FIBOCOM NL668-LA Series

Hardware Guide

Version: V1.0.7

Date: 2021-05-12

Applicability Type

No.	Product Model	Description
1	NL668-LA	MCP is 2+1，support MAIN_ANT, DIV_ANT, GNSS_ANT
2	NL668-LA-30	MCP is 4+2，support MAIN_ANT, DIV_ANT, GNSS_ANT
3	NL668-LA-05	MCP is 2+1，support MAIN_ANT, DIV_ANT, GNSS_ANT
4	NL668-LA-10	MCP is 1+1，support MAIN_ANT, DIV_ANT, GNSS_ANT

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Change History

Version	Author	Reviewer	Approver	Update Date	Description
V1.0.7	Guo Zhenqi	Tan Lefan		2021-05-10	Modify pin 138 refer to design description
V1.0.6	Tan Lefan	Hu Wenkai	Luke Liu	2021-03-10	Add model NL668-LA-05 and NL668-LA-10
V1.0.5	Lee Du	Hu Wenkai	Luke Liu	2020-08-10	Update product appearance
V1.0.4	Hu Wenkai	Lee Du	Luke Liu	2020-03-13	Update power consumption
V1.0.3	Lee Du	Hu Wenkai	Luke Liu	2020-01-10	Add model NL668-LA-01
V1.0.2	Tan Lefan	Hu Wenkai	Luke Liu	2019-10-09	Modify module size. Increase the requirements of boot_config1, 2, 3 pins forbidden to pull up externally.
V1.0.1	Liu Qiang	Li Xiyi	Chen Guojiang	2019-07-09	Update RF parameters
V1.0.0	Gao Ying	Tu Min	Chen Guojiang	2019-06-06	Initial version

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Content

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1 Introduction

1.1 Document Introduction

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

1.2 Safety Precautions

By following the safety guidelines below, you can protect the 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 Wireless 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 (U)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.

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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.

2 Product Overview

2.1 Product Introduction

The NL668-LA series wireless module is a broadband wireless terminal product applicable to various network formats and multi-bands include TDD-LTE/FDD-LTE/WCDMA/GSM.

2.2 Product Specification

Table 2-1 Product specification

Specification			
Operating frequency	NL668-LA NL668-LA-05 NL668-LA-10 NL668-LA-30	LTE FDD: Band 1, 2, 3, 4, 5, 7, 8, 12, 17, 28, 66	
		LTE TDD: Band 38, 40	
		WCDMA/HSPA+: Band 1, 2, 3, 4, 5, 8	
		GSM/GPRS/EDGE: 850/900/1800/1900MHz	
Data transmission		LTE FDD Rel.9	150Mbps DL/50Mbps UL (Cat 4) LTE Downlink MIMO 2×2, 4×2 (support part of R10)
		LTE TDD Rel.9	130Mbps DL/30.5Mbps UL (Cat 4) LTE Downlink MIMO 2×2, 4×2 (support part of R10)
		WCDMA Rel.8	UMTS: 384 kbps DL/384 kbps UL
			DC-HSDPA+: 42MbpsDL (Cat24)/HSUPA:5.76Mbps UL (Cat 6)
		GPRS/EDGE Rel.5	GPRS: 107kbps DL/85.6kbps UL (multi-slot class 33)
			EDGE(E-GPRS): 296kbps DL/236.8kbps UL (multi-slot class 33)
Power		3.3V to 4.3V (typical 3.8V)	
Temperature		Normal: -30°C to +75°C	
		Extended:-40°C to +85°C	
		Storage:-40°C to +90°C	
Power consumption		Base current: < 2mA	
		Sleep mode: ≤ 4mA	
		Idle mode: < 20mA (USB sleep), < 30mA (USB wakeup)	
Physical characteristics		Package: LCC+LGA 144 Pin	
		Size: (32.0±0.15) mm × (29.0±0.15) mm × (2.4±0.2) mm	

	Weight: about 5.2g
Interface	
Antenna	Antenna: MAIN, GNSS, DIV
Functional Interface	(U)SIM 3.0V/1.8V
	USB 2.0
	Status Indicator
	UART x 2, PCM, I2C, SGMII, SPI, SDIO, GPIOs
	ADC x 2
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

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 specification.

2.3 Functional Diagram

Functional diagram shows the main hardware features of the NL668-LA series module, including baseband and RF features.

Baseband includes:

- PMIC
- MCP
- USB, (U)SIM, PCM, I2C, SPI, UART, SGMII, SDIO, GPIOs
- GSM/CDMA/EVDO/WCDMA/TD-SCDMA/LTE TDD/LTE FDD controller

RF includes:

- RF Transceiver
- RF PA
- RF filter
- Antenna
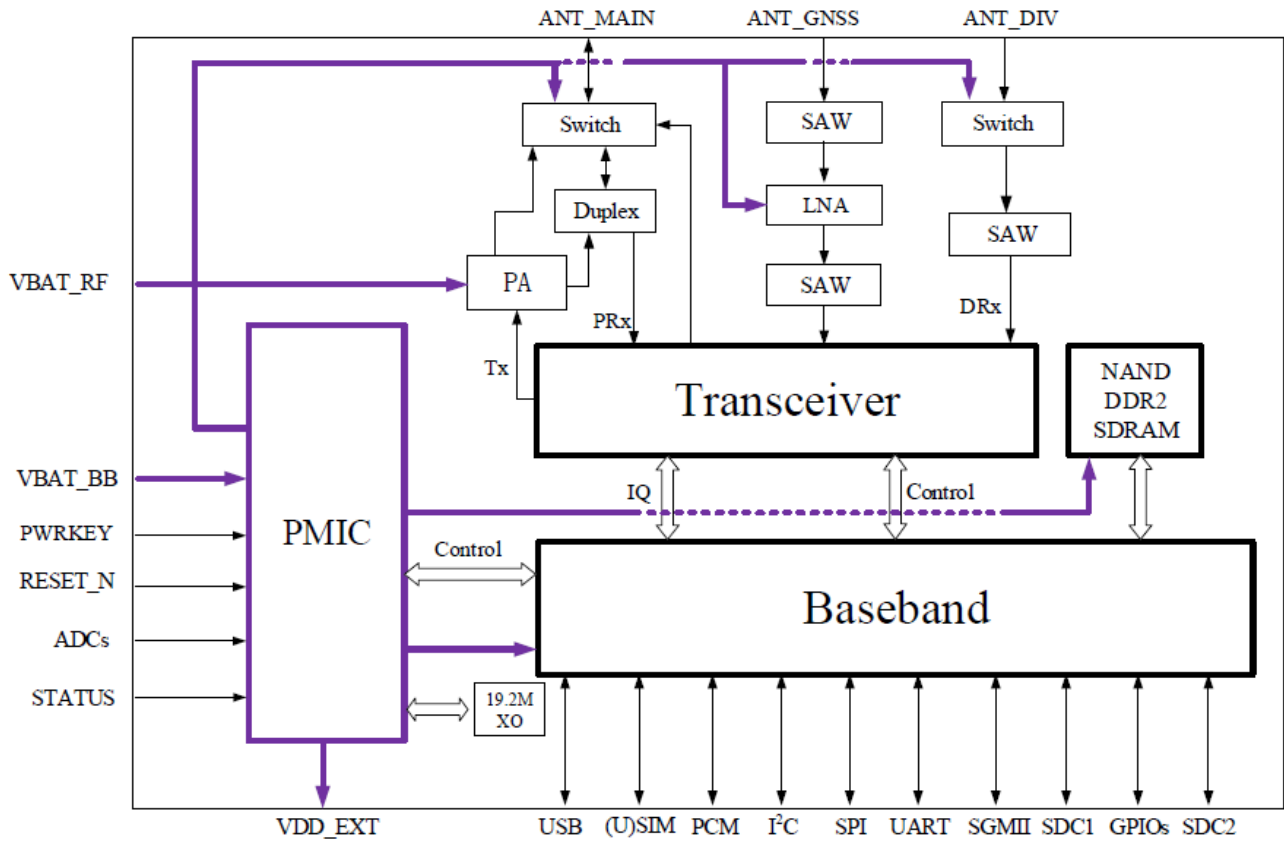
![Fibocom]

Figure 2-1 Functional diagram

2.4 Evaluation Board

Fibocom provides EVK-GT8230-NL, ADP-NL668-LA evaluation board to convenient module's debug and use.

3 Pin Description

3.1 Pin Assignment

The NL668-LA series module is available in 144 pins. The numbers of the LCC pins are 80, and the LGA pins are 64. the top view of the pin assignment is shown as follow figure:
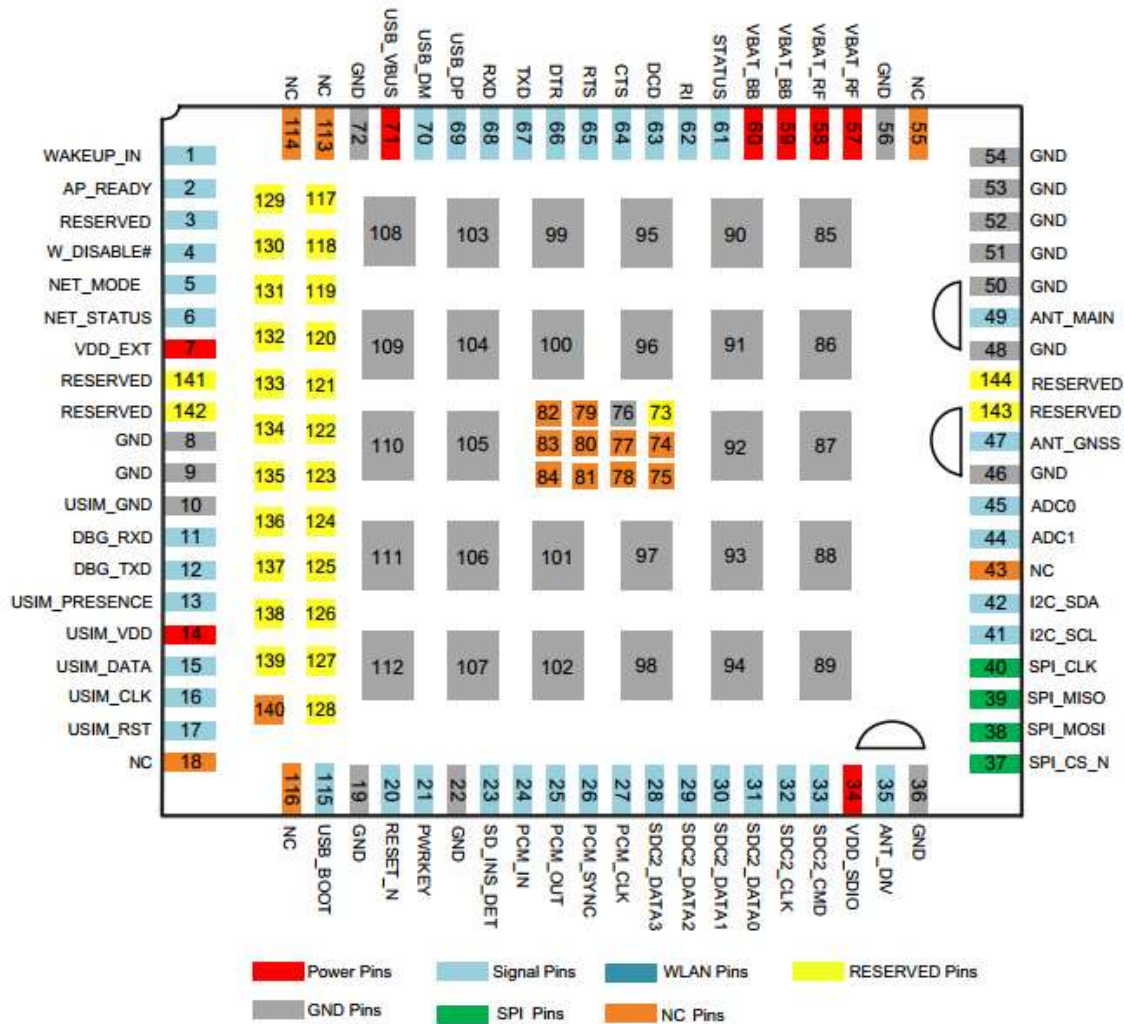
Figure 3-1 Pin assignment (top view diagram)

Note:

85 to 112 are thermal pins, and the module is grounded internally. It is recommended that the heat sink pad is reserved for PCB packaging and welded.

3.2 Pin Function

Table 3-1 I/O description parameters

Symbol	Description
IO	Input/Output
DI	Digital input
DO	Digital output
PI	Power input
PO	Power output
AI	Analog input
AO	Analog output
OD	Open drain
OC	Open collector

The pin function description of NL668-LA series module is shown as table 3-2:

Table 3-2 Pin function description

Pin No.	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, low active by default. with software programmable option. Boot_config GPIO, forbidden to pull-up externally.
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. pull up by default. Pull down this pin, module enter airplane mode
5	NET_MODE	O	$V_{OL}max=0.45V$ $V_{OH}min=1.35V$	Module network state indicate (by default), Boot_config GPIO, forbidden to pull-up externally.
6	NET_STATUS	O	$V_{OL}max=0.45V$ $V_{OH}min=1.35V$	Module network state indicate
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

Pin No.	Pin Name	I/O	Level	Description
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	$V_{IL}min=-0.3V$ $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{IH}max=2.0V$	(U)SIM card hot plug detection
14	USIM_VDD	PO	For 1.8V (U)SIM: Vmax=1.9V Vmin=1.7V For 3.0V (U)SIM: Vmax=3.05V Vmin=2.7V $I_O$max=50mA	(U)SIM power, identify 1.8V or 3V (U)SIM card automatically
15	USIM_DATA	IO	For 1.8V (U)SIM: $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{OL}max=0.45V$ $V_{OH}min=1.35V$ For 3.0V (U)SIM: $V_{IL}max=1.0V$ $V_{IH}min=1.95V$ $V_{OL}max=0.45V$ $V_{OH}min=2.55V$	(U)SIM data signal
16	USIM_CLK	O	For 1.8V (U)SIM: $V_{OL}max=0.45V$ $V_{OH}min=1.35V$ For 3.0V (U)SIM: $V_{OL}max=0.45V$ $V_{OH}min=2.55V$	(U)SIM clock signal
17	USIM_RST	O	For 1.8V (U)SIM: $V_{OL}max=0.45V$ $V_{OH}min=1.35V$ For 3.0V (U)SIM:	(U)SIM reset signal

Pin No.	Pin Name	I/O	Level	Description
			$V_{OL}max=0.45V$ $V_{OH}min=2.55V$	
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	$V_{IH}max=2.1V$ $V_{IH}min=1.3V$ $V_{IL}max=0.5V$	Module power on/off signal, active low, no need pull up externally. The input is pulled up to an internal voltage minus a diode drop. As per the design, this causes the voltage of the pin is about 0.8V
22	GND	G	-	Ground
23	SD_INS_DET	I	-	Reserved
24	PCM_IN	I	$V_{IL}min=-0.3V$ $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{IH}max=2.0V$	PCM input signal
25	PCM_OUT	O	$V_{OL}max=0.45V$ $V_{OH}min=1.35V$	PCM output signal
26	PCM_SYNC	IO	$V_{OL}max=0.45V$ $V_{OH}min=1.35V$ $V_{IL}min=-0.3V$ $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{IH}max=2.0V$	PCM synchronization signal
27	PCM_CLK	IO	$V_{OL}max=0.45V$ $V_{OH}min=1.35V$ $V_{IL}min=-0.3V$ $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{IH}max=2.0V$	PCM clock signal
28	SDC2_DATA3	IO	-	Reserved
29	SDC2_DATA2	IO	-	Reserved
30	SDC2_DATA1	IO	-	Reserved
31	SDC2_DATA0	IO	-	Reserved
32	SDC2_CLK	O	-	Reserved

Pin No.	Pin Name	I/O	Level	Description
33	SDC2_CMD	IO	-	Reserved
34	VREG_L13_2P85	PO	-	Reserved
35	ANT_DIV	I	-	Diversity antenna
36	GND	-	-	Ground
37	SPI_CS_N	O	-	Reserved
38	SPI_MOSI	O	-	Reserved
39	SPI_MISO	I	-	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 interface1
45	ADC0	I	-	Analog to digital converter interface 0
46	GND	G	-	Ground
47	ANT_GNSS	I	-	GNSS antenna
48	GND	-	-	Ground
49	ANT_MAIN	IO	-	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	PI	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	RF power input (3.3V~4.3V)
58	VBAT_RF	PI	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	RF power input (3.3V~4.3V)
59	VBAT_BB	PI	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	Baseband power input（3.3V~4.3V）
60	VBAT_BB	PI	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	Baseband Power Input (3.3V~4.3V)

Pin No.	Pin Name	I/O	Level	Description
61	STATUS	O	$V_{OH}min=1.35V$ $V_{OL}max=0.45V$	Module network state indicate
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	O	$V_{OL}max=0.45V$ $V_{OH}min=1.35V$	Request to send
65	RTS	I	$V_{IL}min=-0.3V$ $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{IH}max=2.0V$	Clear to send
66	DTR	I	$V_{IL}min=-0.3V$ $V_{IL}max=0.6V$ $V_{IH}min=1.2V$ $V_{IH}max=2.0V$	Data ready. The control of the sleep mode
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	IO	Conform to USB2.0 standard specification	USB differential data bus (+)
70	USB_DM	IO	Conform to USB2.0 standard specification	USB differential data bus (-)
71	USB_VBUS	PI	Vmax=5.25V Vmin=3.0V Vnorm=5.0V	USB plug detection
72,76	GND	G	-	Ground
73,82	RESERVED	-	-	Reserved
74,75,77~81,83,84	NC	-		NC
85~112	GND	G	-	GND
113	NC	-	-	NC

Pin No.	Pin Name	I/O	Level	Description
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, active high, recommended to reserve test point
116	NC	-	-	NC
117	RESERVED	-	-	Reserved
118	WLAN_SLP_CLK	O	-	Reserved
119	EPHY_RST_N	O	-	Reserved
120	EPHY_INT_N	I	-	Reserved
121	SGMII_MDATA	IO	-	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	O	-	Reserved
128	VREG_L5_UIM2	PO	-	Reserved
129	SDC1_DATA3	IO	-	Reserved
130	SDC1_DATA2	IO	-	Reserved
131	SDC1_DATA1	IO	-	Reserved
132	SDC1_DATA0	IO	-	Reserved
133	SDC1_CLK	O		Reserved
134	SDC1_CMD	O	-	Reserved
135	WAKE_WLAN	I		Reserved
136	WLAN_EN	O	-	Reserved
137	COEX_UART_RXD	I	-	Reserved
138	COEX_UART_TXD	O	-	Reserved, Boot_config GPIO, forbidden to pull-up externally. (Applicable to NL668-LA-00 and NL668-LA-01. But NL668-LA-05 and NL668-LA-10 are not subject to this restriction)
139	BT_EN	O	-	Reserved
140	NC	-	-	NC
141	RESERVED	-	-	Reserved

Pin No.	Pin Name	I/O	Level	Description
142	RESERVED	-	-	Reserved
143	RESERVED	-	-	Reserved
144	RESERVED	-	-	Reserved

⚠ **Note:**

Keep the unused pins floating. The reserved pins are in development.

4 Electrical Characteristics

4.1 Power

Table 4-1 show the power interface of NL668-LA series module.

Table 4-1 Power interface

Pin Name	I/O	Pin	Description
VBAT_RF	PI	57, 58	Module power supply, 3.3V~4.3V, typical value 3.8V
VBAT_BB	PI	59, 60	Module power supply, 3.3V~4.3V, typical value 3.8V
VDD_EXT	PO	7	Module digital voltage output, 1.8V, 80mA
GND	G	8, 9, 10, 19, 22, 36, 46, 48, 50–54, 56, 72, 76, 85–112	All GND pins must be grounded

![Note icon] **Note:**

In the rest of the document, VBAT includes VBAT_BB and VBAT_RF.

4.2 Power Supply

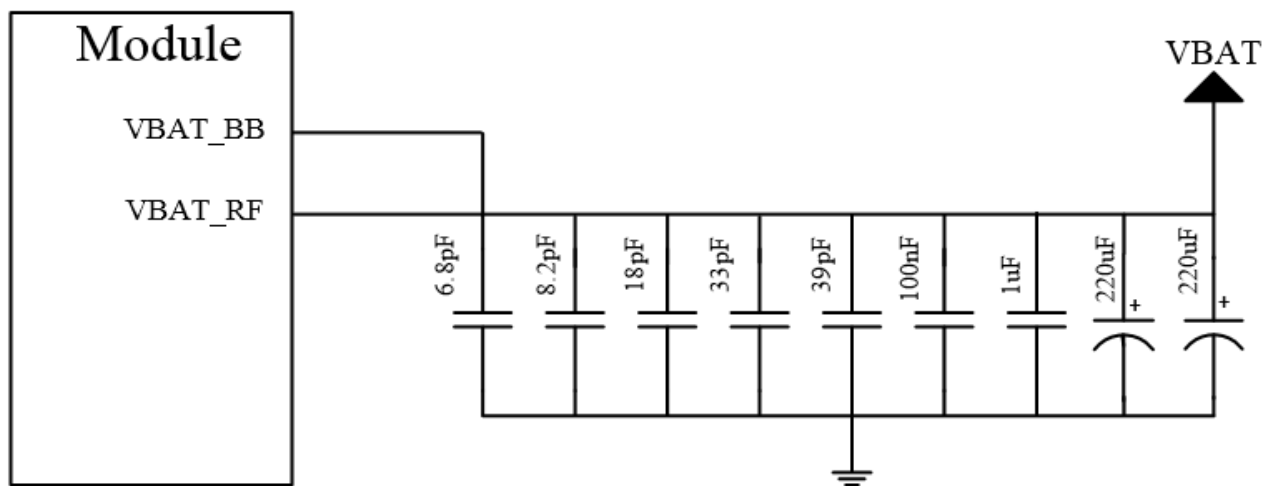The NL668-LA series module needs to be powered by the VBAT pin. The recommend power design is shown in Figure 4-1:

Figure 4-1 Recommend power design

Table 4-2 Filter capacitors design of power supply

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 100uF ~ 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

The power stability can ensure the normal operation of NL668-LA module. The power supply ripple limit for the module is no more than 300mV (the circuit ESR < 100mΩ) requires special attention when design circuit.

When the module is operating in GSM mode (Burst transmit), the maximum operating current can reach 3A, 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 4-2:
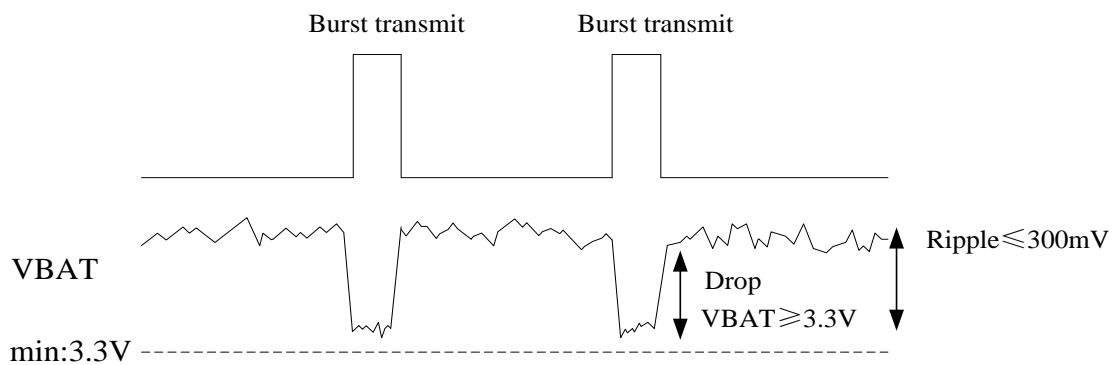

Figure 4-2 Power limit

4.3 1.8V Output

The NL668-LA series module outputs a 1.8V voltage through the VDD_EXT for the use of the internal digital circuit of module. The voltage is the logic level of the module and can be used to indicate module

Power on/off, or for external low current (< 80mA) circuits. leave the signal floating if no use. The logic level of VDD_EXT is defined as follows:

Table 4-3 VDD_EXT logic level

Parameter	Minimum	Typical	Maximum	Unit
VDD_EXT	1.71	1.8	1.89	V

4.4 Power Consumption

The power consumption of NL668-LA series module measured at 3.8V power supply is shown as follow table, for USB sleep and USB wakeup AT commands please refer to 6.1.2 section:

Table 4-4 Power consumption

Parameter	Mode	Condition	Average Current Typ. (mA)
I$_{off}$	Power off	Module power off	0.018
I$_{idle}$ Radio off	GSM	MFRMS=5 (USB sleep)	15
		MFRMS=5 (USB wakeup)	30
	WCDMA	DRX=8 (USB sleep)	15
		DRX=8 (USB wakeup)	30
	LTE FDD	Paging cycle #64 frames (USB sleep)	15
		Paging cycle #64 frames (USB wakeup)	30
	LTE TDD	Paging cycle #64 frames (USB sleep)	15
		Paging cycle #64 frames (USB wakeup)	30
	Radio off	AT+CFUN=0,0 (USB sleep)	15
		AT+CFUN=0,0 (USB wakeup)	30
I$_{sleep}$	GSM	MFRMS=5 (USB sleep)	3
	WCDMA	DRX=8 (USB sleep)	3
	LTE FDD	Paging cycle #64 frames (USB sleep)	3
		Paging cycle #128 frames (USB sleep)	3
		Paging cycle #256 frames (USB sleep)	3
	LTE TDD	Paging cycle #64 frames (USB sleep)	3
		Paging cycle #128 frames (USB sleep)	3
		Paging cycle #256 frames (USB sleep)	3

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Parameter	Mode	Condition	Average Current Typ. (mA)
I_{GSM-RMS}	GSM	GSM850 PCL5	260
		EGSM900 PCL5	260
		DCS1800 PCL0	200
		PCS1900 PCL0	200
I_{GPRS-RMS} CS4	GPRS	GPRS Data transfer GSM850; PCL=5; 1Rx/4Tx	570
		GPRS Data transfer GSM900; PCL=5; 1Rx/4Tx	570
		GPRS Data transfer DCS1800; PCL=0; 1Rx/4Tx	430
		GPRS Data transfer PCS1900; PCL=0; 1Rx/4Tx	430
I_{EGPRS-RMS} MCS9	EDGE	EDGE Data transfer GSM850; PCL=8; 1Rx/4Tx	470
		EDGE Data transfer GSM900; PCL=8; 1Rx/4Tx	460
		EDGE Data transfer DCS1800; PCL=2; 1Rx/4Tx	440
		EDGE Data transfer PCS1900; PCL=2; 1Rx/4Tx	440
I_{WCDMA-RMS}	WCDMA	WCDMA Data transfer Band 1 @+23.5dBm	650
		WCDMA Data transfer Band 2 @+23.5dBm	620
		WCDMA Data transfer Band 3 @+23.5dBm	700
		WCDMA Data transfer Band 4 @+23.5dBm	700
		WCDMA Data transfer Band 5 @+23.5dBm	550
		WCDMA Data transfer Band VIII@+23.5dBm	570
I_{LTE-RMS}	LTE FDD	LTE FDD Data transfer Band 1 @+23dBm	650
		LTE FDD Data transfer Band 2 @+23dBm	650
		LTE FDD Data transfer Band 3 @+23dBm	730
		LTE FDD Data transfer Band 4 @+23dBm	700

Parameter	Mode	Condition	Average Current Typ. (mA)
		LTE FDD Data transfer Band 5 @+23dBm	580
		LTE FDD Data transfer Band 7 @+23dBm	750
		LTE FDD Data transfer Band 8 @+23dBm	580
		LTE FDD Data transfer Band 12 @+23dBm	650
		LTE FDD Data transfer Band 17 @+23dBm	670
		LTE FDD Data transfer Band 20 @+23dBm	650
		LTE FDD Data transfer Band 28 @+23dBm	680
		LTE FDD Data transfer Band 66 @+23dBm	720
	LTE TDD	LTE TDD Data transfer Band 38 @+23dBm	400
		LTE TDD Data transfer Band 40 @+23dBm	420

5 Functional Interface

5.1 Control Interface

Control interfaces used for module power on/off and reset operations. The pin definitions are as follows:

Table 5-1 Control signal

Pin name	I/O	Pin No.	Description
RESET_N	I	20	When the module in operating mode, pull down RESET_N 700ms to 1s, and then release it, the module is reset.
PWRKEY	I	21	When module in power off mode, pull down PWRKEY 100ms to 2s, and release it, the module will power on; When module in operating mode, pull down PWRKEY 3s to 8s, and then release it, the module will power off.

5.1.1 Power On/Off

5.1.1.1 Power On

When NL668-LA series module in power off mode, pull down PWRKEY pin 100ms to 2s, the module will power on, it is recommended to use OC/OD drive circuit to control PWRKEY pin. The OC drive reference circuit is shown as follows:
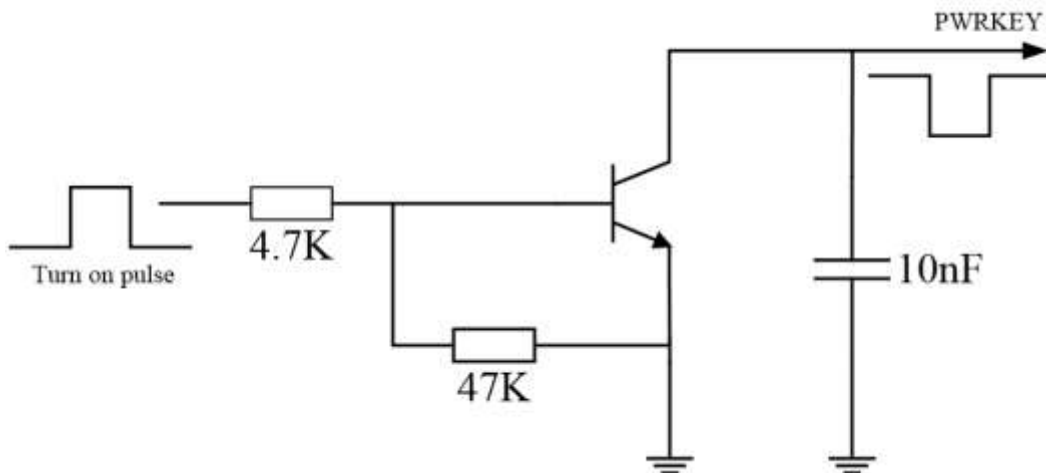

Figure 5-1 OC drive power on reference circuit

The other way to control PWRKEY pin is use a button switch, a TVS should located near the button (recommended ESD9X5VL-2/TR) for ESD protection. The button switch power on reference circuit is shown as follows:

S1

PWRKEY

Close to S1
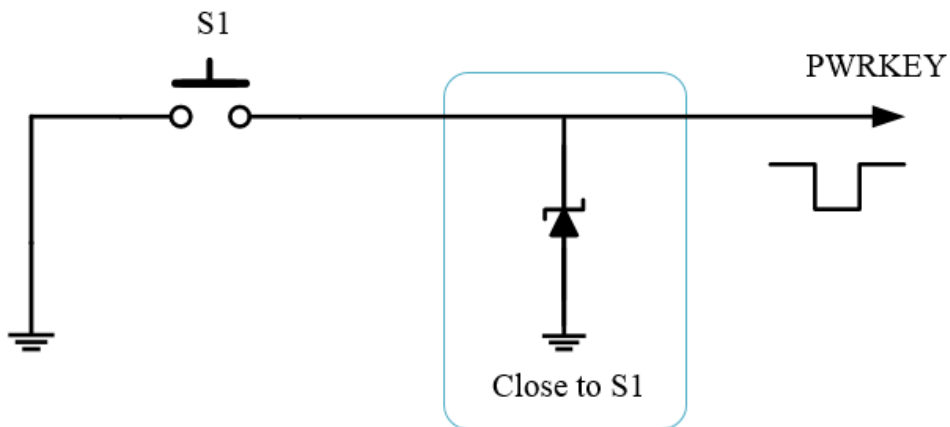
Figure 5-2 Button switch power on reference circuit

Figure 5-3 shows power on timing.

By Note

VBAT

≥100mS

$V_{IH} \geq 1.3V$

PWRKEY

$V_{IL} \leq 0.5V$

RESET_N

VDD_EXT

Figure 5-3 Power on timing

⚠ **Note:**

Before pull down PWRKEY pin, the Voltage of VBAT must be stable, recommended time interval between VBAT enable and pull down PWRKEY pin at least 30ms.

5.1.1.2 Power Off

The module supports three power off methods as table 5-2.

Table 5-2 Power Off
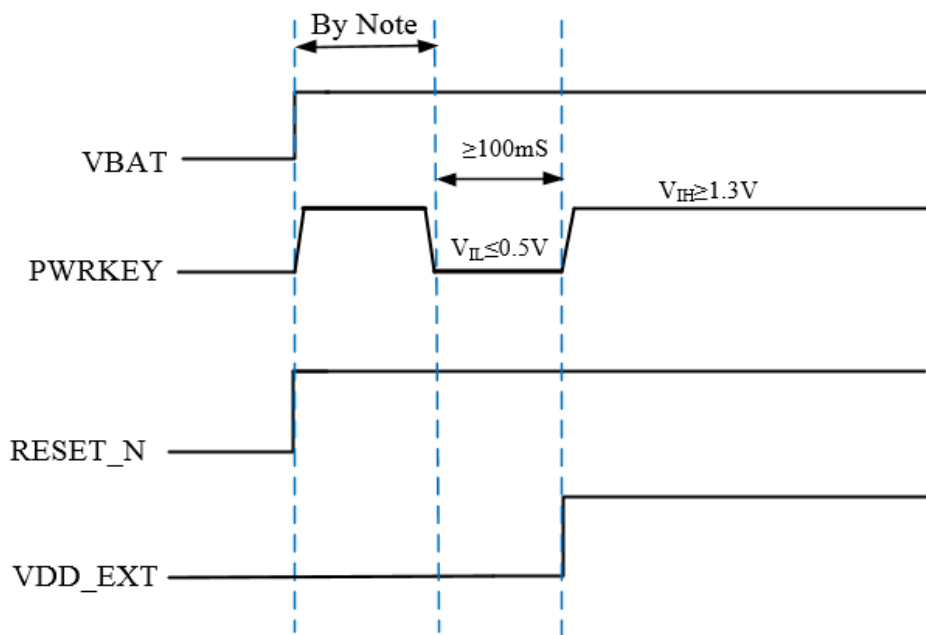
Power Off Mode	Power Off Method	Applicable Scenario
Low-voltage power off	When VBAT voltage is low or power down, the module will power off	The module does not power off through normal process, i.e. does not logout from the base station
Hardware power off	Pull down PWRKEY 3s to 8s	Hardware normal power off
AT power off	AT+ CPWROFF	Software normal power off

Note:

1.When module at operating mode, please do not cut off module power supply to avoid damage internal flash. Recommended by PWRKEY pin or AT commands power off module, then cut off power supply.

2.When power off by AT commands, please don't pull down PWRKEY pin, otherwise module will power on again automatically.

The power off timing is shown as follows:
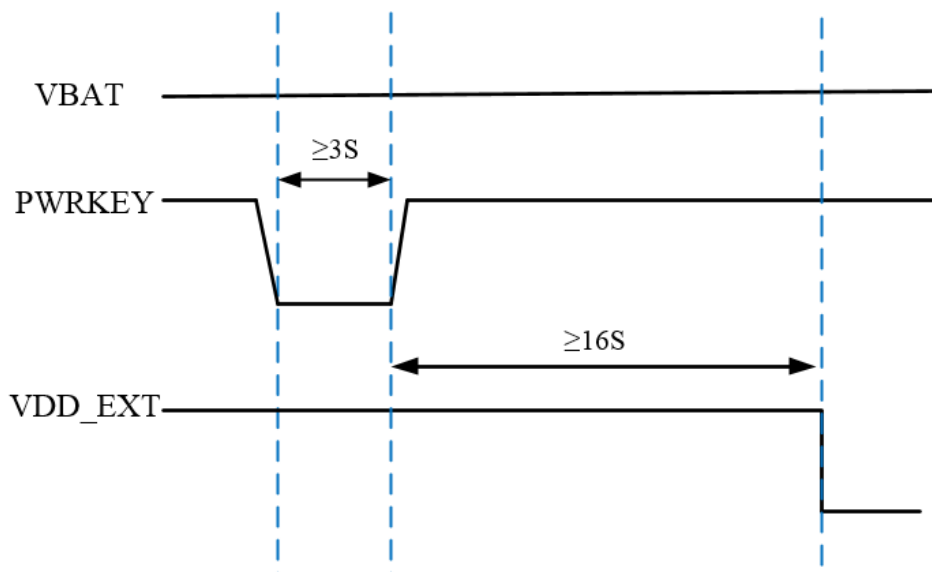
Figure 5-4 Power off timing

5.1.2 RESET

The module supports two modes to reset: hardware reset and software reset.

Table 5-3 Reset

Reset Mode	Reset Method
Hardware reset	Pull down RESET_N pin 700s to 1s, then release it
Software reset	Sent AT commands AT+RESET

![Fibocom]

Clients can control RESET_N pin by two modes: OC/OD drive circuits and button switch, corresponding reference circuit as Figure 5-5 and Figure 5-6:

Figure 5-5 OC driven reset reference circuit

Figure 5-6 Button reset reference circuit

The reset timing is shown as follows:
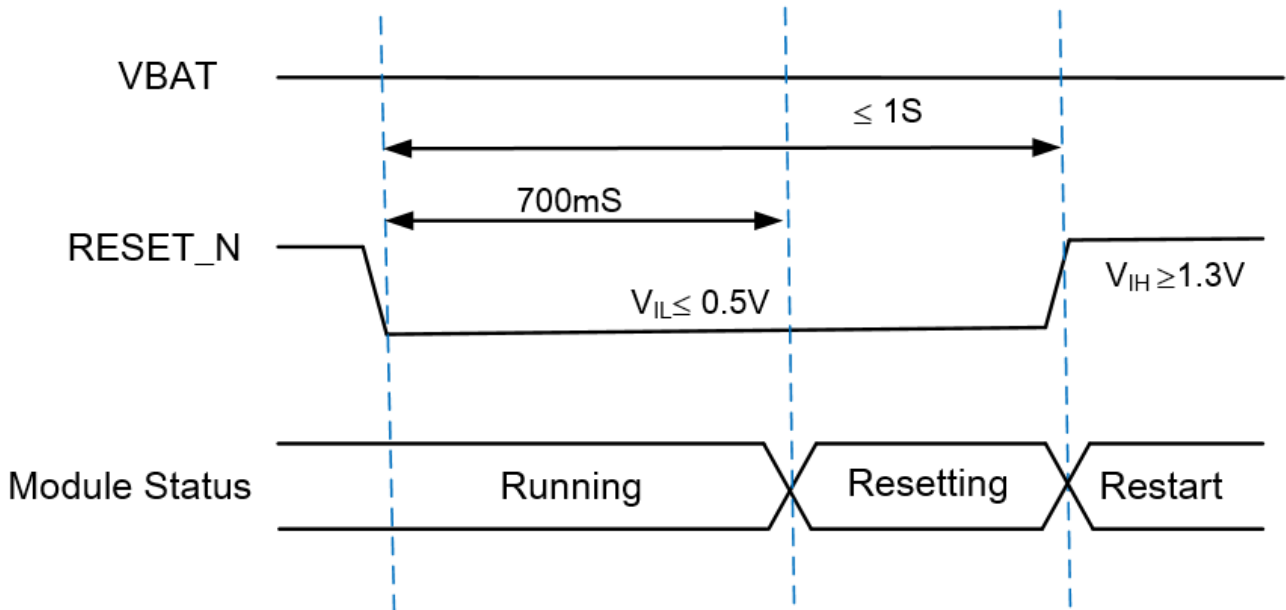
Figure 5-7 Reset timing

5.2 Network Status Indicate Interface

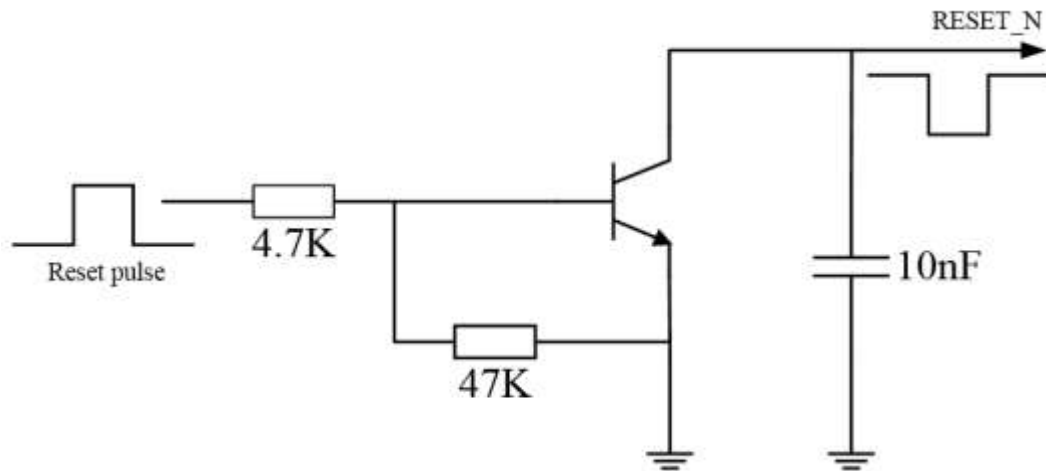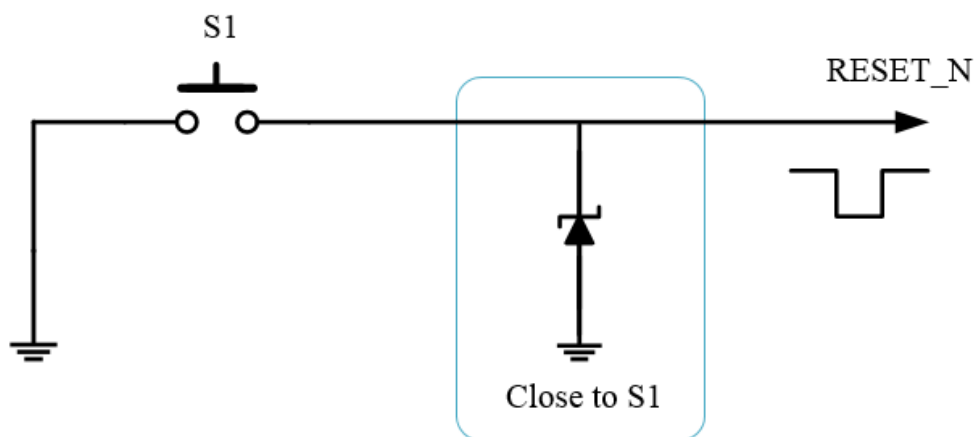NL668-LA series module provides three network status indicate pins. Pin 5 is network status indicator by

default, AT commands AT+LEDCFG can switch to pin6 or pin61, table 5-4 is the pin definition.

Table 5-4 Network status indicator

PIN Name	I/O	PIN No.	Description
NET_MODE	O	5	Network status indicator (by default)
NET_STATUS	O	6	Network status indicator
STATUS	O	61	Network status indicator

5.2.1 Interface Status Description

Network status indicate pins are used to driven indicate light and describe module's network status,

NL668-LA series module network indicates light work status description as follow table:

Table 5-5 Network indicator light work status

Mode	Module Network Indicator Pin Status	Indicator Light Flash/Off Status	Description

Mode	Module Network Indicator Pin Status	Indicator Light Flash/Off Status	Description
1	600ms High/600ms Low	Flash 600ms on/600ms off	No SIM card Request SIM PIN Registering network (T<15s) Register network failed
2	3000ms High/75ms Low	Slow flash 3000ms on/75ms off	Standby
3	75ms High/75ms Low	Speed flash 75ms on/75ms off	Data link established
4	Low	Off	Voice call
5	High	On	Sleep

NL668-LA series module network indicates light reference design circuits shown as follows:
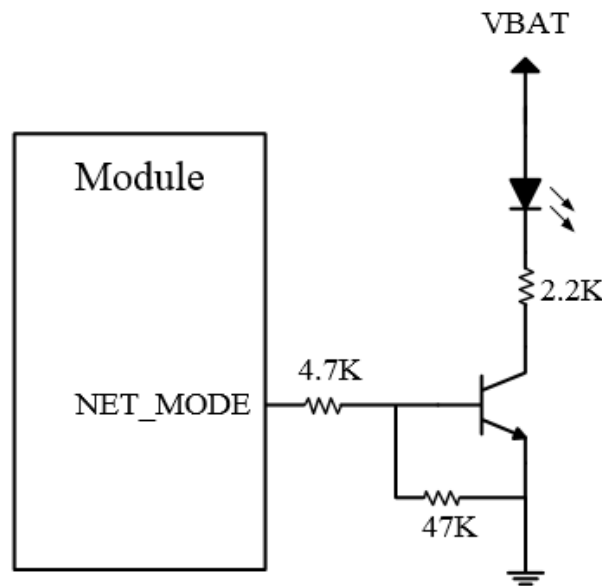

Figure 5-8 Network indicator light reference circuits

5.3 (U)SIM Card Interface

NL668-LA series module has built-in (U)SIM card interface, and supports 1.8V and 3.0V (U)SIM card.

5.3.1 (U)SIM Pin Definition

(U)SIM pin definition is shown in the following table:

Table 5-6 (U)SIM card pin

Pin name	I/O	Pin No.	Description
USIM_PRESENCE	I	13	Detect (U)SIM card for Hot-swap
USIM_VDD	PO	14	(U)SIM Power
USIM_DATA	IO	15	(U)SIM DATA
USIM_CLK	O	16	Clock Signal
USIM_RESET	O	17	Reset Signal

5.3.2 (U)SIM Interface Circuit

5.3.2.1 (U)SIM Card Connector with Card Detection Signal

(U)SIM circuit design requires use (U)SIM card connector, recommend chose with card detect signal that support card hot swap function (Fibocom recommend: SIM016-8P-220P).
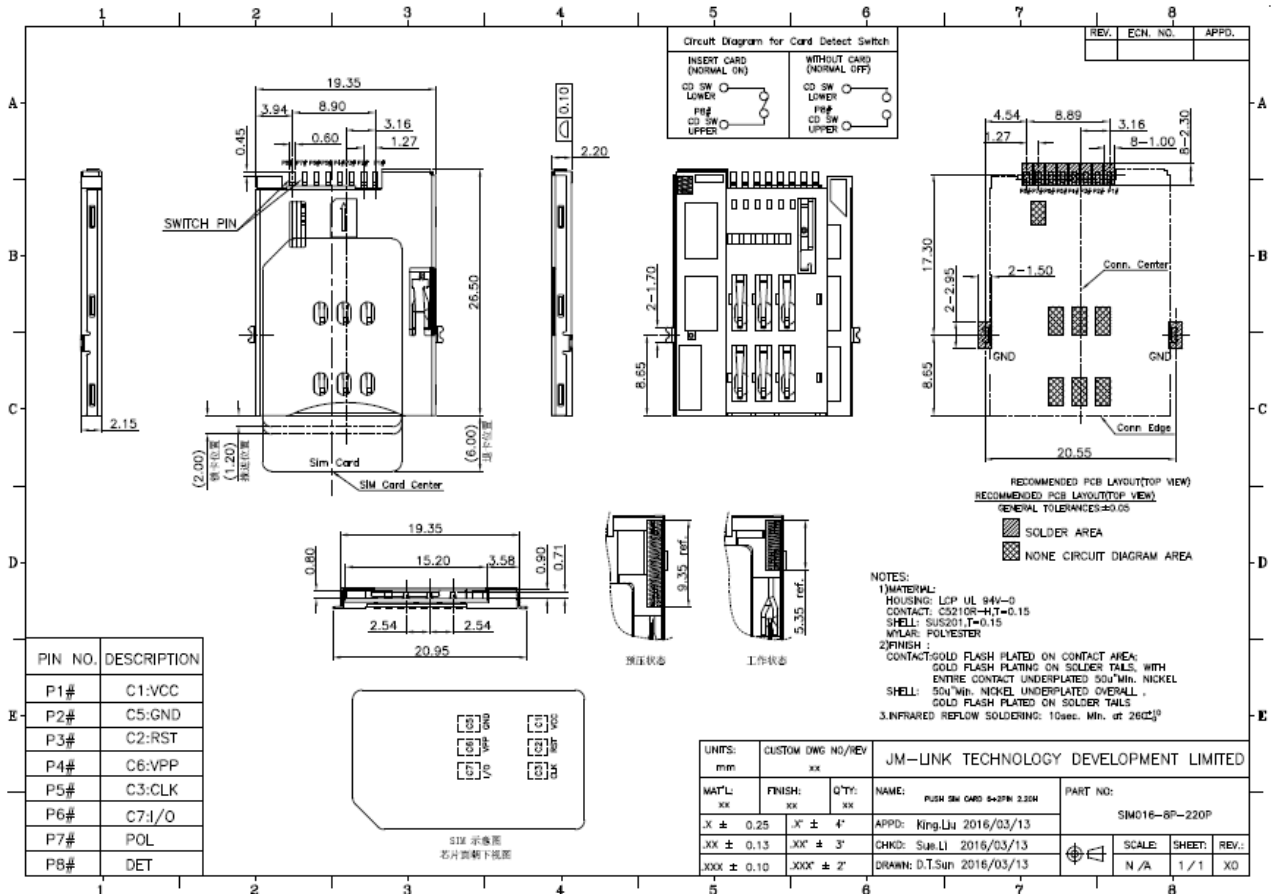
Figure 5-9 (U)SIM card connector (SIM016-8P-220P)

SIM016-8P-220P card connector, DET and POL are short connected when the card is inserted; DET and POL are disconnected when there is no card. The following is the reference design circuit, (U)SIM card insert, USIM_PRESENCE pin is high level; (U)SIM card pull out, USIM_PRESENCE pin is low level.
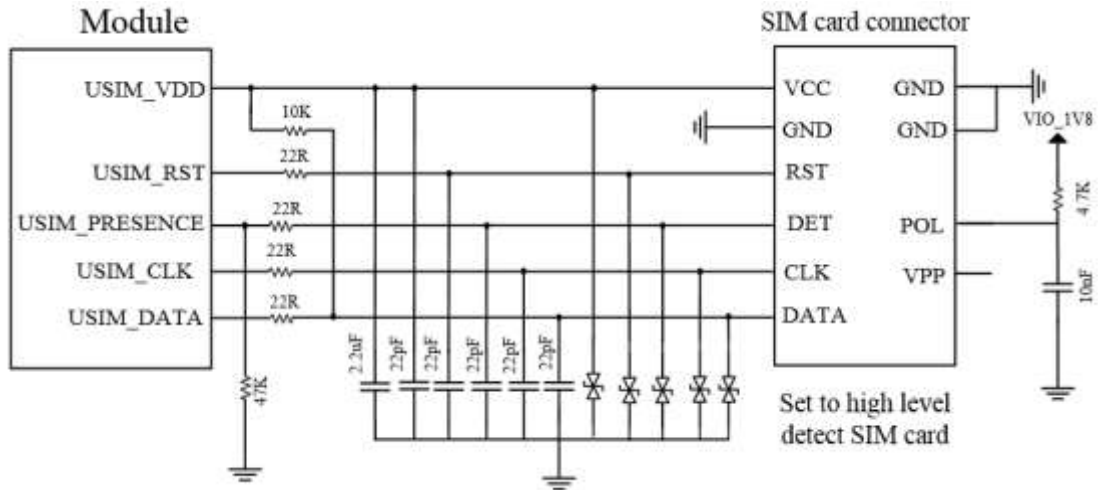
Figure 5-10 (U)SIM card connector with detection signal reference circuit

5.3.2.2 (U)SIM Card Connector Without Detection Signal

If use (U)SIM card connector without detection signal USIM_ PRESENCE pin must keep floating.

Figure 5-11 (U)SIM card connector without detection signal reference circuit

5.3.3 (U)SIM Hot Plug

NL668-LA series module support (U)SIM hot plug function, it determines the insertion and removal of (U)SIM card by detect the USIM_ PRESENCE pin state.

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

Table 5-7 (U)SIM card hot plug function configured

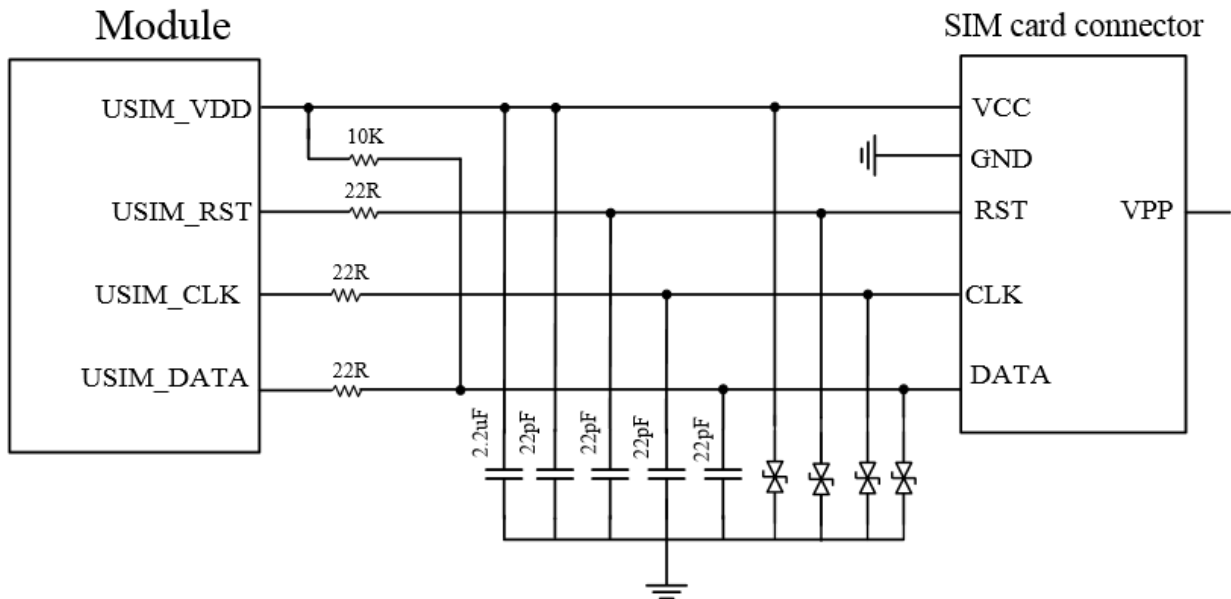| AT Command	(U)SIM Card Hot Plug Detection	Function Description
AT+MSMPD=1	Enabled	(U)SIM card hot plug detection is enabled by default. The module determines the insertion and removal of (U)SIM card by detect the USIM_ PRESENCE pin state
AT+MSMPD=0	Disabled	(U)SIM card hot plug detection function is disabled The module read the (U)SIM card when module power on, and does not detect the USIM_PRESENCE state

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

⚠️ **Note:**

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

Table 5-8 USIM_PRESENCE effective level switched

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

5.3.4 (U)SIM Design Requirements

(U)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 (U)SIM card can work stably. The design needs to strictly observe the following rules:

● (U)SIM card connector 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 (U)SIM card connector with metal shield shell to improve anti-interference ability;

● The length of cable from the module to the (U)SIM card connector 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, (U)SIM signal needs to be ground protected as a set;
- The filter capacitor and ESD device of (U)SIM card signal cable should place close to the (U)SIM card connector.
- Please select equivalent capacitor is 22Pf to 33pF for ESD device.
- USIM_DATA should pull up to USIM_VDD with a 10K resistor.

5.4 USB Interface

5.4.1 USB Pin Definition

Table 5-9 USB pin definition

Pin name	I/O	Pin No.	Description
USB_DP	IO	69	USB differential data bus D+
USB_DM	IO	70	USB differential data bus D-
USB_VBUS	PI	71	USB Plug 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 0Ω 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 90Ω.
- 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.

5.5 UART Interface

5.5.1 UART Interface Definition

NL668-LA series module has two serial ports: the main serial port and debug serial port. The main serial

ports support 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 support 115200bps baud rate for FIBOCOM internal debug. Table 5-8 and table 5-9 are the pin definition of main serial port and debug serial port.

Table 5-10 Main serial port

Pin Name	I/O	Pin No.	Description
RI	O	62	Ring indicator
DCD	O	63	Data carrier detection
CTS	O	64	Request to send
RTS	I	65	Clear to send
DTR	I	66	Data ready, sleep mode control
TXD	O	67	Module Transmit data
RXD	I	68	Module Receive data

Table 5-11 Debug serial port

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

5.5.2 UART Port Application

The serial port level of NL668-LA series module is 1.8V, if the level of the client host system is 3.3V or other, level translator needed between the module and the host. The reference design circuit of level translator is shown as follows:
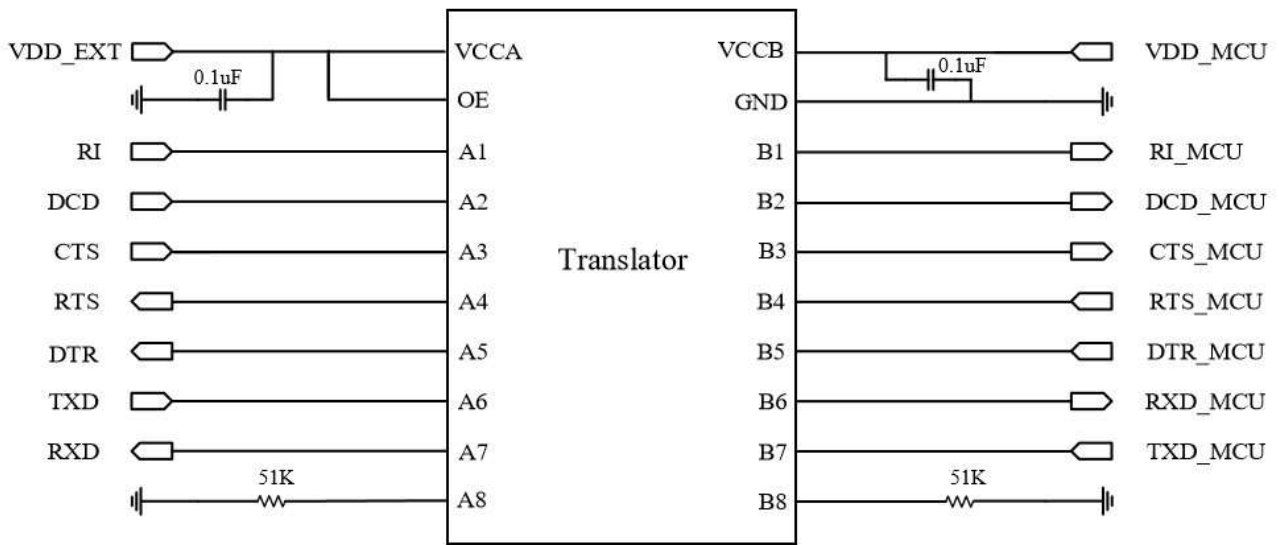
Figure 5-12 UART level translate reference 1

The other level translator circuit is shown as Figure 5-13, The rest input and output circuit design of dotted line please refer to solid line part, but pay attention to signal connection direction.

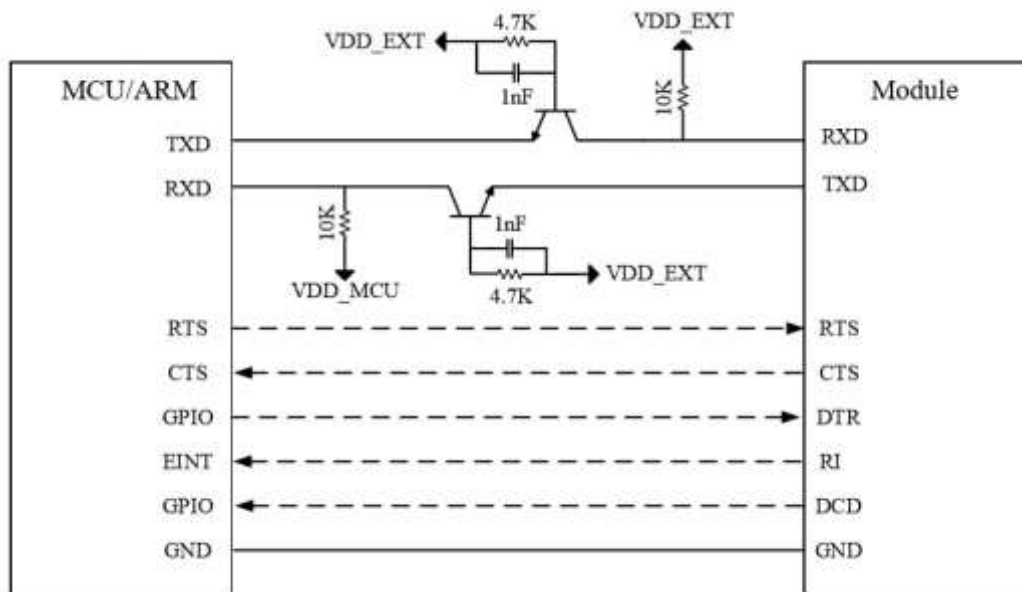Figure 5-13 UART level translate reference 2

⚠ **Note:**

Level translate circuits is not suitable for applications of baud rates above 460Kbps.

5.6 ADC Interface

NL668-LA series module support two channels ADC interface. Use AT+MMAD command can read the value of ADC interface. The voltage range of ADC interface is 0.3V to VBAT_BB.

Table 5-12 ADC pin definition

PIN Name	I/O	Pin No.	Description
ADC0	I	45	Analog to digital converter interface 0
ADC1	I	44	Analog to digital converter interface 1

5.7 PCM Interface

NL668-LA series module provides a PCM interface for communication with digital audio devices such as an external CODEC.

5.7.1 Supported Model

Table 5-13 Supported model of PCM

Product model	Description
NL668-LA-00	Support
NL668-LA-01	Support
NL668-LA-05	Support
NL668-LA-10	Support

5.7.2 PCM Interface Definition

Table 5-14 PCM pin definition

Pin Name	I/O	Pin No.	Description
PCM_IN	I	24	PCM data input
PCM_OUT	O	25	PCM data output
PCM_SYNC	IO	26	PCM data synchronous signal
PCM_CLK	IO	27	PCM clock

5.7.3 PCM Interface Description

Table 5-15 PCM interface description

Pin Name	Frequency	Duty Cycle	Coded Format	Operating Mode	Description
PCM_CLK	2.048MHz	50%			PCM CLK
PCM_OUT	-	-	16bit Liner mono	Module serves as master	PCM Output
PCM_IN	-	-			PCM Input
PCM_SYNC	8KHz	Short pulse			PCM Synchronous

Pin Name	Frequency	Duty Cycle	Coded Format	Operating Mode	Description
					Signal (Falling edge sampling)

NL668-LA series module adopts the above configuration by default, any adjustment please contact Fibocom Wireless technical support.

5.7.4 PCM Signal Description

The PCM signal of NL668-LA series module adopts domestic mainstream Europe E1 standard. PCM_CLK frequency is 2.048MHz clock in 16bit linear format encoding. PCM_SYNC is an 8kHz burst (488nS).
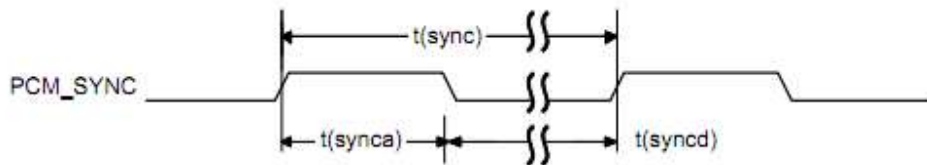
Figure 5-14 PCM_SYNC timing
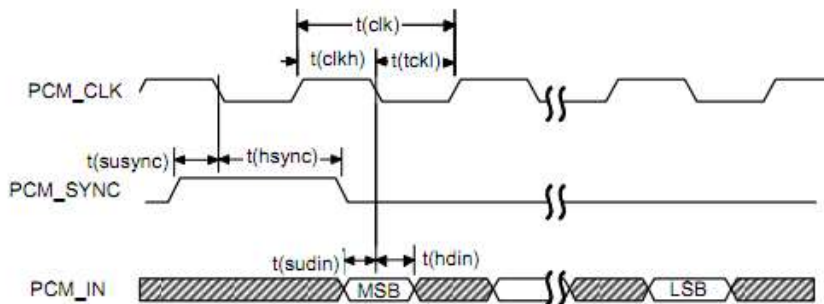
Figure 5-15 PCM_CODEC to NL668-LA timing
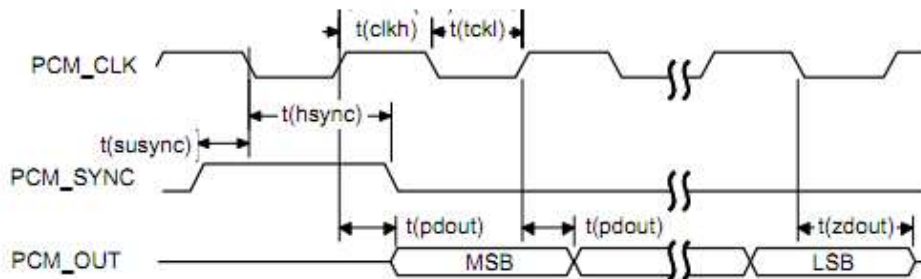
Figure 5-16 NL668-LA to PCM_CODEC timing

Table 5-16 Codec timing parameters

Parameter		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_DIN setup time to PCM_CLK falling	60	–	–	ns
t(hdin)	PCM_DIN hold time after PCM_CLK falling	10	–	–	ns
t(pdout)	Delay from PCM_CLK rising to PCM_DOUT valid	–	–	60	ns
t(zdout)	Delay from PCM_CLK falling to PCM_DOUT high impedance	–	160	–	ns

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6 Low Power Consumption

6.1 Airplane Mode

W_DISABLE# Pin Description:

Table 6-1 W_DISABLE# pin description

Pin name	I/O	Pin No.	Description
W_DISABLE#	I	4	Module airplane mode control

NL668-LA series module supports two ways to enter airplane mode:

Table 6-2 Module enter airplane mode ways

1	Hardware I/O interface button control	First send "AT+WDISABLEEN=1" to enable W_DISABLE# pin function. Pull high or float W_DISABLE# pin (pull high by default), module enter normal mode, pull it down, module enter airplane mode.
2	AT command control	AT+CFUN=4--module enter airplane mode AT+CFUN=1--module enter normal mode

6.2 Sleep Mode

6.2.1 USB Application (Nonsupport USB Suspend, Support VBUS)

If the host nonsupport USB suspend function, the module can enter sleep mode by disconnect

USB_VBUS from the external control circuit:

Sleep:

Send AT+GTUSBDETECTEN=1 to enable USB plug detect function.

AT+GTLPMMODE=1,X command to set the WAKEUP_IN pin's level of control module enter sleep mode.

Reset module, command effective.

(X=0, WAKEUP_IN pin is high level, module enter sleep mode;

X=1, WAKEUP_IN pin is low level, module enter sleep mode)

AT+CSCLK=1 command to enable sleep function.

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

Draw out the USB cable or disable the USB HUB controller, module enter sleep mode.

Wake up:

![Fibocom logo]

Plug in USB cable or enable the USB HUB controller can wake up the module.

6.2.2 USB Application (Nonsupport USB Suspend, Nonsupport VBUS)

If the host nonsupport USB suspend and nonsupport VBUS function, the module can enter sleep mode by disconnect USB_VBUS from the external control circuit:

Sleep:

Send AT+GTLPMMODE=1,X command to set the WAKEUP_IN pin's level of control module enter sleep mode. Reset module, command effective.

(X=0, WAKEUP_IN pin is high level, module enter sleep mode;

X=1, WAKEUP_IN pin is low level, module enter sleep mode)

AT+CSCLK=1 command to enable sleep function.

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

Draw out the USB cable or disable the USB HUB controller, module enter sleep mode.

Wake up:

Plug in USB cable or enable the USB HUB controller can wake up the module.

6.2.3 USB Application (Support USB Suspend)

If the host support USB Suspend/Resume. Setting USB sleep in Linux system.

Sleep:

Send AT+GTLPMMODE=1,X command to set the WAKEUP_IN pin's level of control module enter sleep mode. Reset module, command effective.

(X=0, WAKEUP_IN pin is high level, module enter sleep mode;

X=1, WAKEUP_IN pin is low level, module enter sleep mode)

AT+CSCLK=1 command to enable sleep function.

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

In Linux system, set the level and control of USB device as auto to suspend the devices of module.

Standing the module and host about 2 seconds, the module can enter suspend mode automatically.

Wake up:

Any operation of USB can wake up the module from sleep mode.

6.2.4 UART Application (WAKEUP_IN Pin Level Control)

When host and module connected through UART, use the following steps to make the module enter

Sleep:

Sent AT+GTLPMMODE=1,X command to set et the WAKEUP_IN pin's level of control module enter sleep mode. Reset module, command effective.

(X=0, WAKEUP_IN pin is high level, module enter sleep mode;

X=1, WAKEUP_IN pin is low level, module enter sleep mode)

AT+GTUSBSLEEPEN=2,X command to disable USB function (X can be 0 or 1)

AT+CSCLK=1 command to enable sleep function.

Wake up:

The level of WAKEUP_IN pin contrary with that when the module enters sleep mode, module allow be

waked up.   (X=0, WAKEUP_IN pin is low level, wake up module;

X=1, WAKEUP_IN pin is high level, wake up module)

6.2.5 UART Application (DTR Pin Level Control)

When host and module connected through UART, use the following steps can make the module enter

Sleep:

Send AT+GTLPMMODE=2,X command to set the DTR set pin's level of control module enter sleep

mode. Reset module, command effective.

(X=0, DTR pin is high level, module enter sleep mode;

X=1, DTR pin is low level, module enter sleep mode)

AT+GTUSBSLEEPEN=2,X command to disable USB function (X can be 0 or 1)

AT+CSCLK = 1 command to enable sleep function.

Wake up:

The level of DTR pin contrary with that when the module enters sleep mode, module allow be wake up.

(X=0, DTR pin is low level, wake up module; X=1, DTR pin is high level, wake up module)

6.2.6 ATS24 Command

ATS24 command can also make module enter sleep mode.

Sleep:

Send AT+GTLPMMODE=0   Reset module, command effective.

ATS24=X command to into sleep after X seconds. (X is nonzero integer)

AT+GTUSBSLEEPEN=2,X command to disable USB function (X can be 0 or 1)

Wake up:

Send the AT command fast by UART serial port can wake up the module. If don't send AT commands

between X seconds, module will try to enter sleep mode.

⚠ Note:

Since the level of UART sleep power is different, power consumption of use ATS24 command to

enter sleep mode is higher than that use Pin control to enter sleep mode.

When ATS24 command enter sleep mode countdown, it isn't entering sleep mode once

overtime strictly, but try to enter sleep mode. If system don't support after overtime, it will timekeeping automatically.

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

For more sleep command description, please refer to *FIBOCOM AT Commands _Sleep*

7 RF Interface

NL668-LA series module has ANT_MAIN, ANT_DIV and ANT_ GNSS three antenna interfaces, its pin definition is shown as table 7-1:

Table 7-1 RF Interface

Pin Name	I/O	Pin No.	Description
ANT_DIV	I	35	Diversity antenna
ANT_GNSS	I	47	GPS antenna
ANT_MAIN	IO	49	Main antenna

7.1 Operating Bands

Table 7-2 Operating bands

Operating Band	Description	Mode	Tx (MHz)	Rx (MHz)
Band 1	IMT 2100MHz	LTE FDD/WCDMA	1920 - 1980	2110 - 2170
Band 2	IMT 1900	LTE FDD/WCDMA/GSM	1850-1910	1930-1990
Band 3	DCS 1800MHz	LTE FDD/WCDMA/GSM	1710 - 1785	1805 - 1880
Band 4	IMT 2100	LTE FDD/WCDMA	1710-1755	2110-2155
Band 5	CLR 850MHz	LTE FDD/WCDMA/GSM	824 - 849	869 - 894
Band 7	IMT 2600	LTE FDD	2500-2570	2620-2690
Band 8	E-GSM 900MHz	LTE FDD/WCDMA/GSM	880 - 915	925 - 960
Band 12	IMT 700	LTE FDD	699-716	729-746
Band 17	IMT 700	LTE FDD	704-716	734-746
Band 20	EUDD 800MHz	LTE FDD	832 - 862	791 - 821
Band 28	IMT 700	LTE FDD	703-748	758-803
Band 66	IMT 2100MHz	LTE FDD	1710-1780	2110-2200
Band 38	IMT-E 2600MHz	LTE TDD	2570 - 2620	
Band 40	IMT 2300MHz	LTE TDD	2300 - 2400	

7.2 Output Power

The Output power of NL668-LA series module show as follows:

Table 7-3 Output power

![Fibocom logo]

Mode	Band	Tx Power (dBm)	Note
GSM	GSM 850	32.5±2	
	GSM 900	32.5±2	
	DCS 1800	29.5±2	
	PCS 1900	29.5±2	
WCDMA	Band Ⅰ	23.5±2	
	Band Ⅱ	23.5±2	
	Band Ⅲ	23.5±2	
	Band Ⅳ	23.5±2	
	Band Ⅴ	23.5±2	
	Band VIII	23.5±2	
LTE FDD	Band 1	23±2	10MHz Bandwidth, 1 RB
	Band 2	23±2	10MHz Bandwidth, 1 RB
	Band 3	23±2	10MHz Bandwidth, 1 RB
	Band 4	23±2	10MHz Bandwidth, 1 RB
	Band 5	23±2	10MHz Bandwidth, 1 RB
	Band 7	23±2	10MHz Bandwidth, 1 RB
	Band 8	23±2	10MHz Bandwidth, 1 RB
	Band 12	23±2	10MHz Bandwidth, 1 RB
	Band17	23±2	10MHz Bandwidth, 1 RB
	Band 20	23±2	10MHz Bandwidth, 1 RB
	Band 28	23±2	10MHz Bandwidth, 1 RB
	Band 66	23±2	10MHz Bandwidth, 1 RB
LTE TDD	Band 38	23±2	10MHz Bandwidth, 1 RB
	Band 40	23±2	10MHz Bandwidth, 1 RB

7.3 Receive Sensitivity

Table 7-4 Receive sensitivity

Mode	Band	Rx Sensitivity (dBm) Typ.	RxD Sensitivity (dBm)Typ.
GSM	GSM 850	-109	NA

Mode	Band	Rx Sensitivity (dBm) Typ.	RxD Sensitivity (dBm)Typ.
	GSM 900	-109	NA
	DCS 1800	-108.5	NA
	PCS 1900	-108.5	NA
WCDMA	Band Ⅰ	-109	NA
	Band Ⅱ	-109.5	NA
	Band Ⅲ	-109.5	NA
	Band Ⅳ	-109	NA
	Band Ⅴ	-110	NA
	Band VIII	-110	NA
LTE FDD	Band 1	-97.5	-98
	Band 2	-97.5	-98.5
	Band 3	-98	-98.5
	Band 4	-97	-98.5
	Band 5	-98.5	-99.5
	Band 7	-96	-97.5
	Band 8	-98	-99.5
	Band 12	-97.5	-98
	Band 17	-97.5	-98
	Band 20	-97	-97
	Band 28	-97.5	-97
	Band 66	-97.5	-98.5
LTE TDD	Band 38	-97.5	-96.5
	Band 40	-97.5	-96.5

![Fibocom]

7.4 GNSS Receiver

7.4.1 GNSS Specification

NL668-LA series module (except NL668-LA-01) supports GNSS function and adopts Qualcomm Gen8

technology, its specification show as follows:

Table 7-5 GNSS specification

Description		Condition	Typ.
Power （AT+CFUN=0）		GNSS fixing	62mA
		GNSS tracking	62mA
		Standby	34mA
TTFF	GNSS	Cold start	45s
		Warm start	40s
		Hot Start	5s
Sensitivity	Acquisition		-144dbm
	Tracking		-155dbm
	CN0	GNSS Signal@-130dBm	38.5 dB-Hz
Positional accuracy	CEP	GNSS Signal@-130dBm	<3.5m

7.4.2 GNSS Observe Protocol

NL668-LA series module adopts NMEA-0183 protocol.

7.5 Antenna Design

7.5.1 Antenna Index

1) Antenna efficiency

Antenna efficiency is the ratio of antenna input power to radiated power. Due to the antenna return loss,

material loss, and coupling loss, the radiated power is always lower than the input power.

Recommended > 40% (-4dB).

2) S11 or VSWR

S11 shows that the matching degree of the antenna's 50Ω impedance, to a certain extent, affects the

antenna efficiency. VSWR test methods can be used to measure this parameter. Recommended 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 x 10mm wide x 100mm long.

Antenna radiation direction: Omni_directional (all direction).

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 ≤ 3dBi.

6) Interference

In addition to the antenna performance, other interferences on the PCB also 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 away from the antenna as far as possible, and make the appropriate isolation and shielding, or filtering on the path.

7) Antenna index requirements

Table 7-6 Main antenna requirements

NL668-LA series module main antenna requirements	
Frequency range	It must use the most suitable antenna to adapt to the relevant frequency band
Bandwidth (GSM/EDGE)	GSM850: 70 MHz GSM900: 80 MHz GSM1800 (DCS): 170 MHz GSM1900 (DCS): 140 MHz
Bandwidth (WCDMA)	WCDMA band 1 (2100): 250 MHz WCDMA band 2 (1900): 140 MHz WCDMA band 3 (1800):170 MHz WCDMA band 4 (2100): 440 MHz WCDMA band 5 (800): 70 MHz WCDMA band 8 (900): 80 MHz

NL668-LA series module main antenna requirements	
Bandwidth (LTE)	LTE band 1 (2100): 250 MHz
	LTE band 2 (1900): 140 MHz
	LTE Band 3 (1800): 170 MHz
	LTE Band 4 (2100): 440 MHz
	LTE Band 5 (850): 70 MHz
	LTE Band 7 (2600): 190 MHz
	LTE Band 8 (900): 80 MHz
	LTE Band 12 (700): 50 MHz
	LTE Band 17 (700): 50 MHz
	LTE Band 20 (800): 71 MHz
	LTE Band 28 (700): 100 MHz
	LTE Band 66 (2100): 490 MHz
	LTE band 38 (2600): 50 MHz
	LTE band 40 (2300): 100 MHz
Impedance	50Ω
Input power	> 33dBm (2 W) peak power GSM
	> 23dBm average power WCDMA & LTE &TD-SCDMA&CDMA&EVDO
Standing wave ratio recommended	≤ 2:1

7.5.2 Antenna Reference Design

Antenna is a sensitive device, susceptible to the external environment. For example, the size of the module, the location of the antenna, the space it occupies, and the surrounding ground all may affect antenna performance. In addition, the RF cable connect with antenna, and the location of the fixed antenna also may affect its performance. NL668-LA series module's three antenna all led by welding plate. recommended clients use the U.FL-R-SMT-1 antenna connector and corresponding match adapter cable. Figure 7-1 is reference design of main antenna and diversity antenna.
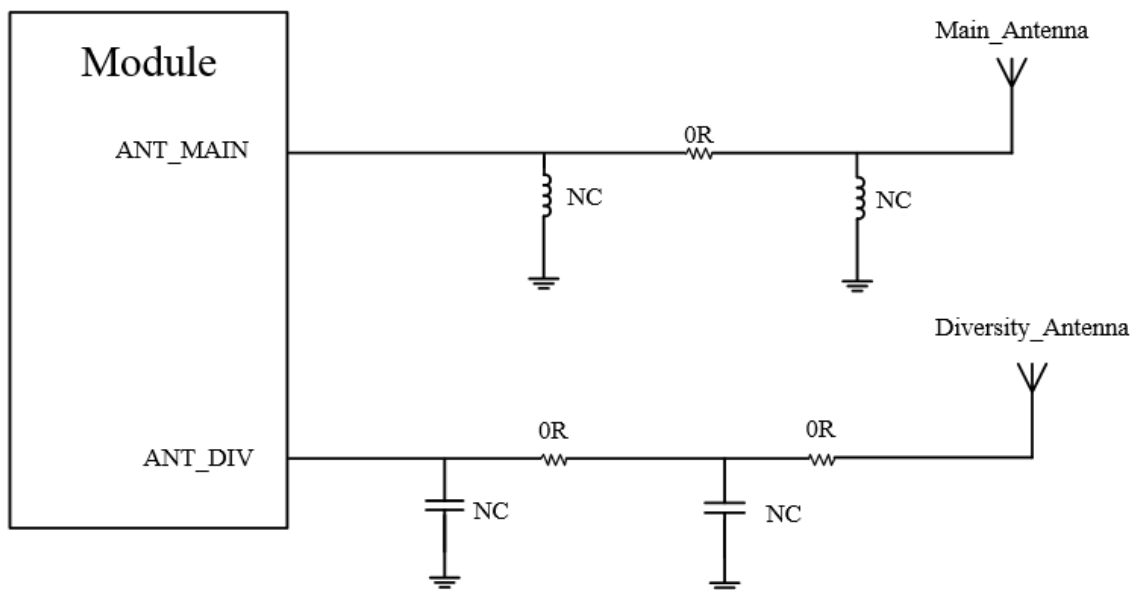
Figure 7-1 Main and diversity antenna reference circuit
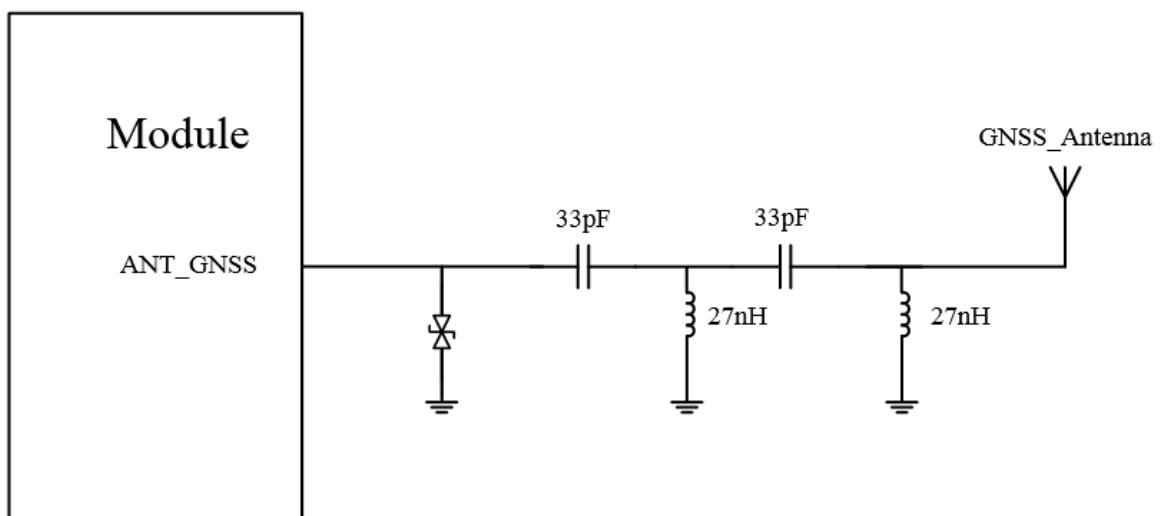
Figure 7-2 is reference design of GNSS antenna.

Figure 7-2 GNSS antenna reference circuit

⚠ **Note：**

● All matches must be placed close to antenna to make sure the characteristic impedance of transmission cable is 50 ohms.

● Since the antenna loss should be less than 0.3dB, keep PCB cable as short as possible.

● Keep the PCB LAYOUT straight, 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.

- Ground around antenna must be keep connect with main ground.

- For more design information please refer to *FIBOCOM Design Guide_Antenna.*

8 Reliability

8.1 Limiting Voltage Range

The limiting voltage range is maximum voltage range that power supply and digital or analog input/output interfaces can withstand.

8.1.1 Absolute Voltage Range

The absolute voltage range of NL668-LA series module is shown as table 8-1.

Table 8-1 Absolute voltage range

Parameter	description	Min	Typ.	Max	Unit
VBAT	Power supply	-0.3	3.8	4.7	V
GPIO	Digital IO supply voltage	-0.3	1.8	2.0	V

8.1.2 Operating Voltage Range

Table 8-2 Operating Voltage Range

V_L: logic low level; V_H: logic high level;

Parameter	V_L		V_H		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	PI	3.3	3.8	4.3	V
USIM_VDD	PO	1.7/2.75	1.8/2.85	1.9/2.95	V

8.2 Environment Temperature Range

The recommended operating temperature range of NL668-LA series module.is -30℃ to +75℃. When module operating at limited temperature range, some RF indexes may exceed standard, so module application terminal should consider temperature control measurement. The module application terminal is recommended storage in certain temperature conditions. Modules out of the temperature range may not operate or may be damaged.

Table 8-3 Environment temperature range

Temperature	Min	Typ.	Max	Unit
Operating temperature	-30	25	75	℃
Limited operating temperature	-40		85	℃
Storage temperature	-40		90	℃

8.3 Environmental Reliability Requirements

Table 8-4 Environmental reliability requirements

Test Item	Test Condition
Low temperature storage test	Temperature -40℃±3℃, 24 hours in shutdown state
High temperature storage test	Temperature +85℃±3℃, 24 hours in shutdown state
Temperature shock test	In shutdown state, 0.5 hour at -40℃ and +85℃ environment respectively, the temperature conversion time < 3min, for 24 cycles
High temperature and humidity test	Temperature +85℃±3℃, humidity 90–95% RH, 24 hours in shutdown state
Low temperature operating test	Temperature -30℃±3℃, 24 hours in operating state
High temperature operating test	Temperature +75℃±3℃, 24 hours in operating state
Vibration test	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>0.96m²/s³</td></tr><tr><td>20–500Hz</td><td>0.96m²/s³ (20Hz), other –3dB/octave</td></tr></table>
Connector life test	30 times of insertion/removal for RF antenna interface cable

The vibration test table contents:

Frequency	Random vibration ASD (Acceleration Spectral Density)
5–20Hz	$0.96 m^2/s^3$
20–500Hz	$0.96 m^2/s^3$ (20Hz), other –3dB/octave

8.4 ESD Characteristics

NL668-LA series module design has considered ESD issue and provided ESD protect measurements, but take ESD issue taken by module carrier and secondary development into consideration, developers should care ESD protection of module application terminal. In addition to considering anti-static treatment

of packaging, please refer to recommended circuit of interface design in the document.

ESD allowable discharge range of NL668-LA series module show as table below:

Table 8-5 ESD allowable discharge range

Interface	Air Discharge	Contact Discharge
GND	±10KV	±5KV
Antenna port	±8KV	±4KV
Other port	±1KV	±0.5KV

![Fibocom]

9 Structure Specification

9.1 Product Appearance

The product appearance of NL668-LA series module is shown in Figure 9-1:
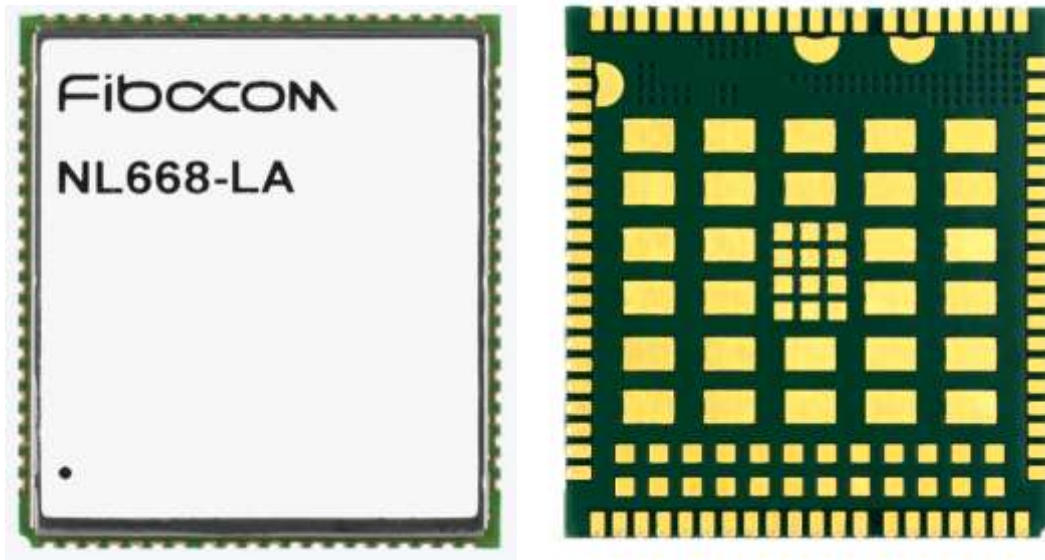
Figure 9-1 Product appearance

9.2 Structure Dimension

The structure dimension of NL668-LA series module is shown as Figure 9-2:
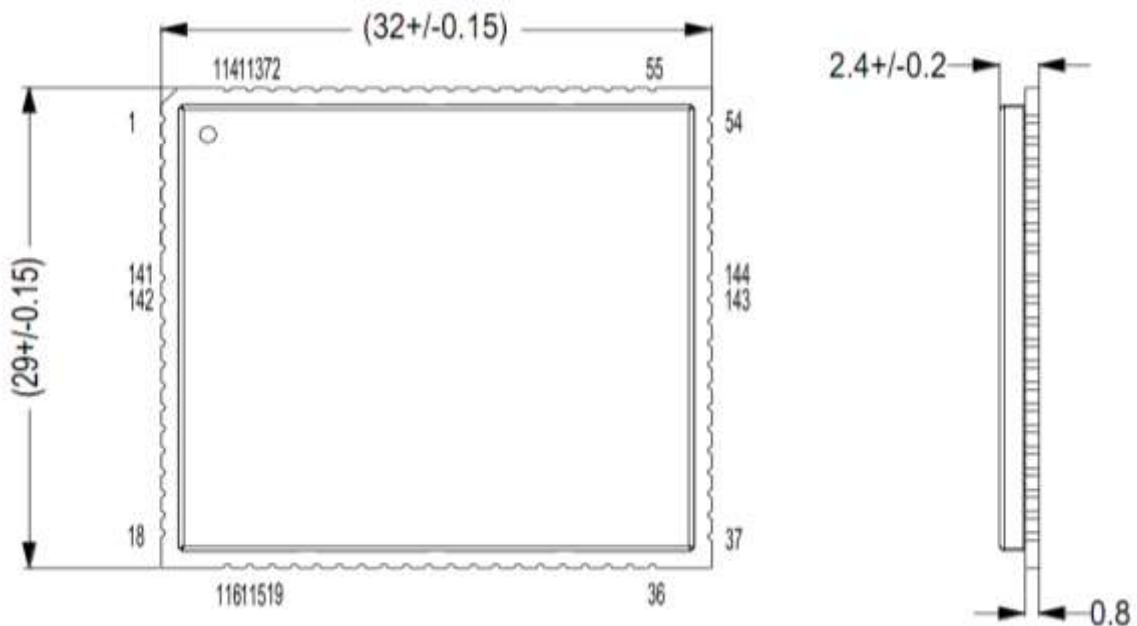
Figure 9-2 Structure dimension (unit: mm)

9.3 PCB Soldering Pad and Stencil Design

PCB soldering pad and stencil design please refer to *FIBOCOM NL668 LCC SMT Design Guide*.

9.4 SMT

SMT production process parameters and related requirements please refer to *FIBOCOM NL668 LCC SMT Design Guide*.

9.5 Carrier and storage

Carrier and storage please refer to *FIBOCOM NL668 LCC SMT Design Guide*.

10 Approval

NL668-LA series module approval show as table 10-1:

Table 10-1 Approval

| Certification Scheme	NL668-LA-00, NL668-LA-05, NL668-LA-10
FCC	PASS
HF	PASS
RoHS	PASS
TBD	TBD
TBD	TBD
Certification Scheme	NL668-LA-01
FCC	PASS (ID:ZMONL668LA01)
CE	PASS
GCF	PASS
SUBTEL(Chile)	PASS
ENACOM(Argentina)	PASS
Anatel	PASS
MTC(Peru)	PASS
CRC(Colombia)	PASS
TBD	TBD
TBD	TBD

For more information, please refer to Fibocom net.

11 Appendixes

11.1 GPRS and EGPRS Encoding Scheme

Table 11-1 GPRS encoding scheme

Encoding method	CS-1	CS-2	CS-3	CS-4
Rate	1/2	2/3	3/4	1
USF	3	3	3	3
Pre-coded USF	3	6	6	12
Radio Block excl.USF and BCS	181	268	312	428
BCS	40	16	16	16
Tail	4	4	4	-
Coded Bits	456	588	676	456
Punctured Bits	0	132	220	-
Data rate Kb/s	9.05	13.4	15.6	21.4

In the GPRS standard, 29 types of GPRS multislot modes are defined for use by mobile stations. The multislot class defines the maximum rate of uplink and downlink. The expression is 3+1 or 2+2, the first number indicates the number of downlink timeslots, and the second number indicates the number of uplink timeslots. Active timeslots indicate the total number of timeslots that the GPRS device can use for both uplink and downlink communications.

Table 11-2 Multilevel multislot allocation

Multislot Class	Downlink Slot	Uplink Slot	Active Slot
1	1	1	2
2	2	1	3
3	2	2	3
4	3	1	4
5	2	2	4
6	3	2	4
7	3	3	4
8	4	1	5

Multislot Class	Downlink Slot	Uplink Slot	Active Slot
9	3	2	5
10	4	2	5
11	4	3	5
12	4	4	5
33	5	4	6

Table 11-3　EGPRS modulation and encoding method

Coding Scheme	Modulation	Coding Family	1 Timeslot	2 Timeslot	4 Timeslot
CS-1	GMSK	/	9.05kbps	18.1kbps	36.2kbps
CS-2	GMSK	/	13.4kbps	26.8kbps	53.6kbps
CS-3	GMSK	/	15.6kbps	31.2kbps	62.4kbps
CS-4	GMSK	/	21.4kbps	42.8kbps	85.6kbps
MCS-1	GMSK	C	8.80kbps	17.6kbps	35.2kbps
MCS-2	GMSK	B	11.2kbps	22.4kbps	44.8kbps
MCS-3	GMSK	A	14.8kbps	29.6kbps	59.2kbps
MCS-4	GMSK	C	17.6kbps	35.2kbps	70.4kbps
MCS-5	8-PSK	B	22.4kbps	44.8kbps	89.6kbps
MCS-6	8-PSK	A	29.6kbps	59.2kbps	118.4kbps
MCS-7	8-PSK	B	44.8kbps	89.6kbps	179.2kbps
MCS-8	8-PSK	A	54.4kbps	108.8kbps	217.6kbps
MCS-9	8-PSK	A	59.2kbps	118.4kbps	236.8kbps

11.2 Terms and Acronyms

Table 11-4 Terms and acronyms

Term	Definition
AMR	Adaptive Multi-rate
bps	Bits Per Second
CS	Coding Scheme
DRX	Discontinuous Reception
EGSM	Extended GSM900 Band
FDD	Frequency Division Duplexing

Term	Definition
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
CA	Carrier Aggregation
DLCA	Downlink Carrier Aggregation
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
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

Term	Definition
(U)SIM	(Universal) Subscriber Identity Module
USSD	Unstructured Supplementary Service Data
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
VIHmax	Maximum Input High Level Voltage Value
VIHmin	Minimum Input High Level Voltage Value
VILmax	Maximum Input Low Level Voltage Value
VILmin	Minimum Input Low Level Voltage Value
VImax	Absolute Maximum Input Voltage Value
VImin	Absolute Minimum Input Voltage Value
VOHmax	Maximum Output High Level Voltage Value
VOHmin	Minimum Output High Level Voltage Value
VOLmax	Maximum Output Low Level Voltage Value
VOLmin	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access

11.3 Related Documents

- FIBOCOM EVK-GT8230-NL User Guide
- FIBOCOM ADP-NL668-LA Evaluation Board Instructions
- FIBOCOM NL668 LCC SMT Design Guide
- FIBOCOM Design Guide_RF Antenna
- FIBOCOM NL668 AT Commands

11.4 Reference Standards

The 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)

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12 FCC Conformance information

Important Notice to OEM integrators

1. This module is limited to OEM installation ONLY.

2. This module is limited to installation in mobile applications, according to Part 2.1091(b).

3. The separate approval is required for all other operating configurations, including portable configurations with respect to Part 2.1093 and different antenna configurations

4. For FCC Part 15.31 (h) and (k): The host manufacturer is responsible for additional testing to verify compliance as a composite system. When testing the host device for compliance with Part 15 Subpart B, the host manufacturer is required to show compliance with Part 15 Subpart B while the transmitter module(s) are installed and operating. The modules should be transmitting and the evaluation should confirm that the module's intentional emissions are compliant (i.e. fundamental and out of band emissions). The host manufacturer must verify that there are no additional unintentional emissions other than what is permitted in Part 15 Subpart B or emissions are complaint with the transmitter(s) rule(s). The Grantee will provide guidance to the host manufacturer for Part 15 B requirements if needed.

Important Note

notice that any deviation(s) from the defined parameters of the antenna trace, as described by the instructions, require that the host product manufacturer must notify to Fibocom Wireless Inc. that they wish to change the antenna trace design. In this case, a Class II permissive change application is required to be filed by the USI, or the host manufacturer can take responsibility through the change in FCC ID (new application) procedure followed by a Class II permissive change application.

End Product Labeling

When the module is installed in the host device, the FCC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily re-moved. If not, a second label must be placed on the outside of the final device that contains the following text: "Contains FCC ID: ZMONL668LA05"

The FCC ID can be used only when all FCC compliance requirements are met.

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Antenna Installation

(1) The antenna must be installed such that 20 cm is maintained between the antenna and users,

(2) The transmitter module may not be co-located with any other transmitter or antenna.

(3) Only antennas of the same type and with equal or less gains as shown below may be used with this module. Other types of antennas and/or higher gain antennas may require additional authorization for operation.

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID/IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization. if host antenna gain exceeds that of guidance provided. the integrator that additional compliance testing would be required

Manual Information to the End User

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

Federal Communication Commission Interference Statement

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 equipment 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 radiate 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 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.

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

List of applicable FCC rules

This module has been tested and found to comply with part 22, part 24, part 27, part 90,part 96, part 15B requirements for Modular Approval.

The modular transmitter is only FCC authorized for the specific rule parts (i.e., FCC transmitter rules) listed on the grant, and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

This device is intended only for OEM integrators under the following conditions: (For module device use)

1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed.

Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.