 1.8V Output

The NL668-AM outputs a 1.8V voltage through the VDD_EXT for use of the internal digital circuit of the module. The voltage is the logic level voltage of the module and can be used to indicate that the module is on or off, or for external low current (<80mA) circuit. If it is not in use, keep it in floating status. The logic level of VDD_EXT is defined as follows:

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

Table 3-4 VDD_EXT Logic Level

3.2.3 Power consumption

The power consumption of NL668-AM module in the case of 3.8V power supply is shown in the following table.

Parameter	**Mode**	**Condition**	**Average Typ.Current(mA)**
I_{off}	Power off	Power supply, module power off	0.015
I_{Idle}	WCDMA	DRX=8	⩽20
	LTE FDD	Paging cycle #256 frames	⩽20
	Radio Off	AT+CFUN=4	⩽15
I_{sleep}	WCDMA	DRX=6	⩽3
		DRX=7	⩽3
		DRX=8	⩽3
		DRX=9	⩽3

Parameter	Mode	Condition	Average Typ.Current(mA)
	FDD-LTE	Paging cycle #64 frames	≤3
		Paging cycle #128 frames	≤3
		Paging cycle #256 frames	≤3
$I_{WCDMA-RMS}$	WCDMA	WCDMA Data transfer Band II @+23.5dBm	≤630
		WCDMA Data transfer Band IV @+23.5dBm	≤670
		WCDMA Data transfer Band V @+23.5dBm	≤530
$I_{LTE-RMS}$	LTE FDD	LTE FDD Data transfer Band 2 @+23dBm	≤680
		LTE FDD Data transfer Band 4 @+23dBm	≤750
		LTE FDD Data transfer Band 5 @+23dBm	≤640
		LTE FDD Data transfer Band 12 @+23dBm	≤640
		LTE FDD Data transfer Band 13 @+23dBm	≤680
		LTE FDD Data transfer Band 17 @+23dBm	≤680
		LTE FDD Data transfer Band 66 @+23dBm	≤750
		LTE FDD Data transfer Band 71 @+23dBm	≤680

Table 3-5 Power Consumption

3.3 Control Signal

The NL668-AM module provides two control signals for power on/off and reset operations. The pin definitions are as follows.

Pin name	I/O	Pin	Description
RESET_N	I	20	When the module is in work, give it a Tst (750ms~2s) low level, and then pull it high, the module is reset
PWRKEY	I	21	When module is in power off mode , give it a Tst (100ms~2s) low level, and then pull it high, the module will power on; When module is in power

Pin name	I/O	Pin	Description
			on mode, give it a Tst (2s~8s) low level, and then pull it high, the module will power off

Table 3-6 Control Signal

3.3.1 Module power on

3.3.1.1 power on circuit reference

When the NL668-AM module is in power off mode, the module will power on by pulling down PWRKEY for 100ms~ 2s . It is recommended to use OC/OD drive circuit to control PWRKEY pin. The reference circuit is shown in Figure 3-4:

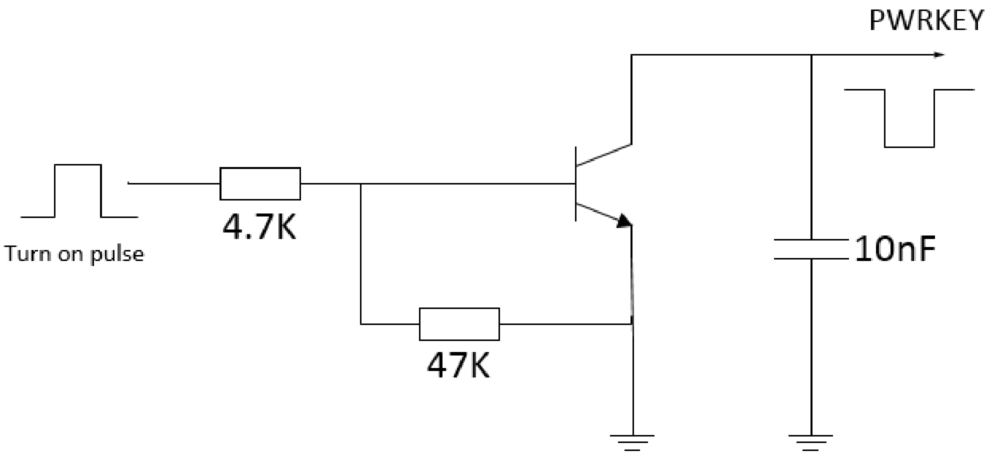


Figure 3-4 OC/OD Drive Power on Reference Circuit

Another method to control PWRKEY pin is to directly control through a button, and place a TVS （recommended：ESD9X5VL-2/TR) near the button for ESD protection.

The reference circuit is shown in Figure 3-5.

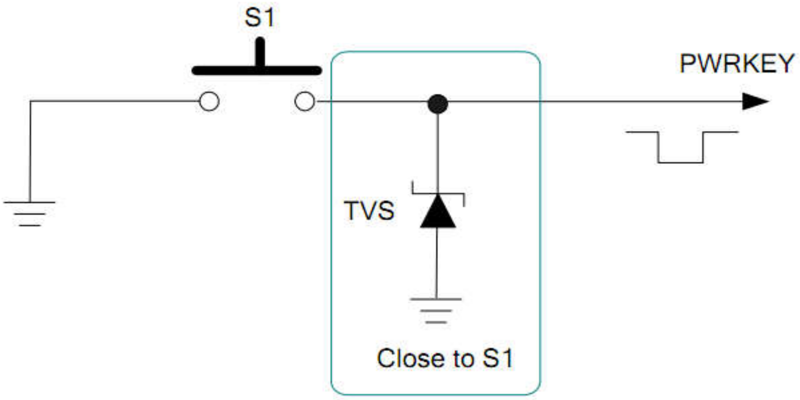


Figure 3-5 Button Power on Reference Circuit

3.3.1.2 Power on Timing

The power on timing is shown in Figure 3-6:

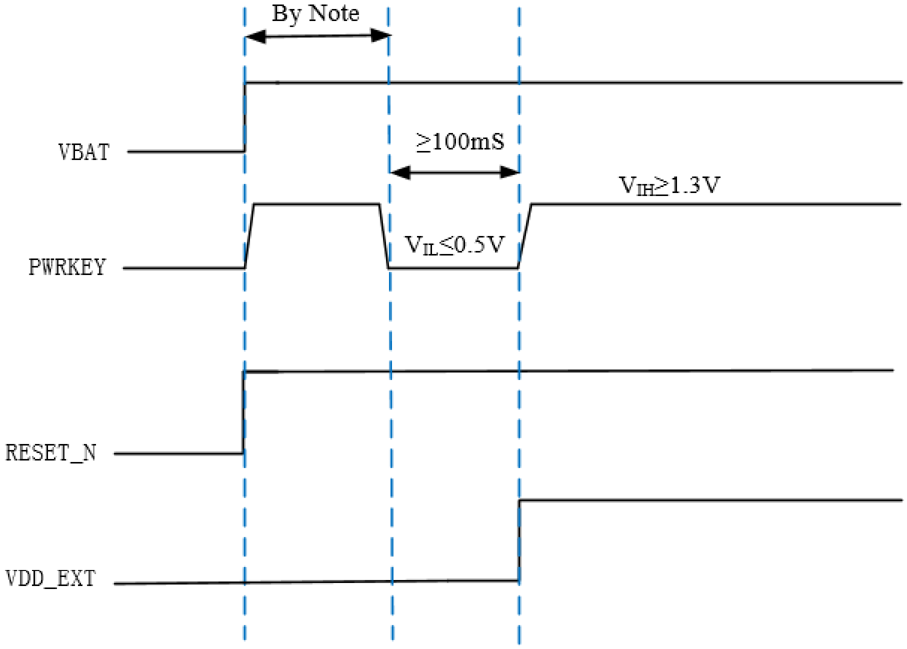


Figure 3-6 Power on Timing Control Diagram

Note:

Before pulling down the PWRKEY pin, make sure the VBAT voltage is stable. It is recommended that the interval between power up VBAT and pull down PWRKEY pin should not be less than 30ms.

3.3.2 Module power off

The module supports the following three power off modes:

Power off mode	Power off methods	Applicable scenarios
Low-voltage power off	When VBAT voltage is low or power down, the module will power off	The module does not power off through normal process, i.e. does not logout process from the base station
Hardware power off	Pull down PWRKEY (2s~ 8s)	Normal power off
AT power off	AT+ CPWROFF	Software power off

Table 3-7 Power Off Modes

3.3.2.1 Power off Timing

1. When the module is working properly, do not cut off the power of the module immediately to avoid

damaging the internal Flash . It is strongly recommended to power off the module by PWRKEY or AT command before cut off the power supply.

2. When using the AT command to power off, make sure that the PWRKEY is in a high level state after the power off command is executed, otherwise the module will power on again after the power off complete.

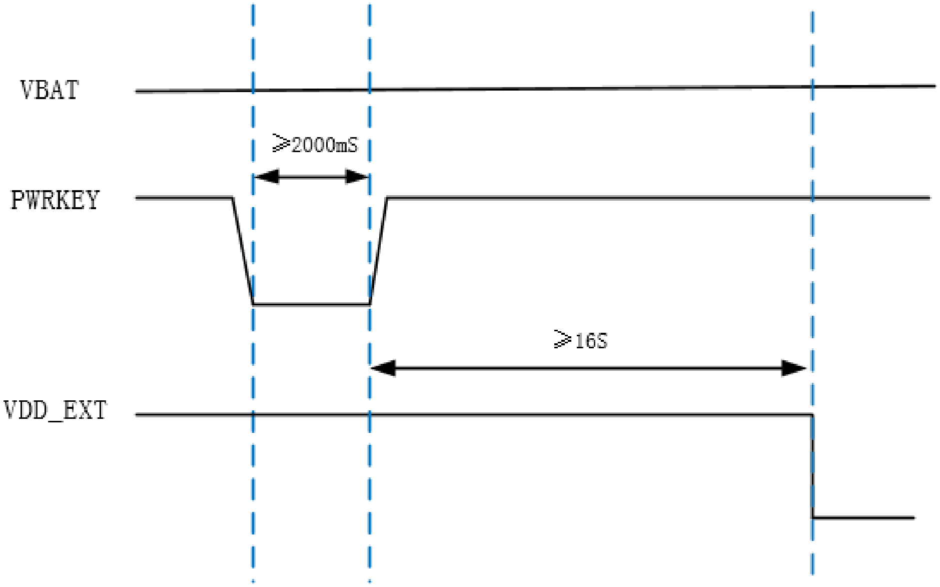


Figure 3-7 Power off Timing Control Diagram

3.3.3 Module reset

NL668-AMmodule can reset by hardware and AT command.

Reset mode	Reset method
Hardware	Pull down RESET_N about 750ms~2s and then pull up the level
AT command	AT+RESET

Table 3-8 Module Reset

3.3.3.1 Reset circuit

Refer to Figure 3-8 reset circuit. It is similar to the PWRKEY control circuit. The client can control the RESET_N pin using an OC/OD drive circuit or push button.

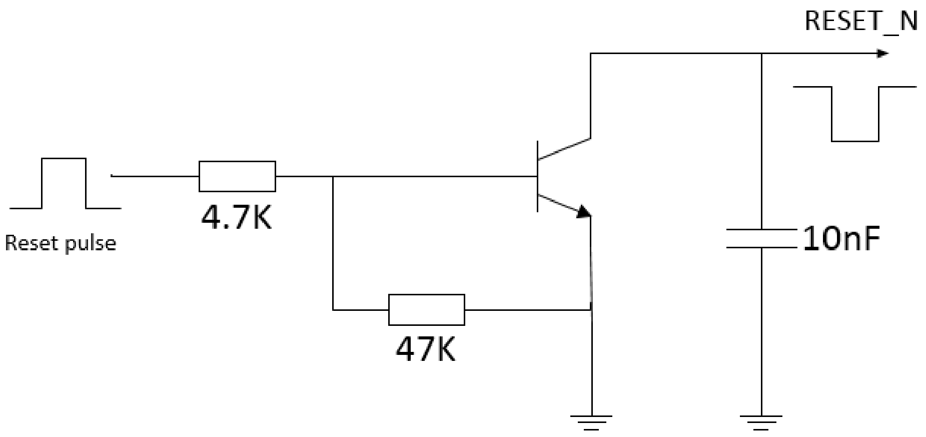

RESET_N
Reset pulse
4.7K
47K
10nF

Figure 3-8 RESET_N OC/OD Drive Reference Circuit

Another reset control is shown in Figure 3-9.

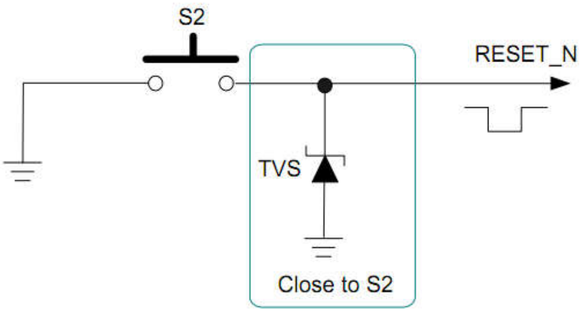

S2
RESET_N
TVS
Close to S2

Figure 3-9 RESET_N Button Reference Circuit

3.3.3.2 RESET control Timing

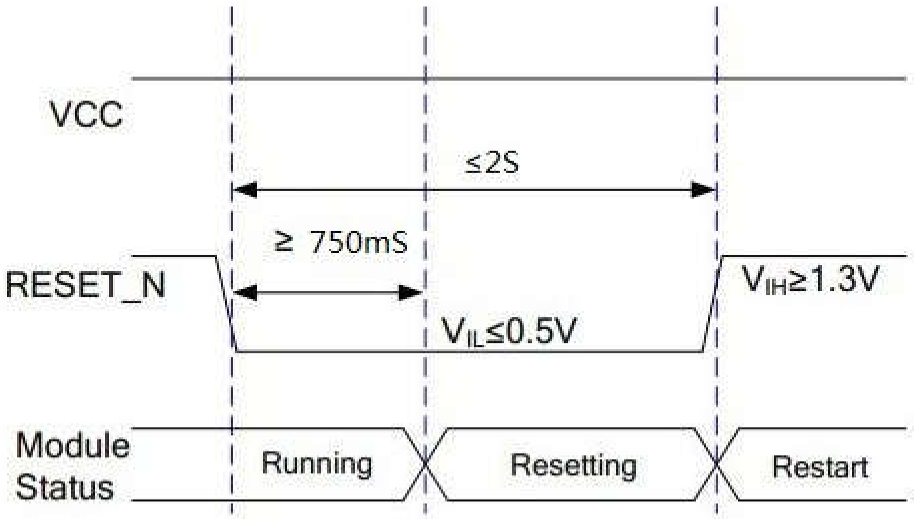

VCC
≤2S
≥ 750mS
RESET_N
V_IH≥1.3V
V_IL≤0.5V
Module Status
Running
Resetting
Restart

Figure 3-10 Reset Control Timing

Note:

RESET is a sensitive signal, so it is recommended to add an avoid debouncing capacitor close to the module. In case of PCB layout, the RESET signal lines should keep away from the RF interference and protected by Ground. Also, the RESET signal lines shall neither near the PCB edge nor route on the surface planes(avoid module reset caused by ESD problems).

3.4 USB Interface

The NL668-AM module supports USB2.0 and is compatible with USB High-Speed (480Mbits/s) and USB Full-Speed (12Mbits/s). Refer to “Universal Serial Bus Specification 2.0” for the timing and electrical characteristics of the NL668-AM module USB bus.

3.4.1 USB interface definition

Pin name	I/O	Pin	Description
USB_DM	I/O	70	USB differential data bus (D+)
USB_DP	I/O	69	USB differential data bus (D-)
USB_VBUS	PI	71	USB_DET

Table 3-9 USB Interface Definition

At present, USB just support USB_VBUS detect.

For more information about the USB 2.0 specification, please refer to http://www.usb.org/home

Note:

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

Connect a 0 ohm resistor to USB_DM / DP differential line to help analyze problems.

USB_DM and USB_DP are high-speed differential signal cables, can achieve the maximum transmission rate of 480Mbits/s, and must follow the rules below in PCB Layout:

- USB_DM and USB_DP signal cable’s control differential impedance is 90 ohm
- USB_DM and USB_DP signal cables shall be parallel and equal in length, and avoid the right-angle route;
- USB_DM and USB_DP signal cables are routed on the signal layer closest to the ground layer, and the cables shall be grounded;

3.5 USIM Interface

NL668-AM module has built-in USIM card interface, and supports 1.8V and 3.0V SIM card.

3.5.1 USIM pin

USIM pin is shown in the following table:

Pin name	I/O	Pin	Description
USIM_DATA	I/O	15	USIM/SIM DATA
USIM_CLK	O	16	Clock Signal
USIM_RESET	O	17	RESET Signal
USIM_VDD	O	14	USIM/SIM Power
USIM_PRESENCE	I	13	Detect USIM/SIM card for Hot-swap

Table 3-10 SIM Card Pin

3.5.2 USIM interface circuit

3.5.2.1 SIM card slot with detection signal

USIM/SIM design requires the use of SIM card slot (Fibocom recommend: SIM016-8P-220P). We recommend using hot plug slot with SIM_DECTECT function.

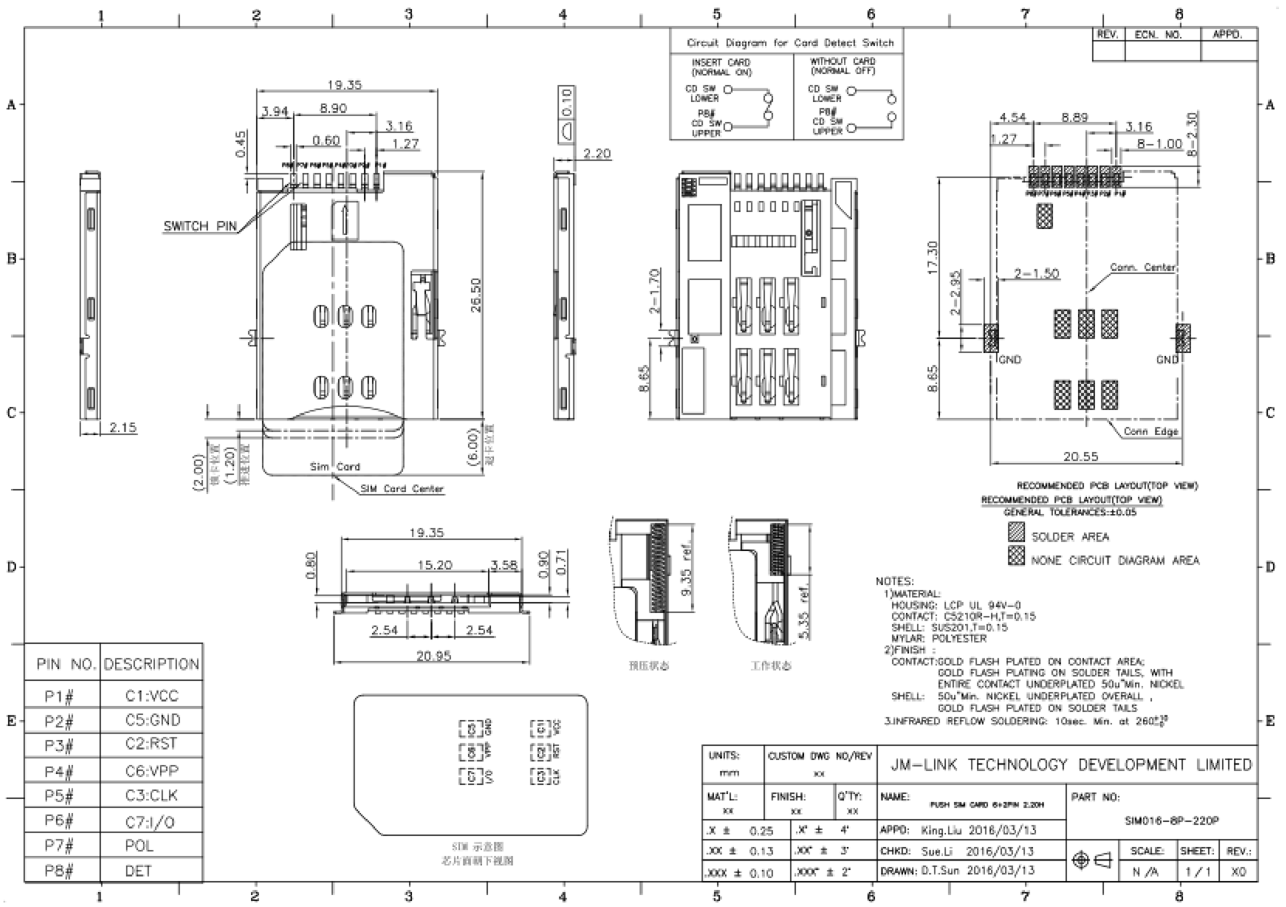

PIN NO.
DESCRIPTION
P1# C1:VCC
P2# C5:GND
P3# C2:RST
P4# C6:VPP
P5# C3:CLK
P6# C7:I/O
P7# POL
P8# DET
Circuit Diagram for Card Detect Switch
INSERT CARD (NORMAL ON)
WITHOUT CARD (NORMAL OFF)
SWITCH PIN
Sim Card
SIM Card Center
RECOMMENDED PCB LAYOUT(TOP VIEW)
GENERAL TOLERANCES:±0.05
SOLDER AREA
NONE CIRCUIT DIAGRAM AREA
JM-LINK TECHNOLOGY DEVELOPMENT LIMITED
SIM016-8P-220P
DRAWN: D.T.Sun 2016/03/13
CHKD: Sue.Li 2016/03/13
APPD: King.Liu 2016/03/13

Figure 3-11 SIM Card Slot Diagram SIM016-8P-220P

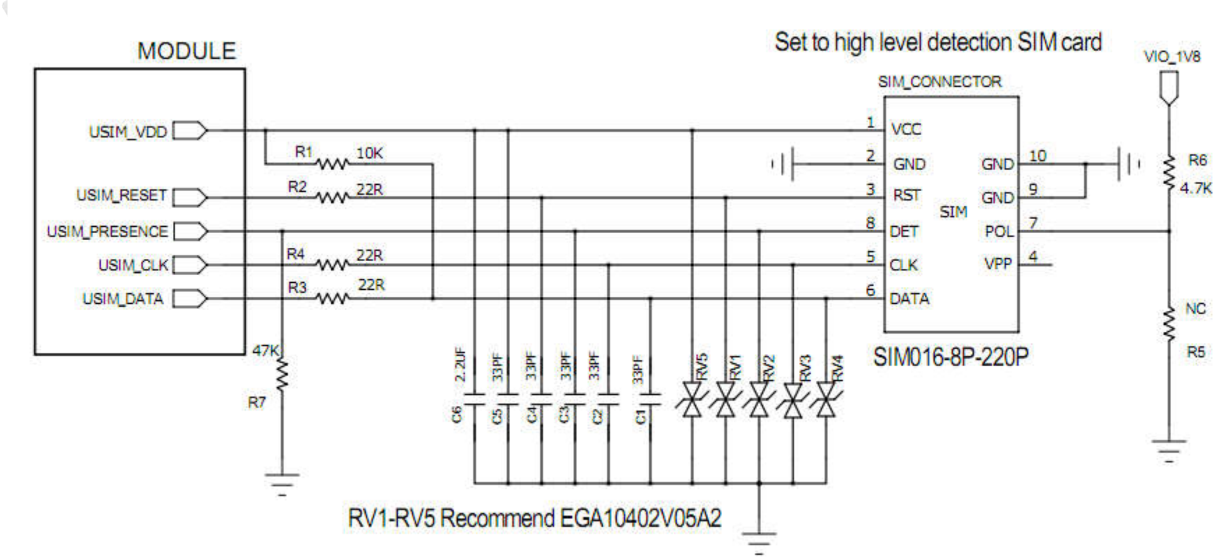

MODULE
USIM_VDD
USIM_RESET
USIM_PRESENCE
USIM_CLK
USIM_DATA
R1 10K
R2 22R
R4 22R
R3 22R
47K
R7
Set to high level detection SIM card
SIM_CONNECTOR
VCC
GND
RST
DET
CLK
DATA
SIM
GND
GND
POL
VPP
SIM016-8P-220P
VIO_1V8
R6 4.7K
NC
R5
C6 2.2UF
C5 33PF
C4 33PF
C3 33PF
C2 33PF
C1 33PF
RV5
RV1
RV2
RV3
RV4
RV1-RV5 Recommend EGA10402V05A2

Figure 3-12 USIM/SIM Interface with Detection Signal Reference Design

Principles of SIM card slot with detection signal are as follows:

SIM card is insert, USIM_PRESENCE pin is high level

SIM card is no insert, USIM_PRESENCE pin is low level

3.5.2.2 SIM card slot without detection signal

SIM card slot without detection signal, and USIM_ PRESENCE pin remains floating.

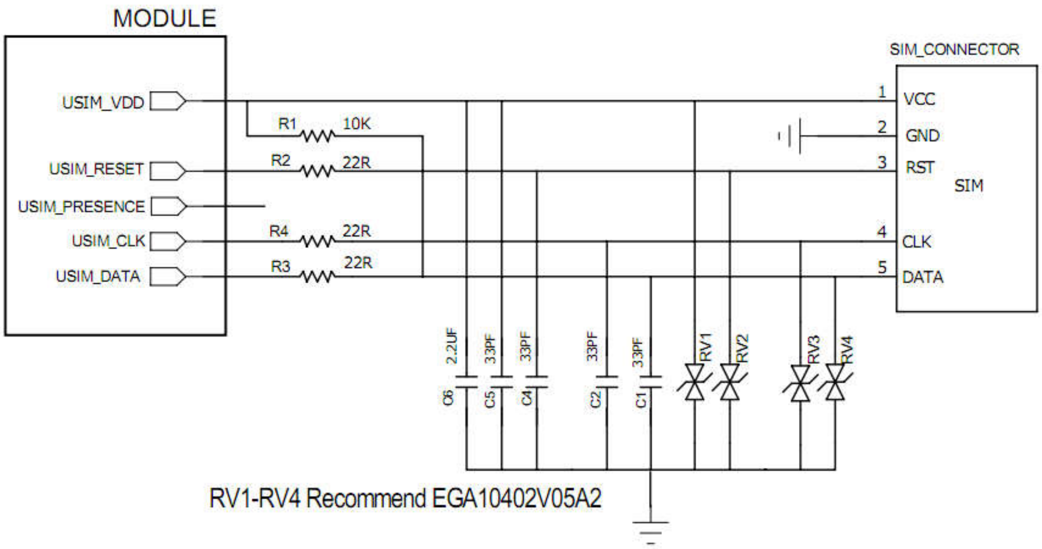

MODULE
USIM_VDD
USIM_RESET
USIM_PRESENCE
USIM_CLK
USIM_DATA
R1
10K
R2
22R
R4
22R
R3
22R
SIM_CONNECTOR
1
VCC
2
GND
3
RST
SIM
4
CLK
5
DATA
2.2UF
C6
33PF
C5
33PF
C4
33PF
C2
33PF
C1
RV1
RV2
RV3
RV4
RV1-RV4 Recommend EGA10402V05A2

Figure 3-13 USIM/SIM Interface without Detection Signal Reference Design Diagram

3.5.3 USIM hot plug

NL668-AM SIM card supports hot plug function. It determines the insertion and removal of SIM card on the slot by detecting the USIM_ PRESENCE pin state to support hot plug function.

The SIM card hot plug function can be configured by the "AT+MSMPD" command, and the AT commands are shown in the following table:

AT command	**SIM card hot plug detection**	**Function description**
AT+MSMPD=1	Enabled	Default, SIM card hot plug detection is enabled The module detects whether the SIM card is inserted through the USIM_PRESENCE pin state
AT+MSMPD=0	Disabled	SIM card hot plug detection function is disabled The module reads the SIM card when the device starts, and does not detect the USIM_PRESENCE state

Table 3-11SIM Card Hot Plug Function Configured AT Commands

After enabled the hot plug detection function of the SIM card, when USIM_PRESENCE is in high level, the module will detect the SIM card insertion and then execute the initialization program of the SIM card. After reading the SIM card information, the module will register network. When the USIM_PRESENCE is in low level, the module detects that the SIM card is removed, then it will not read the SIM card.

Note:

The USIM_PRESENCE is in active high by default, and can be switched to active low by AT command.

AT command	Function description
AT+GTSET="SIMPHASE",1	Default ,high level detect
AT+GTSET="SIMPHASE",0	Low level detect

Table 3-12 USIM_PRESENCE Effective Level Switched AT command

3.5.4 USIM design requirements

SIM card circuit design shall meet EMC standards and ESD requirements, and at the same time, shall improve anti-interference ability to ensure that the SIM card can work stably. The design needs to strictly observe the following rules:

- SIM card slot is placed as close to the module as possible, away from the RF antenna, DCDC power, clock signal lines and other strong interference sources;
- Adopt the SIM card slot with metal shield shell to improve anti-interference ability;
- The length of cable from the module to the SIM card slot shall not exceed 100mm. Longer cable reduces signal quality.
- USIM_CLK and USIM_DATA signals are ground isolated to avoid mutual interference. If it is difficult to do so, SIM signal needs to be ground protected as a set;
- The filter capacitor and ESD device of SIM card signal cable are placed close to the SIM card slot. Select 22 ~ 33pF capacitor for ESD device equivalent capacitor.

3.6 UART Interface

3.6.1 UART interface definition

NL668-AM module has two serial interfaces: the main serial interface and debug serial ports. The following describes the main features of these two serial ports:

The main serial ports supports 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, baud rate. The default baud rate is 115200bps, used for data transmission and AT command transmission.

Debug serial port supports 115200bps baud rate for FIBOCOM debug.

The following table describes the main serial port pin.

Pin name	I/O	Pin	Description
RI	O	62	Ring indicator
DCD	O	63	Data carrier detection
CTS	I	64	Clear to send

Pin name	I/O	Pin	Description
RTS	O	65	Request to send
DTR	I	66	Sleep mode control
TXD	O	67	Module Transmit data
RXD	I	68	Module Receive data

Table 3-13 Main Serial Port Pin

The following table describes the debug serial interface pin.

Pin name	I/O	Pin	Description
DBG_RXD	I	11	Module Receive data
DBG_TXD	O	12	Module Transmit data

Table 3-14 Debug Serial Port Pin

3.6.2 UART port application

The serial port level of NL668-AM LCC module is 1.8V. If the level of the client host system is 3.3V or other, a level translate shall be added to the serial port connection between the module and the host. The following figure shows the reference circuit design using level translate chip:

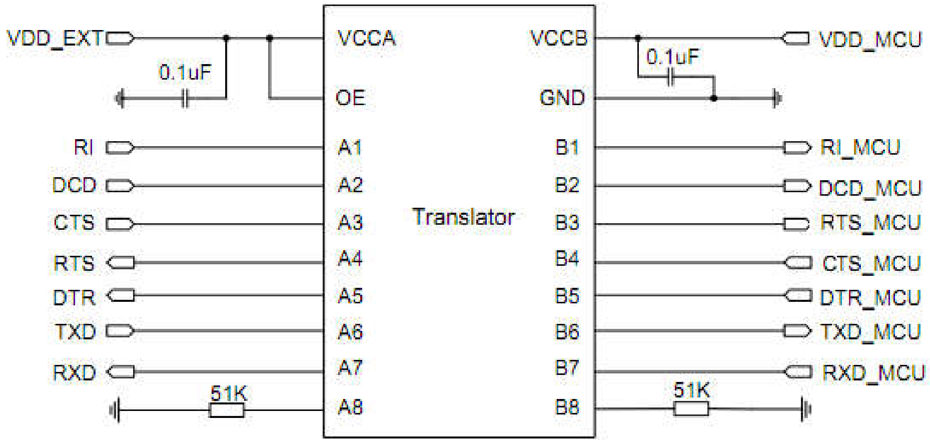

VDD_EXT
0.1uF
VCCA
VCCB
VDD_MCU
0.1uF
OE
GND
RI
A1
B1
RI_MCU
DCD
A2
B2
DCD_MCU
CTS
A3
Translator
B3
RTS_MCU
RTS
A4
B4
CTS_MCU
DTR
A5
B5
DTR_MCU
TXD
A6
B6
TXD_MCU
RXD
A7
B7
RXD_MCU
51K
A8
B8
51K

Figure 3-14 UART Level Translate Reference Circuit 1

Another level translate circuit is shown below. The input and output circuit design in the following dashed part can refer to that in the solid line part, but pay attention to the connection direction.

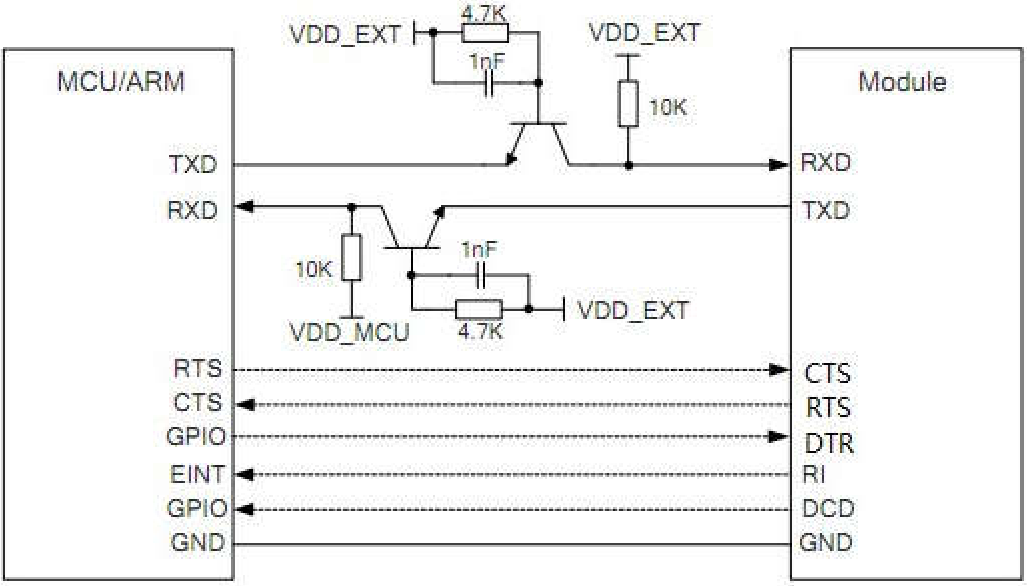

VDD_EXT
4.7K
1nF
VDD_EXT
10K
MCU/ARM
Module
TXD
RXD
RXD
TXD
10K
1nF
VDD_EXT
VDD_MCU
4.7K
RTS
CTS
GPIO
EINT
GPIO
GND
CTS
RTS
DTR
RI
DCD
GND

Figure 3-15 UART Level Translate Reference Circuit 2

Note:

This level translate circuit is not suitable for applications with baud rates above 460Kbps.

3.7 Status Indicator

NL668-AM provides three network indication pins (Pin 5 is network status indicator by default, AT commands AT+LEDCFG can switch to pin 6 or pin 61).

PIN Name	I/O	PIN Num.	Description
NET_MODE	O	5	Network status indicator
NET_STATUS	O	6	Reserved
STATUS	O	61	Reserved

Table 3-15 Network Indication pins

3.7.1 NET_MODE Signal

NL668-AM module network indicator status description.

Mode	NET_MODE	Description
1	Flash (600ms High/600ms Low)	No SIM card Request SIM PIN Registering network (T<15S) Register network failed
2	Slow flash (75ms Low /3000ms High)	Standby

Mode	NET_MODE	Description
3	Speed flash (75ms Low /75ms High)	Data link established
4	Low	Voice call

Table 3-16 Network Indicator Status Description

NL668-AM NET_MODE interface reference circuit is as shown below.

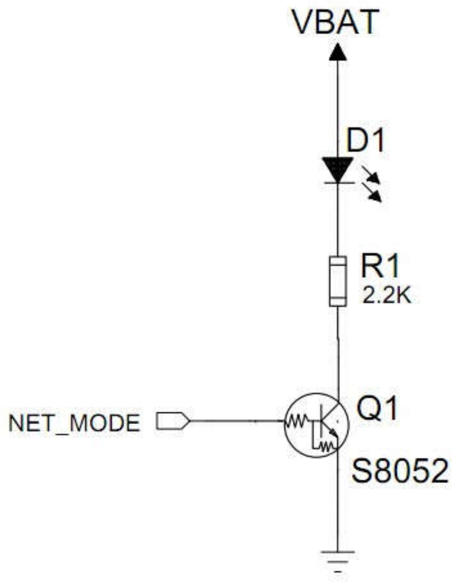


Figure 3-16 NET_MODE Reference Design Diagram

3.8 Low Power Mode

3.8.1 Flight mode

W_DISABLE# Pin Description:

Pin name	I/O	Pin	Description
W_DISABLE#	I	4	Module flight mode control

Table 3-17 W_DISABLE# Pin Description

NL668-AM supports two ways to enter the flight mode:

1	Hardware I/O interface button control	First to transmit the “AT+WDISABLEEN=1”to enable the W_DISABLE# function. Pull high or float (pull high by default)the W_DISABLE# signal to enter the normal mode, pull low it to enter the flight mode.
2	AT command control	AT+CFUN=0,0--enter the flight mode AT+CFUN=1,0--enter the normal mode

Table 3-18 Module enter Fly Mode

3.8.2 Sleep Mode

3.8.2.1 USB Application (nonsupport USB Suspend, support VBUS）

If the host does not support the USB Suspend function, the module can enter sleep mode by disconnecting USB_VBUS from the external control circuit:

Sleep:

Sent AT+GTLPMMODE=1,X command to set the WAKEUP_IN control enter the sleep mode. Reset the module become effective. (X=0, high level active to sleep; X=1, low level active to sleep)

AT+CSCLK = 1 command to enable sleep function.

AT+GTUSBSLEEPEN=1,0 command to set USB sleep mode

To draw out the USB line or disable the USB HUB controller to enter the sleep.

Wake up:

Wake up the module by plugging in the USB cable or enable the USB HUB controller.

3.8.2.2 USB application (nonsupport USB Suspend, nonsupport VBUS)

If the host does not supports USB Suspend and does not support VBUS function, the module can enter sleep mode by disconnecting USB_VBUS from the external control circuit:

Sleep:

Sent AT+GTLPMMODE=1,X command to set the WAKEUP_IN control enter the sleep mode. Reset the module become effective. (X=0,high level active to sleep; X=1, low level active to sleep)

AT+CSCLK = 1 command to enable sleep function.

Use AT+GTUSBDETECTEN=1 command to enable the USB software detection

AT+GTUSBSLEEPEN=1,0 command to set USB sleep mode

To draw out the USB line or disable the USB HUB controller to enter the sleep.

Wake up:

Wake up the module by plugging in the USB cable or enable the USB HUB controller.

3.8.2.3 USB application (Supports USB Suspend)

If the host supports USB Suspend/Resume. Setting the USB into sleep by Linux.

Sleep:

Sent AT+GTLPMMODE=1,X command to set the WAKEUP_IN control enter the sleep mode. Reset the module become effective. (X=0,high level active to sleep; X=1,low level active to sleep)

AT+CSCLK = 1 command to enable sleep function.

AT+GTUSBSLEEPEN=0,0 command to set USB sleep mode

In Linux environment, set the USB level and control to AUTO. Standing the module and host about 2 seconds, that will be in suspend mode.

Wake up:

Any operation on USB will wake up the module from sleep.

3.8.2.4 UART application (WAKEUP_IN level control)

When host and NL668 module has connected through UART, use the following steps to make the module enter sleep mode:

Sent AT+GTLPMMODE=1,X command to set the WAKEUP_IN control enter the sleep mode. Reset the module become effective. (X=0,high level active to sleep; X=1, low level active to sleep)

AT+CSCLK = 1 command to enable sleep function.

AT+GTUSBSLEEPEN=2,X command to disable USB function (X is an arbitrary value)

Wake up:

Wake up the module by set a signal contrary with sleep on WAKEUP_IN line.(X=0,low level active to be recall;X=1,high level active to be recall)

3.8.2.5 UART application (DTR level control)

When host and NL668 module has connected through UART, use the following steps to make the module enter sleep mode:

Sent AT+GTLPMMODE=2,X command to set the DTR control enter the sleep mode. Reset the module become effective. (X=0, high level active to sleep; X=1, low level active to sleep)

AT+CSCLK = 1 command to enable sleep function.

AT+GTUSBSLEEPEN=2,X command to disable USB function (X is an arbitrary value)

Wake up the module by set a signal contrary with sleep on DTR line.(X=0, low level active to be recall; X=1, high level active to be recall).

3.8.2.6 ATS24 Command

Set the module into sleep by ATS24 command . use the following steps:

Sleep:

Sent AT+GTLPMMODE=0

AT+GTUSBSLEEPEN=2,X command to disable USB function (X is an arbitrary value without 0)

ATS24=X command to into sleep after X seconds.(X is not zero)

Wake up:

Wake up the module by send the AT command fast.

Note:

Since the level of UART sleep power is different, power dissipation when use ATS24 command to enter sleep mode is higher than Pin control to enter sleep mode.

The ATS24 function cannot ensure the module must be in sleep after X seconds, if the timer over and the module cant into sleep. It will try again.

If you want to use the RI signal to represent the state of the module, please refer to the AT+GTWAKE command in the AT manual.

3.9 Digital audio interface PCM

NL668-AM provides a PCM interface for communication with digital audio devices such as an external CODEC. Digital audio interface including PCM_CLK, PCM_SYNC, and PCM_IN / PCM_OUT.

3.9.1 Support model

NUM.	Product model	Description
1	NL668-AM-00	support
2	NL668-AM-01	support

Table 3-19 Support model

3.9.2 PCM interface definition

PIN Name	I/O	PIN Num.	Description
PCM_IN	I	24	PCM Input
PCM_OUT	O	25	PCM Output
PCM_SYNC	I/O	26	PCM Synchronous Signal
PCM_CLK	I/O	27	PCM CLK

Table 3-20 PCM Interface Definition

3.9.3 PCM interface description

Single Name	Freq.	Duty Cycle	Coded Format	Operating Mode	Description
PCM_CLK	2.048MHz	50%	16bit Liner mono	Module serves as the master that supports PCM slave	PCM CLK
PCM_OUT	-	-			PCM Output
PCM_IN	-	-			PCM Input
PCM_SYNC	8KHz	BURST			PCM Synchronous Signal (Falling edge sampling)

Table 3-21 PCM Interface Description

NL668-AM adopts the above configuration by default, if you need to make adjustment, please contact our technical support.

3.9.4 PCM signal description

NL668-AM main chip support PCM signal adopts domestic mainstream Europe E1 standard. PCM_CLK is a 2.048MHz clock in 16bit linear format encoding. PCM_SYNC is a 8kHz burst (488nS).

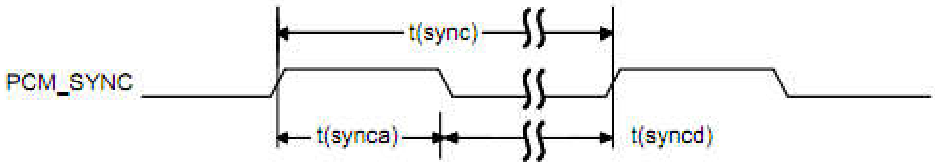

t(sync)
PCM_SYNC
t(synca)
t(syncd)

Figure 3-17 PCM_SYNC Timing

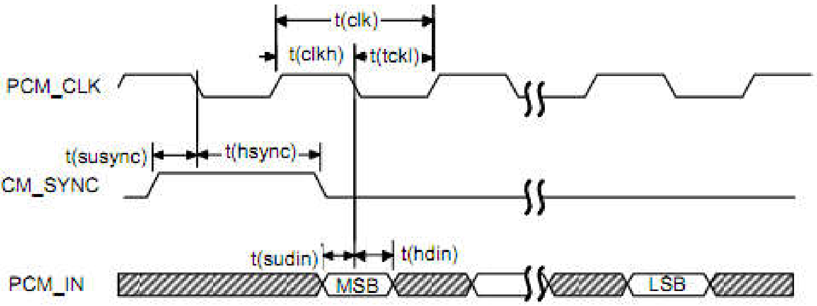

t(clk)
t(clkh)
t(tckl)
PCM_CLK
t(susync)
t(hsync)
PCM_SYNC
t(sudin)
t(hdin)
PCM_IN
MSB
LSB

Figure 3-18 PCM_CODEC to NL668-AM Timing

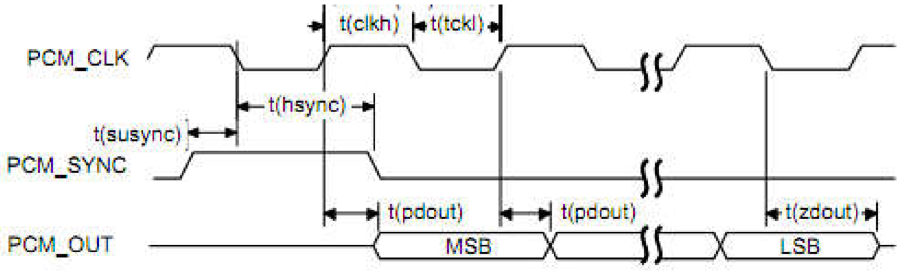
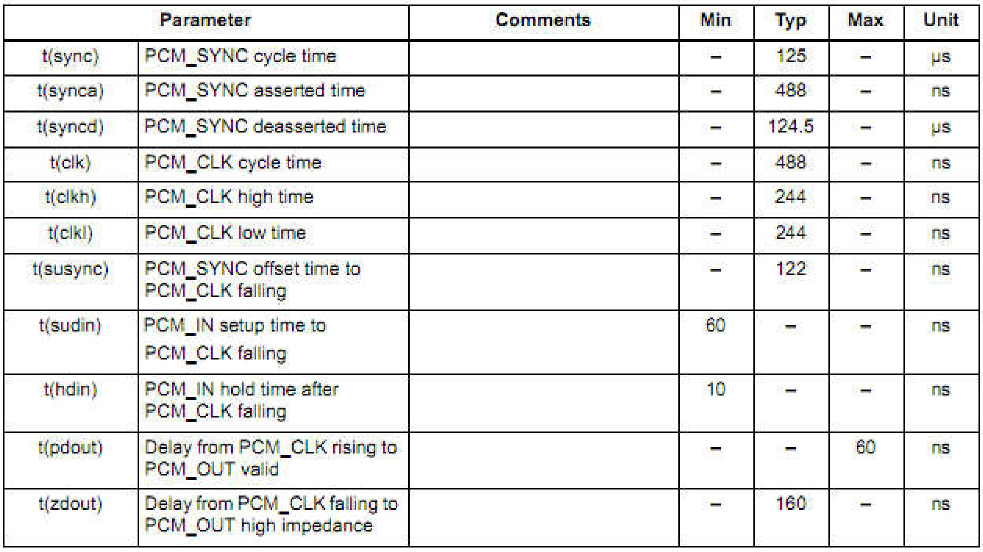

t(clkh)
t(tckl)
PCM_CLK
t(hsync)
t(susync)
PCM_SYNC
t(pdout)
t(pdout)
t(zdout)
PCM_OUT
MSB
LSB

Figure 3-19 NL668-AM to PCM_CODEC Timing



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

Figure 3-20 CODEC Timing Parameters

3.10 ADC function

NL668-AM support the 2 channels ADC interface. Use AT+TADC=0 to read the value on the ADC0 interface. Use AT+TADC=1 to read the value on the ADC1 interface. The ADC range is 0.3V-VBAT_BB.

PIN Name	I/O	PIN NUM.	Description
ADC0	I	45	Analog to digital converter interface 0
ADC1	I	44	Analog to digital converter interface 1

Table 3-22 ADC Interface

4 RF Interface

4.1 NL668-AM Operating Frequency

Operating Band	Description	Mode	Tx (MHz)	Rx (MHz)
Band 2	PCS 1900MHz	LTE FDD/WCDMA	1850- 1910	1930 - 1990
Band 4	AWS-1 1700	LTE FDD/WCDMA	1710 - 1755	2110 - 2155
Band 5	CLR 850MHz	LTE FDD/WCDMA	824 - 849	869 - 894
Band 12	Lower SMH blocks A/B/C 700	LTE FDD	699-716	729-746
Band 13	Lower SMH blocks A/B/C 700	LTE FDD	777-787	746-756
Band 17	Lower SMH (Blocks B–C)	LTE FDD	704-716	734-746
Band 66	Extended AWS-1 (Blocks A–I)	LTE FDD	1710-1780	2110 - 2200
Band 71	US 600	LTE FDD	663-698	617-652

Table 4-1Operating Frequency

4.2 RF Output Power of NL668-AM

The RF output power of NL668-AM is shown in the following table.

Mode	Band	Tx Power(dBm)	Note
WCDMA	Band II	23.5±1	
	Band IV	23.5±1	
	Band V	23.5±1	
LTE FDD	Band 2	23±1	10MHz Bandwidth, 1 RB
	Band 4	23±1	10MHz Bandwidth, 1 RB
	Band 5	23±1	10MHz Bandwidth, 1 RB
	Band 12	23±1	10MHz Bandwidth, 1 RB
	Band 13	23±1	10MHz Bandwidth, 1 RB
	Band 17	23±1	10MHz Bandwidth, 1 RB
	Band 66	23±1	10MHz Bandwidth, 1 RB
	Band 71	23±1	10MHz Bandwidth, 1 RB

Table 4-2 RF Output Power

4.3 RF Receiving Sensitivity of NL668-AM

Mode	Band	Rx Sensitivity(dBm) PRX Typ.	Rx Sensitivity(dBm) DRX Typ.	Note
WCDMA	Band II	-109	NA	BER<0.1%
	Band IV	-109.5	NA	BER<0.1%
	Band V	-111	NA	BER<0.1%
LTE FDD	Band 2	-97.8	-98.5	10MHz Band width
	Band 4	-97.8	-98	10MHz Band width
	Band 5	-99	-100	10MHz Band width
	Band 12	-98	-99	10MHz Band width
	Band 13	-97	-99	10MHz Band width
	Band 17	-98	-98	10MHz Band width
	Band 66	-97.8	-98	10MHz Band width
	Band 71	-98	-99	10MHz Band width

Table 4-3 RF Receiving Sensitivity

Note:

The sensitivity in the above table is the result of test conducted with the main and diversity dual antenna. If only the main antenna is used (without the diversity antenna), the sensitivity of each band of LTE will be reduced by about 3dBm.

4.4 GNSS Receiver

4.4.1 Basic description

The NL668-AM module supports the GPS/GLONASS/BeiDou functions using Qualcomm Gen8 technology.

Description		Condition	Typ.
Current consumption （AT+CFUN=0）		GNSS fixing	68mA
		GNSS tracking	68mA
		Standby	33mA
TTFF	GNSS	Cold start	40s
		Warm start	37s

Description		Condition	Typ.
		Hot Start	4s
Sensitivity	fixing		-147dbm
	tracking		-158dbm
	CN0	GNSS Signal@-130dBm	38.5dB-HZ
Positional Accuracy	CEP	GNSS Signal @-130dBm	<4m

Table 4-4 GNSS Receiver

Note:

The current in above table test with USB plug in.

4.5 RF PCB Design

4.5.1 Antenna RF connector

The NL668-AM three-way antenna adopts the pad-out way. It is recommended that clients use the U.FL-R-SMT-1 antenna connector and the matching RF adapter cable.

Antenna is a sensitive device, susceptible to the external environment. For example, the location of the antenna, the space it occupies, and the surrounding ground all may affect antenna performance. In addition, the RF cable connecting the antenna, and the location of the fixed antenna also may affect the performance of the antenna.

Figure 4-1 is the reference circuit design for the main and diversity antenna. These matches need to be placed close to the antenna:

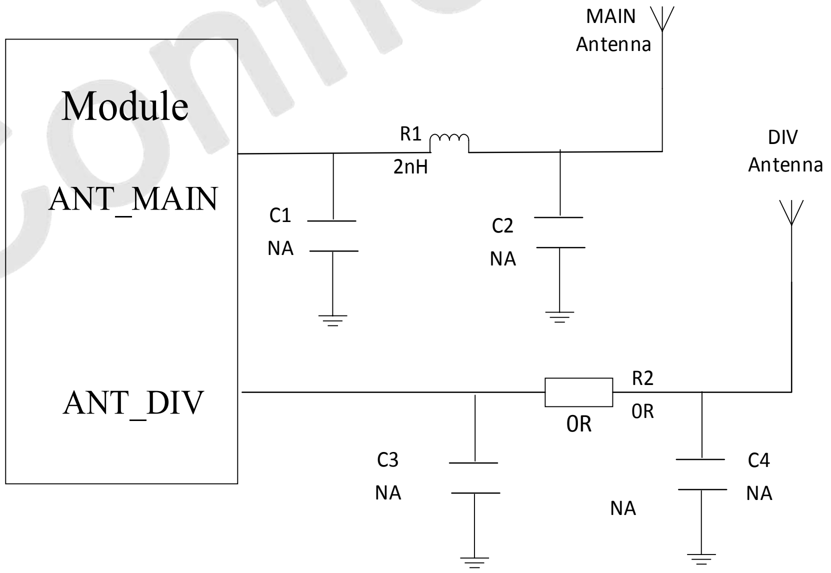


Figure 4-1RF Reference Circuit Design

Figure 4-2 shows the reference circuit design for the GNSS antenna. These matches need to be placed close to the antenna:

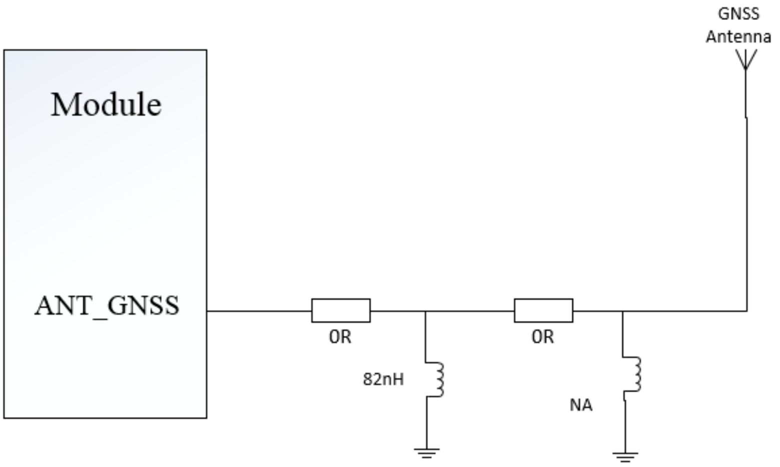


Figure 4-2 GNSS RF Reference Circuit

- Make sure the characteristic impedance of the transmission cable is 50 ohms.
- Since the antenna cable loss is less than 0.3dB, keep the PCB cable as short as possible.
- Keep the PCB LAYOUT as straight as possible, and reduce holes on the route to another layer; also avoid right-angle and acute-angle wiring.
- PCB cable should have a good reference ground to avoid other signal cable near the antenna.
- Recommend a complete ground level, and use this complete ground level as a reference ground.

The ground around the antenna must be connected to the main ground through the holes placed near the edge of the ground and tracking the cable route.

Note:

Refer to the document《FIBOCOM_RF Antenna Application Design Instruction》for specific design

4.6 Antenna Design

1) Antenna efficiency

Antenna efficiency is the ratio of antenna input power to emissivity. Due to the antenna return loss, material loss, and coupling loss, the radiated power is always lower than the input power. Recommend> 40% (-4dB).

2) S11 or VSWR

S11 shows that the matching degree of the antenna’s 50 ohm impedance, to a certain extent, affects the antenna efficiency. VSWR test methods can be used to measure this parameter. Recommend S11 <-10dB.

3) Polarization

Polarization is the rotation direction of the electric field in the maximum radiation direction of the antenna. It is recommended to use linear polarization.

4) Radiation pattern

Radiation pattern refers to the antenna’s electromagnetic field strength in the far field in all directions. Half-wave dipole antenna is the most suitable terminal antenna. For built-in antenna, PIFA antennas or IFA antennas are recommended:

Antenna area: 6mm high*10mm wide*100mm long.

Antenna radiation direction: Omni_directional.

5) Gain and directivity

Antenna directivity refers to the electromagnetic field strength of electromagnetic wave in all directions. Gain is a collection of antenna benefits and antenna directivity.

Recommended antenna gain ≤2.5dBi.

6) Interference

In addition to the antenna performance, other interferences on the PCB also may affect the performance of the module. In order to ensure the high performance of the module, interference must be controlled. Suggestions: For example, LCD, CPU, FPC cable, audio circuit, power supply should be as far as possible away from the antenna, and make the appropriate isolation and shielding, or filtering on the path.

7) Antenna index requirements

NL668-AM module main antenna requirements	
Frequency range	It must use the most suitable antenna to adapt to the relevant frequency band
Bandwidth (WCDMA)	WCDMA band II(1900) : 170 MHz WCDMA band IV(1700) :170 MHz WCDMA band V(850) : 70 MHz
Bandwidth (LTE)	LTE band 2(1900): 140 MHz LTE Band 4(1700): 445 MHz LTE Band 5(850): 70 MHz LTE Band 12(700): 47 MHz LTE band 17(700): 42 MHz LTE band 13(700): 41 MHz LTE Band 66(1700): 470MHz LTE band 71(600): 81MHz
Impedance	50 ohms

NL668-AM module main antenna requirements	
Input power	> 23dBm average power WCDMA & LTE
Standing wave ratio recommended	≤ 2:1
GNSS	Frequency range: 1559MHz~1607MHz Polarization type: right-circular or linear polarization VSWR:：＜2(Type) Passive antenna gain:> 0dBi

Table 4-5 Main Antenna Requirement

5 Electrical Characteristics

5.1 Limiting voltage range

The limiting voltage range refers to the power voltage of the module and the maximum voltage range that the digital and analog input/output interfaces can withstand.

The voltage range of NL668-AM is shown in the following table.

Parameter	Description	Min	Typ	Max	Unit
VBAT	Power supply	-0.3	-	4.7	V
GPIO	Power supply voltage of digital I/O	-0.3	-	2.0	V

Table 5-1 Voltage Range

5.2 Environment temperature range

NL668-AM module is recommended to operate at -30~+75℃ ambient. It is recommended that the application uses temperature control measures under harsh environmental conditions. At the same time, the limited operating temperature range of the module should be provided. Under these temperature conditions, some RF parameters may exceed the limit. It is recommended that the module application terminal be stored in certain temperature conditions. Modules outside this range may not operate or may be damaged.

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

Table 5-2Environment Temperature Range

5.3 Electrical characteristics of the interface in operating status

V_L: logic low level;

V_H: logic high level;

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

Parameter	I/O	Min	Typ	Max	Unit
VBAT	I	3.3	3.8	4.3	V
SIM_VDD	O	1.7/2.75	1.8/2.85	1.9/2.95	V

Table 5-3 Electrical Characteristics of the Interface in Operating Status

5.4 Environmental reliability requirements

<table>
<tr><th>Test items</th><th>Test conditions</th></tr>
<tr><td>Low temperature storage test</td><td>Temperature -40℃±3℃, 24 hours in shutdown state</td></tr>
<tr><td>High temperature storage test</td><td>Temperature +85℃±3℃, 24 hours in shutdown state</td></tr>
<tr><td>Temperature shock test</td><td>In shutdown state, 0.5 hour at -40℃ and +85℃ environment respectively, the temperature conversion time <3min, for 24 cycles</td></tr>
<tr><td>High temperature and humidity test</td><td>Temperature +85℃±3℃, humidity 90 ~ 95% RH, 24 hours in shutdown state</td></tr>
<tr><td>Low temperature operating test</td><td>Temperature -30℃±3℃, 24 hours in operating state</td></tr>
<tr><td>High temperature operating test</td><td>Temperature +75℃±3℃, 24 hours in operating state</td></tr>
<tr><td>Vibration test</td><td>Conduct vibration test according to the requirements shown in the table below:
<table>
<tr><td>Frequency</td><td>Random vibration ASD (Acceleration Spectral Density)</td></tr>
<tr><td>5~20Hz</td><td>$0.96m^2/s^3$</td></tr>
<tr><td>20~500Hz</td><td>$0.96m^2/s^3$(20Hz), other -3dB/octave</td></tr>
</table>
</td></tr>
<tr><td>Connector life test</td><td>30 times of insertion/removal for RF antenna interface cable</td></tr>
</table>

Table 5-4 Environmental Reliability Requirements

5.5 ESD characteristics

NL668-AM is a consumer product. Although the design of the module has considered the ESD issue and provided ESD protection, the ESD issue may occur in the transport and secondary development, so developers should consider ESD protection for the final product. In addition to considering anti-static treatment for packaging, please refer to recommended circuit for interface design in the document for client's application.

Refer to the following table for the ESD allowable discharge range of the NL668-AM module.

Part	Air discharge	Contact discharge
VBAT,GND	±10KV	±5KV
Antenna interface	±8KV	±4KV
Other interface	±1KV	±0.5KV

Table 5-5 ESD Allowable Discharge Range

6 Structure Specification

6.1 Product Appearance

The product appearance for NL668-AM module is shown in Figure 6-1 and 6-2：

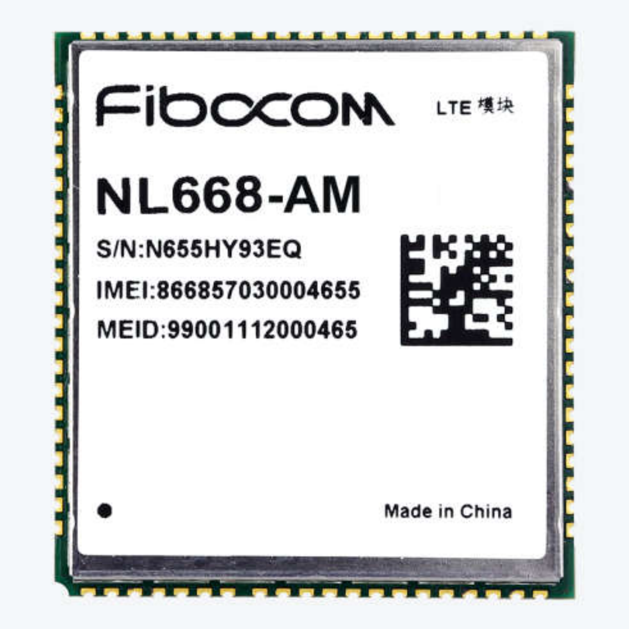

Fibocom
LTE 模块
NL668-AM
S/N:N655HY93EQ
IMEI:866857030004655
MEID:99001112000465
Made in China

Figure 6-1Module Product Appearance (Top)

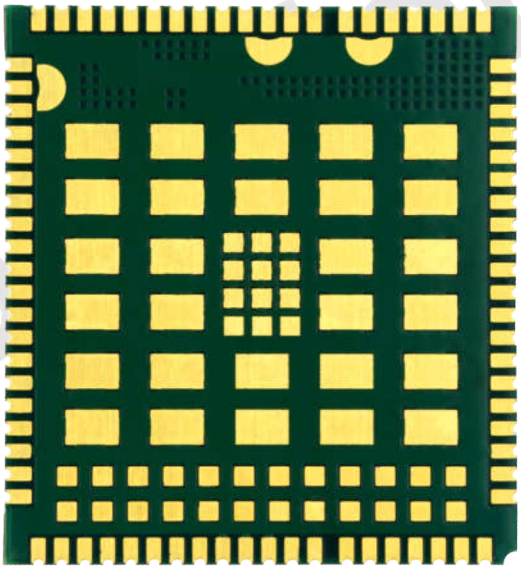


Figure 6-2 Module Product Appearance (Bottom)

6.2 Dimension of Structure

The structural dimension of the NL668-AM module is shown in Figure 6-3:

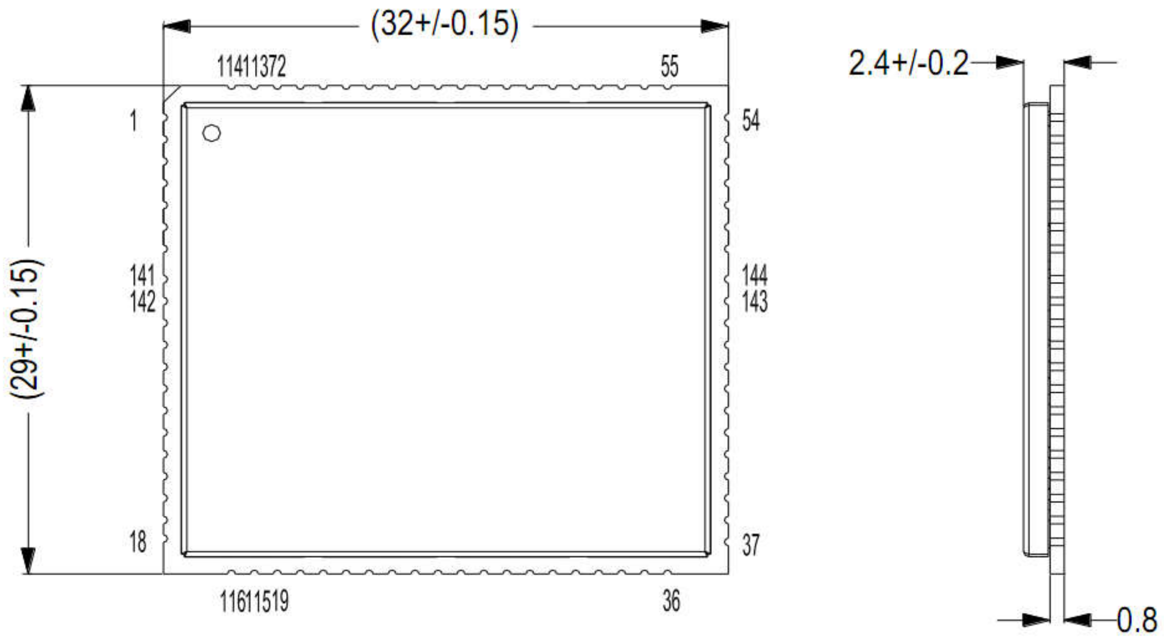

(32+/-0.15)
11411372
55
1
54
141
142
144
143
18
37
11611519
36
(29+/-0.15)
2.4+/-0.2
0.8

Figure 6-3 Dimension of Structure (Unit: mm)

6.3 SMT Patch

For module stencil design, please refer to FIBOCOM_ NL668 LCC SMT Application Design Instruction.

Appendix A Terms and Acronyms

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

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

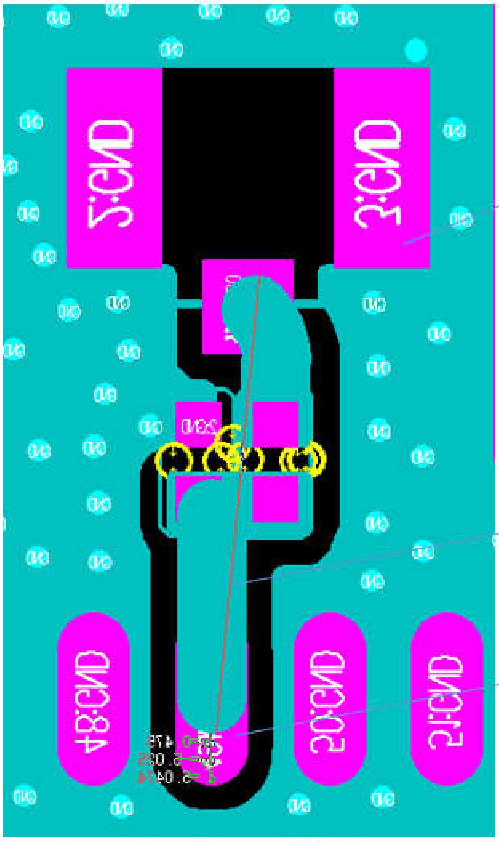
Terms	Description
V_{ILmin}	Minimum Input Low Level Voltage Value
V_{Imax}	Absolute Maximum Input Voltage Value
V_{Imin}	Absolute Minimum Input Voltage Value
V_{OHmax}	Maximum Output High Level Voltage Value
V_{OHmin}	Minimum Output High Level Voltage Value
V_{OLmax}	Maximum Output Low Level Voltage Value
V_{OLmin}	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access

Table A-0-1 Terms and Acronyms

Appendix B ADP & MiniPCIe RF ports trace

1. NL668-AM MiniPCIe

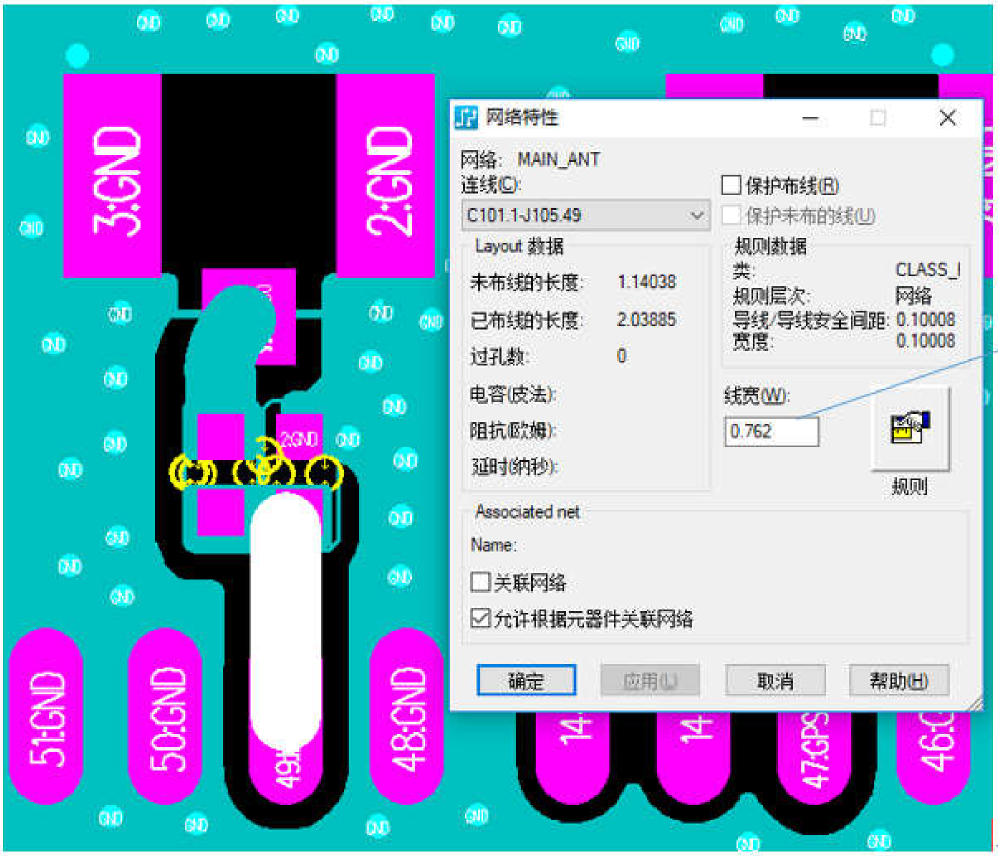
   a) Primary Antenna


3:GND
2:GND
48:GND
20:GND
21:GND

Primary Antenna Interface Port

Trace Length 5mm

RF I/O Port Primary Path


3:GND
2:GND
51:GND
50:GND
48:GND
47:GPS
网络特性
规则
确定
应用(L)
取消
帮助(H)

网络: MAIN_ANT

连线(C): C101.1-J105.49

□ 保护布线(R)

□ 保护未布的线(U)

Layout 数据

未布线的长度:	1.14038
已布线的长度:	2.03885
过孔数:	0
电容(皮法):	
阻抗(欧姆):	
延时(纳秒):	

规则数据

类:	CLASS_I
规则层次:	网络
导线/导线安全间距:	0.10008
宽度:	0.10008

线宽(W): 0.762

Associated net

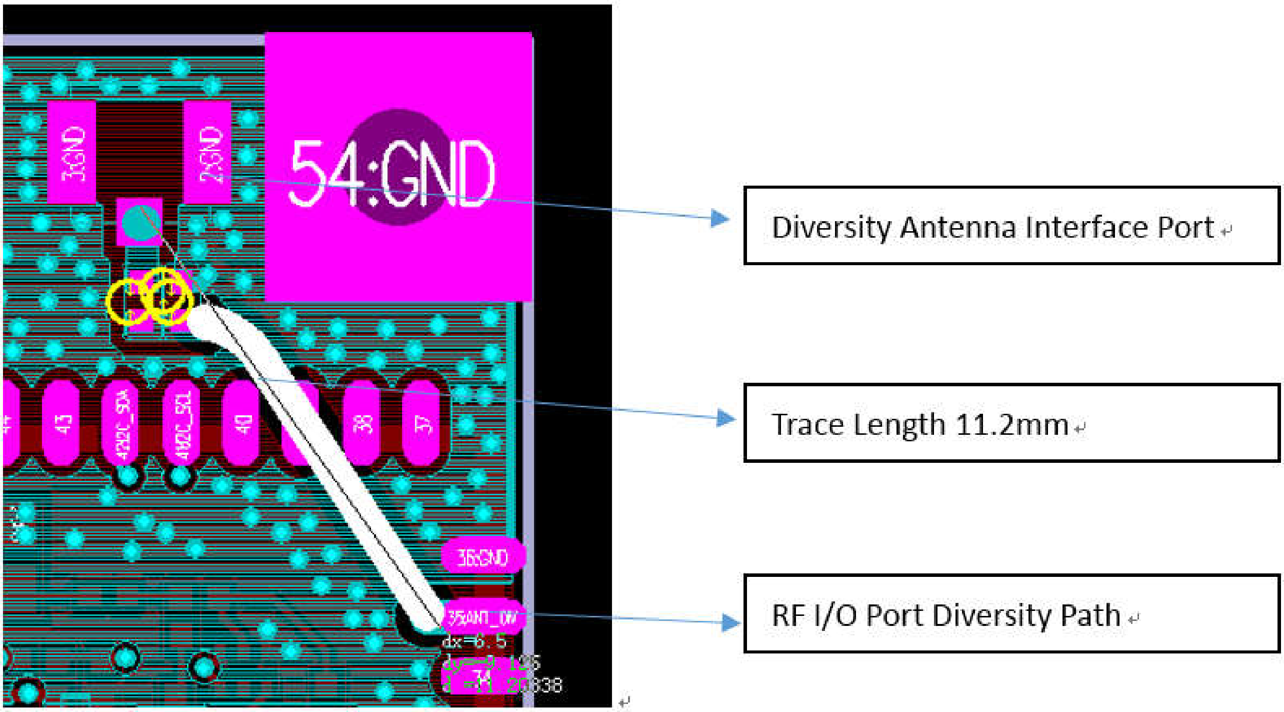
Name:

□ 关联网络

☑ 允许根据元器件关联网络

Trace Width 0.762mm

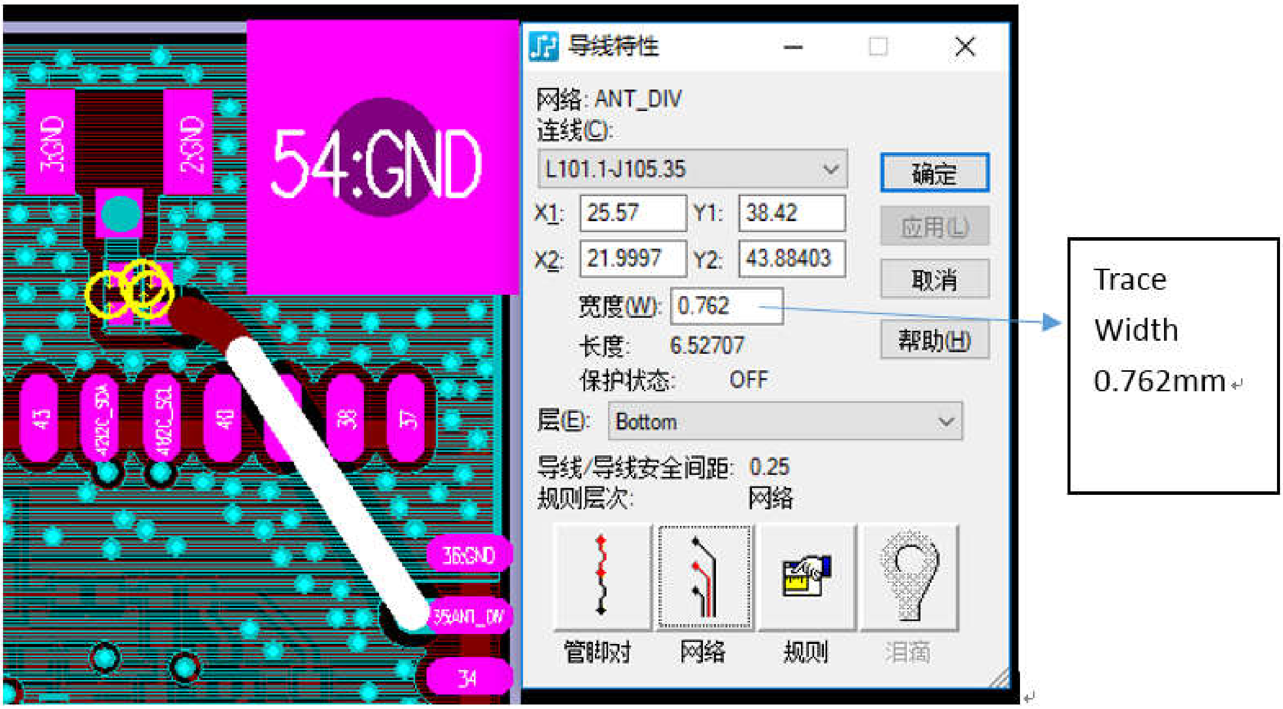
b) Diversity Antenna


3:GND
2:GND
54:GND
43
42:I2C_SDA
41:I2C_SCL
40
38
37
36:GND
35:ANT_DIV
dx=6.5

Diversity Antenna Interface Port

Trace Length 11.2mm

RF I/O Port Diversity Path


3:GND
2:GND
54:GND
43
42:I2C_SDA
41:I2C_SCL
40
38
37
36:GND
35:ANT_DIV
34
导线特性
确定
应用(L)
取消
帮助(H)
管脚对
网络
规则
泪滴

网络: ANT_DIV

连线(C): L101.1-J105.35

X1: 25.57 Y1: 38.42

X2: 21.9997 Y2: 43.88403

宽度(W): 0.762

长度: 6.52707

保护状态: OFF

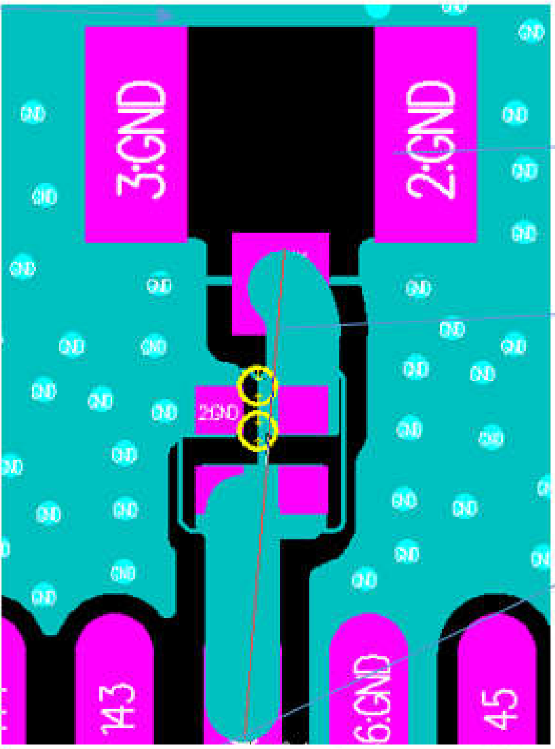
层(E): Bottom

导线/导线安全间距: 0.25

规则层次: 网络

Trace Width 0.762mm

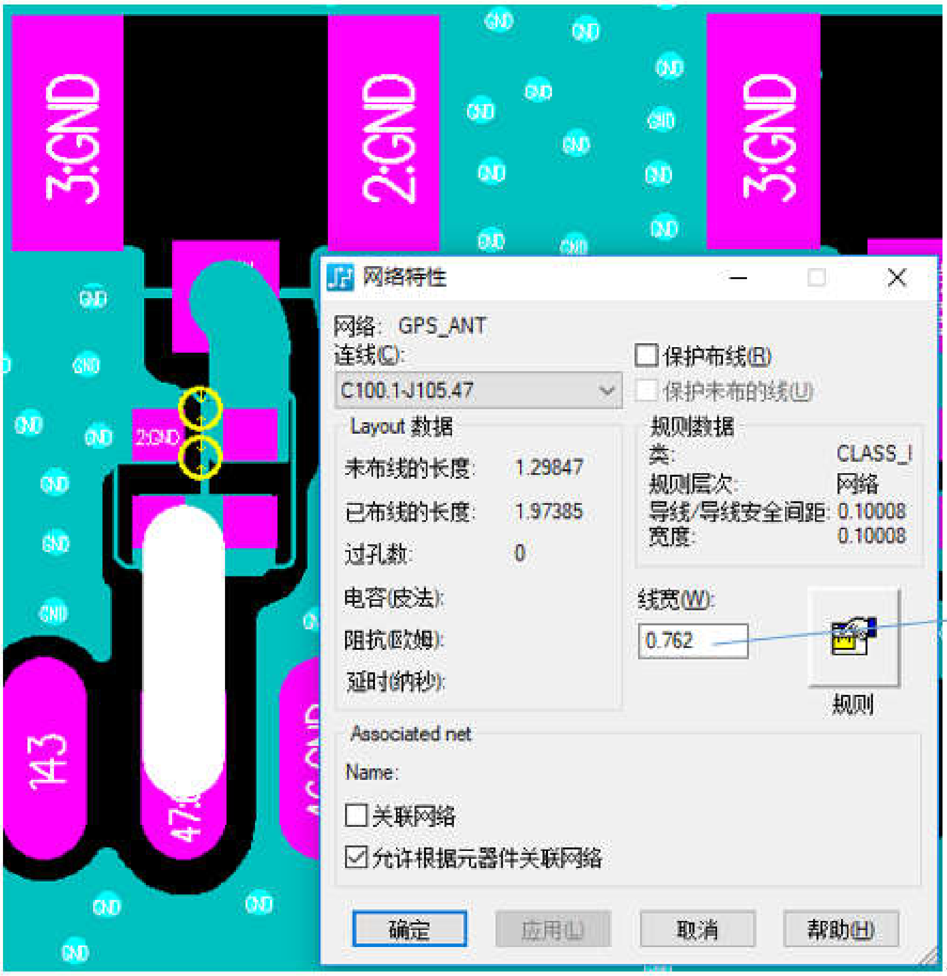
c) GNSS Antenna


3:GND
2:GND
2:GND
GND
143
6:GND
45

GNSS Antenna Interface Port

Trace Length 5mm

RF I/O Port Diversity Path


3:GND
2:GND
3:GND
2:GND
GND
143
47

网络特性

网络: GPS_ANT

连线(C): C100.1-J105.47

☐ 保护布线(R)

☐ 保护未布的线(U)

Layout 数据

未布线的长度: 1.29847

已布线的长度: 1.97385

过孔数: 0

电容(皮法):

阻抗(欧姆):

延时(纳秒):

规则数据

类: CLASS_I

规则层次: 网络

导线/导线安全间距: 0.10008

宽度: 0.10008

线宽(W): 0.762

Associated net

Name:

☐ 关联网络

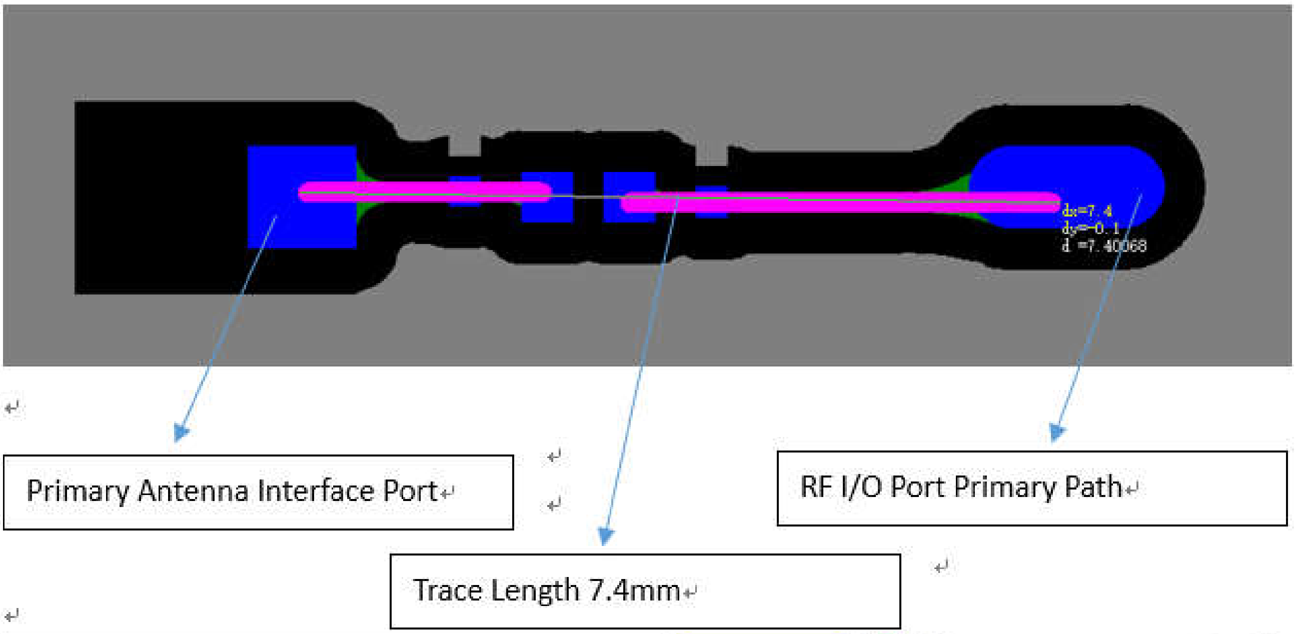
☑ 允许根据元器件关联网络

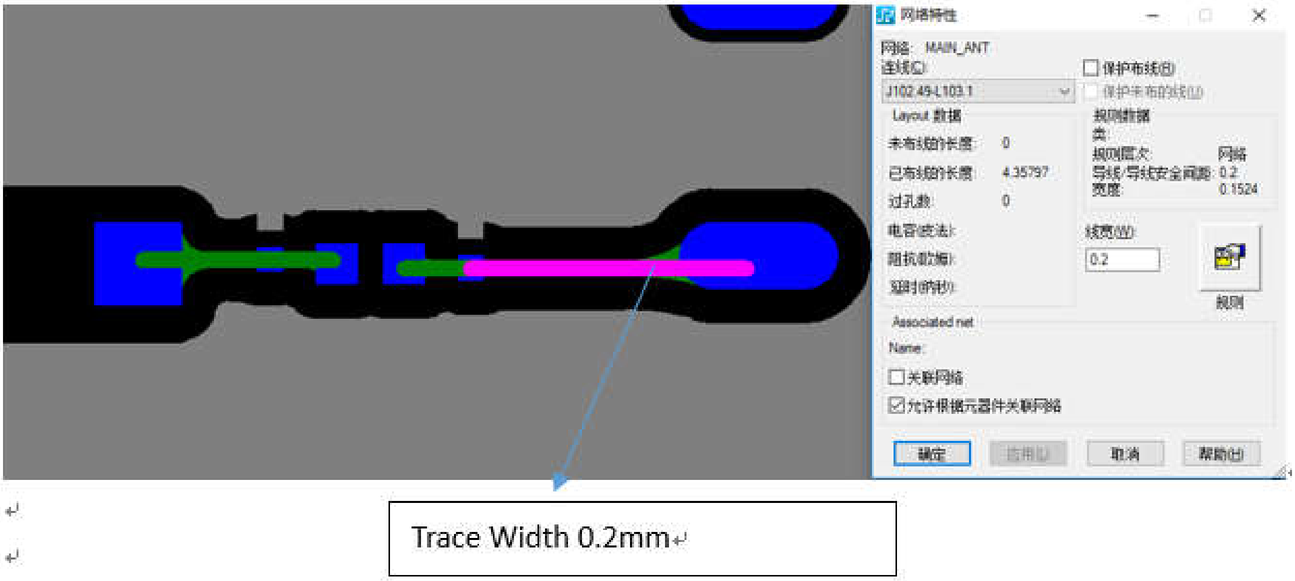
规则
确定
应用(L)
取消
帮助(H)

Trace Width 0.762mm

2. NL668-AM ADP

a) Primary Antenna


dx=7.4
dy=-0.1
d =7.40068
Primary Antenna Interface Port
RF I/O Port Primary Path
Trace Length 7.4mm



网络特性

网络: MAIN_ANT
连线(C): J102.49-L103.1
☐ 保护布线(B)
☐ 保护未布的线(U)

Layout 数据
未布线的长度: 0
已布线的长度: 4.35797
过孔数: 0
电容(皮法):
阻抗(欧姆):
延时(纳秒):

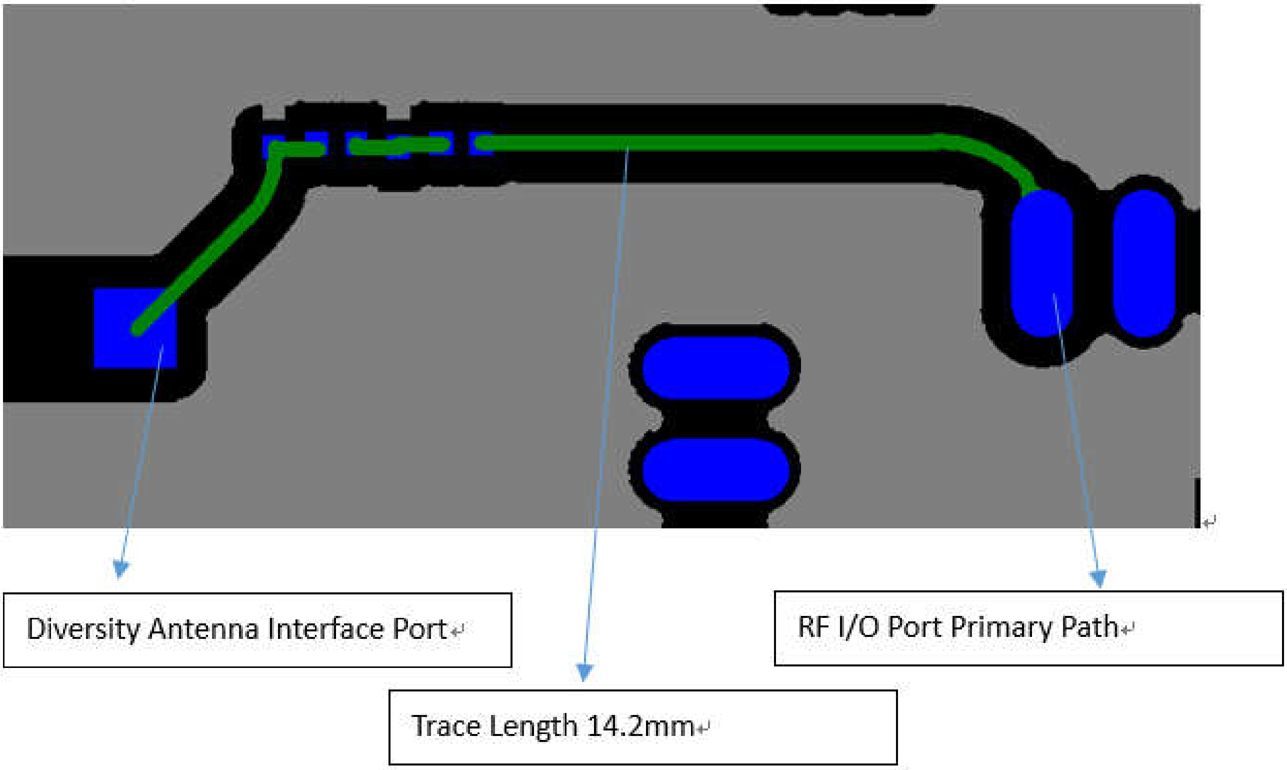
规则数据
类:
规则层次: 网络
导线/导线安全间距: 0.2
宽度: 0.1524

线宽(W): 0.2

Associated net
Name:
☐ 关联网络
☑ 允许根据元器件关联网络

规则
确定
应用(A)
取消
帮助(H)
Trace Width 0.2mm

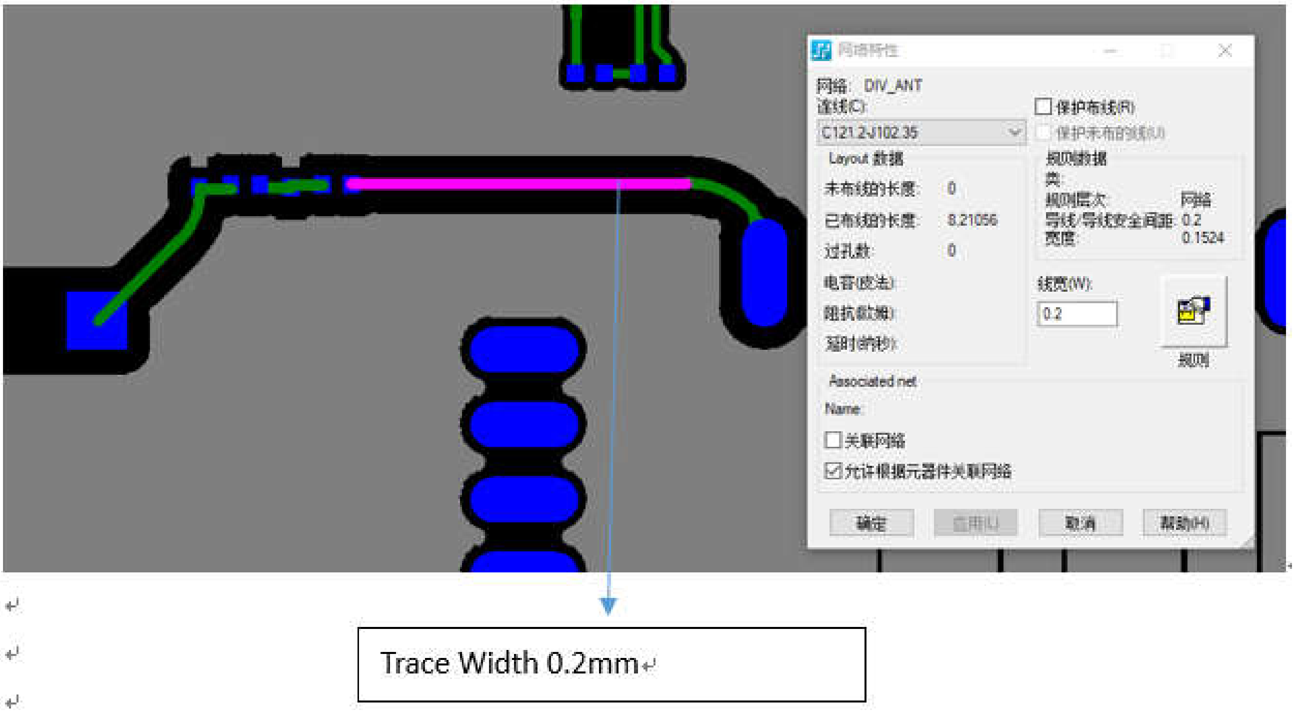
b) Diversity Antenna



Diversity Antenna Interface Port

RF I/O Port Primary Path

Trace Length 14.2mm



网络: DIV_ANT

连线(C): C121.2-J102.35

☐ 保护布线(R)

☐ 保护未布的线(U)

Layout 数据

未布线的长度: 0

已布线的长度: 8.21056

过孔数: 0

电容(皮法):

阻抗(欧姆):

延时(纳秒):

规则数据

类:

规则层次: 网络

导线/导线安全间距: 0.2

宽度: 0.1524

线宽(W): 0.2

Associated net

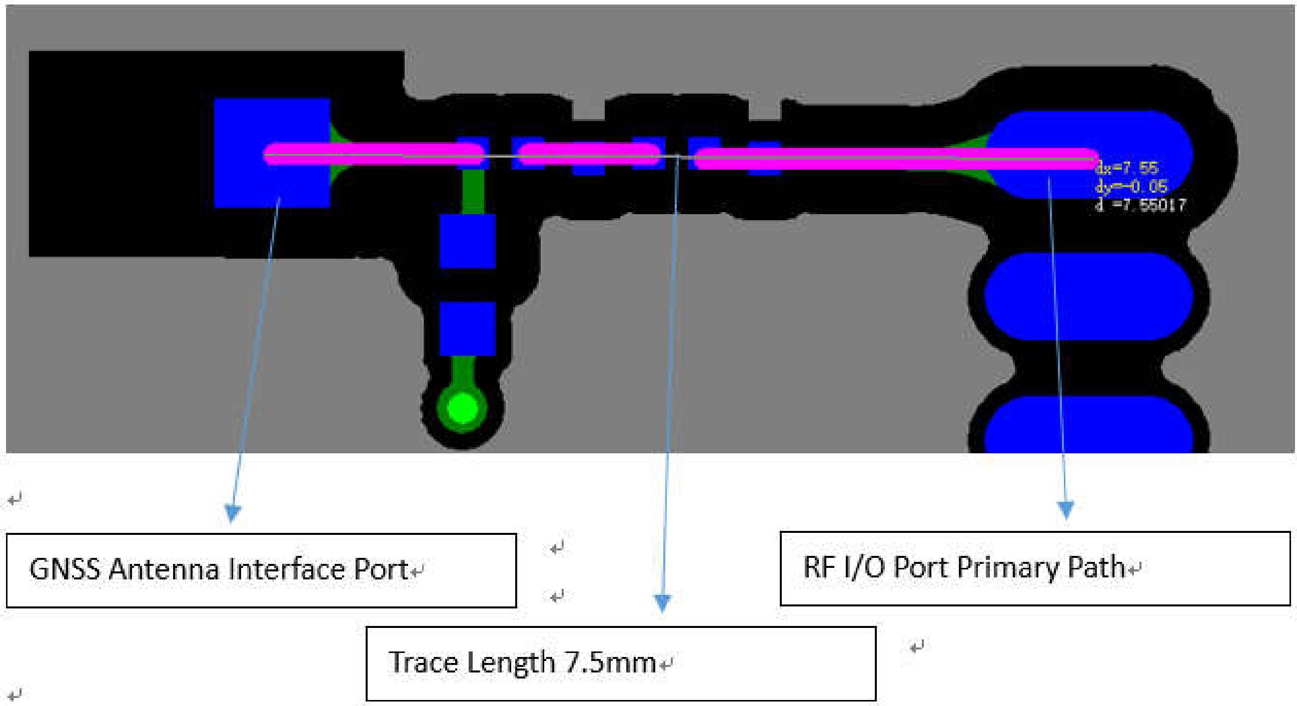
Name:

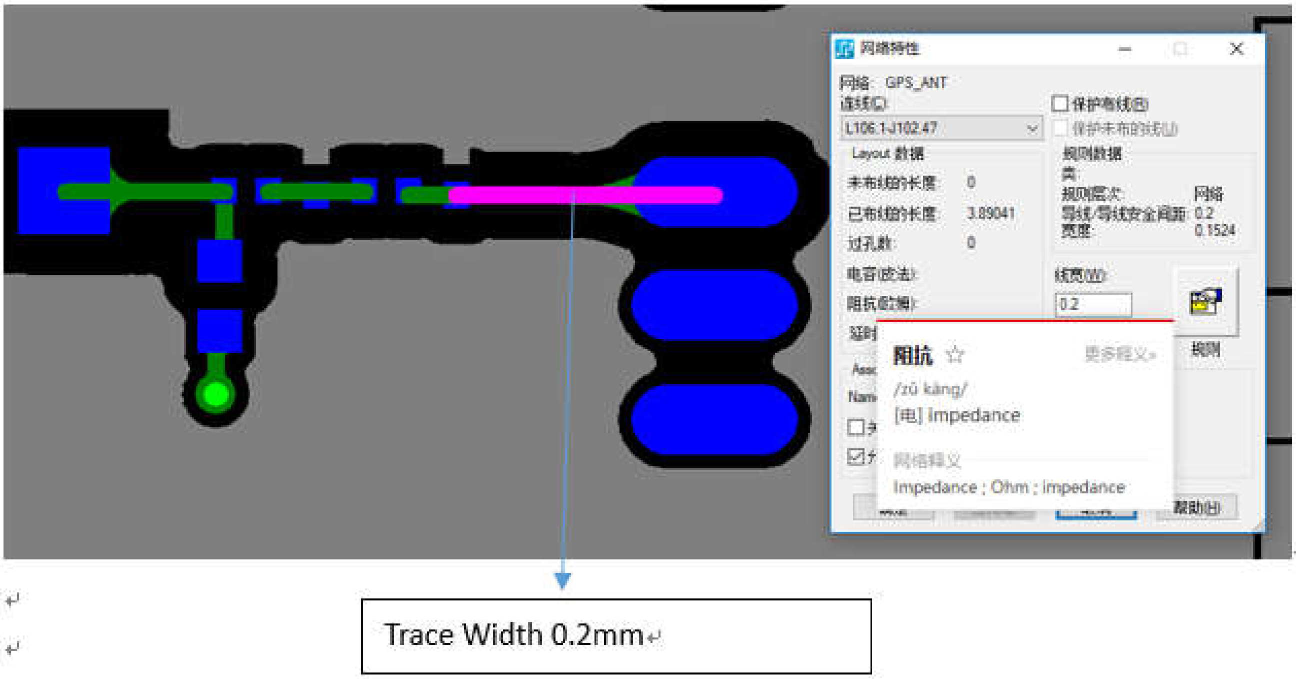
☐ 关联网络

☑ 允许根据元器件关联网络

Trace Width 0.2mm

c) GNSS Antenna


dx=7.55
dy=-0.05
d =7.55017
GNSS Antenna Interface Port
RF I/O Port Primary Path
Trace Length 7.5mm


网络特性
Trace Width 0.2mm

网络: GPS_ANT
连线(C): L106.1-J102.47
☐ 保护布线(R)
☐ 保护未布的线(U)

Layout 数据
未布线的长度: 0
已布线的长度: 3.89041
过孔数: 0
电容(皮法):
阻抗(欧姆):

规则数据
类:
规则层次: 网络
导线/导线安全间距: 0.2
宽度: 0.1524

线宽(W): 0.2

阻抗 ☆ 更多释义»
/zǔ kàng/
[电] Impedance
网络释义
Impedance ; Ohm ; impedance