SIM7028
Hardware Design

LPWA Module

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1 Introduction

This document describes the electronic specifications, RF specifications, interfaces, mechanical characteristics and testing results of the SIMCom SIM7028 module. With the help of this document and other SIM7028 software application notes/user guides, users can understand and use SIM7028 module to design and develop applications quickly.

1.1 Product Outline

The SIM7028 module support LTE Category NB2, 2-HARQ. The physical dimension of SIM7028 is 17.6mm ×15.7mm×2.3 mm. It is designed for applications that need low latency, Low throughput data communication in a variety of radio propagation conditions.

Table 1: SIM7028 frequency bands

Network Type	Band	SIM7028
LTE-HD-FDD	Category	NB2
	LTE-FDD B1	✓
	LTE-FDD B2	✓
	LTE-FDD B3	✓
	LTE-FDD B4	✓
	LTE-FDD B5	✓
	LTE-FDD B8	✓
	LTE-FDD B12	✓
	LTE-FDD B13	✓
	LTE-FDD B14	✓
	LTE-FDD B17	✓
	LTE-FDD B18	✓
	LTE-FDD B19	✓
	LTE-FDD B20	✓
	LTE-FDD B25	✓
	LTE-FDD B26	✓
	LTE-FDD B28	✓
	LTE-FDD B66	✓
	LTE-FDD B70	✓
	LTE-FDD B85	✓

1.2 Hardware Interface Overview

The interfaces are described in detail in the next chapters include:

- Power Supply
- UART Interface
- SIM Interface
- ADC
- Power Output
- GPIOs
- Antenna Interface

1.3 Hardware Block Diagram

The block diagram of the SIM7028 module is shown in the figure below.

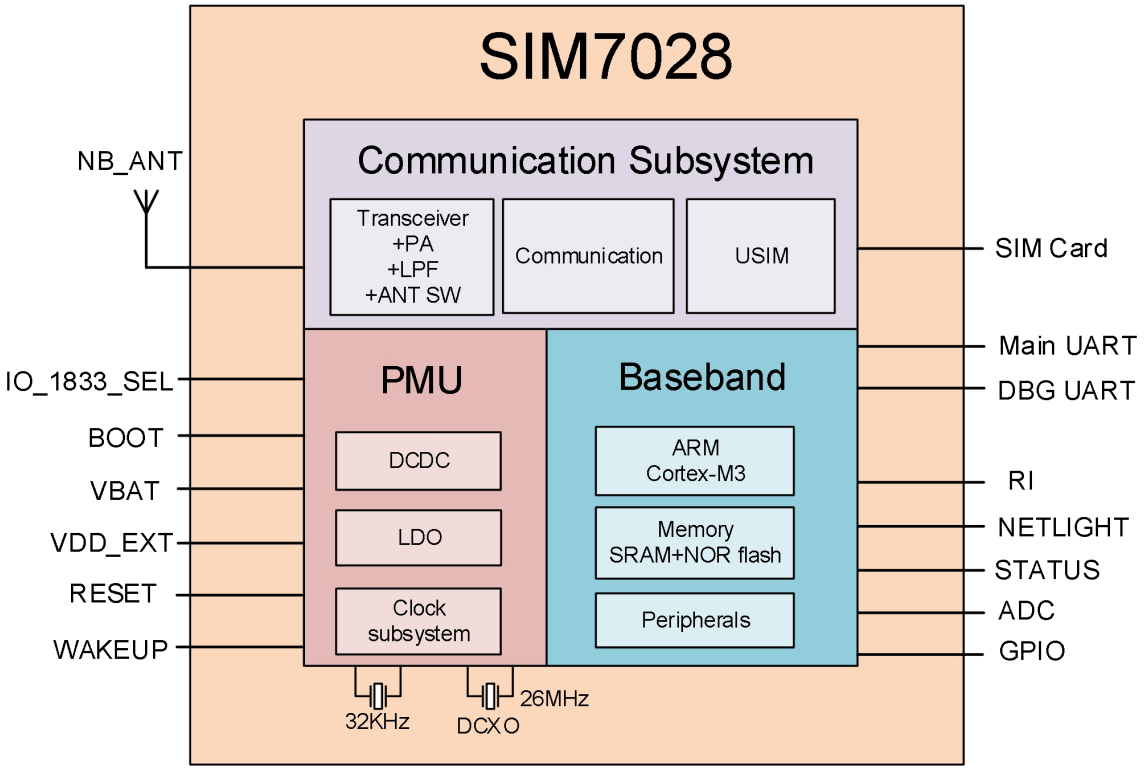

Figure 1: SIM7028 block diagram

1.4 Functional Overview

Table 2 describes the features of the SIM7028 modules.

Table 2: General features

Feature	Implementation
Power supply	Power supply voltage：2.2V～4.3V.
Power saving	DRX:0.11mA (DRX=2.56s) eDRX:0.018mA (PTW=25.6s；eDRX=163.84s；DRX=2.56s) PSM mode Typical: 0.8uA
Radio frequency bands	Please refer to the table 1
Transmitting power	LTE power class: 3 (23dBm±2.7dB)
Data Transmission Throughput	LTE CAT NB2: 127Kbps (DL). LTE CAT NB2: 159Kbps (UL).
Antenna	LTE main antenna.

SIM interface	Support identity card: 1.8V/3V.
UART1 interface	A full modem serial port by default Can be used as the AT commands Can be used for firmware upgrade and RF calibration Baud rate: default:115200bps
UART0	Software debugging and debugging log output. The default baud rate is 3Mbps.
Firmware upgrade	Firmware upgrade over UART1 interface
Physical characteristics	Size: 17.6mm×15.7mm×2.3 mm Weight: 1.3g±0.2g
Temperature range	operation temperature: -40°C to +85°C Storage temperature: -45°C to +90°C

NOTE

When VBAT is lower than 3V, the radio frequency can work but the performance of some indicators may not meet the 3GPP standard.

2 Package Information

2.1 Pin Assignment Overview

All functions of the SIM7028 will be provided through 42 pads that will be connected to the customers' platform. The Figure 2 is the pin assignment of the SIM7028.

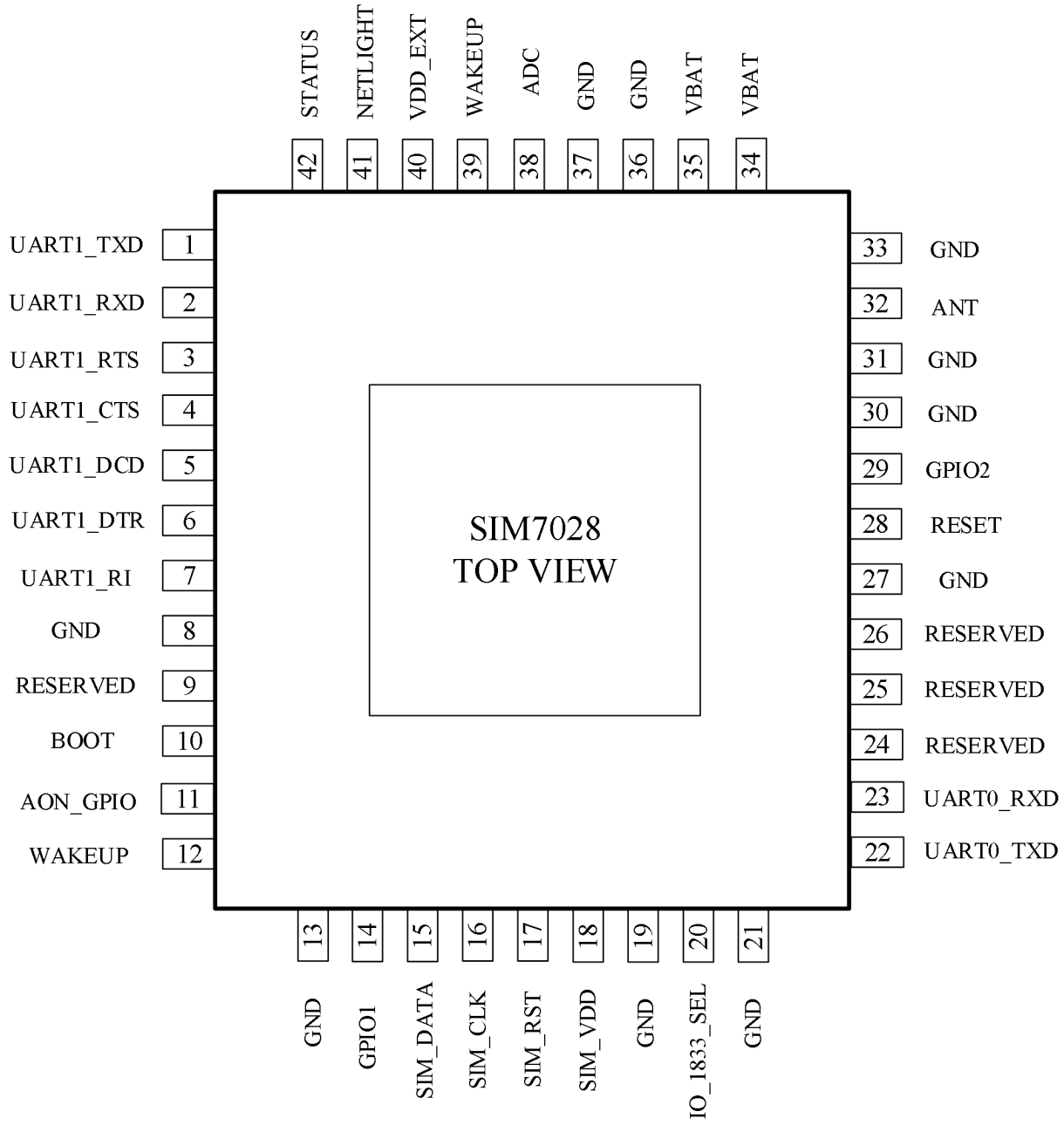

Figure 2: SIM7028 Pin assignment overview

Table 3: Lists the SIM7028 module pin numbers and pin definitions

Pin No.	Pin Name	Pin No.	Pin Name
1	UART1_TXD	22	UART0_TXD
2	UART1_RXD	23	UART0_RXD
3	UART1_RTS	24	RESERVED
4	UART1_CTS	25	RESERVED
5	UART1_DCD	26	RESERVED
6	UART1_DTR	27	GND
7	UART1_RI	28	RESET
8	GND	29	GPIO2
9	RESERVED	30	GND
10	BOOT	31	GND
11	AON_GPIO	32	ANT
12	WAKEUP	33	GND
13	GND	34	VBAT
14	GPIO1	35	VBAT
15	SIM_DATA	36	GND
16	SIM_CLK	37	GND
17	SIM_RST	38	ADC
18	SIM_VDD	39	WAKEUP
19	GND	40	VDD_EXT
20	IO_1833_SEL	41	NETLIGHT
21	GND	42	STATUS

2.2 Pin Description

This section describes the SIM7028 of pins and pin function definitions

Table 4: IO parameters definition

Pin type	Description
PI	Power input
PO	Power output
AI	Analog input
AIO	Analog input/output
I/O	Bidirectional input /output
DI	Digital input

DO	Digital output
DOH	Digital output with high level
DOL	Digital output with low level
PU	Pull up
PD	Pull down

Table 5: Pin description

Pin name	Pin No.	Default status	Description	Comment
Power supply				
VBAT	34、35	PI	Power supply, voltage range: 2.2-4.3V.	
VDD_EXT	40	PO	Power output. The voltage domain is 1.8V/3.3V optional. The default is 1.8 V. The output voltage of VDD_EXT will not exceed VBAT.	There is no voltage output in PSM mode. It can supply power to the pull-up circuit of the module; it is not recommended to supply power to external circuits.
GND	8、13、19、21、27、30、31、33、36、37		Ground	
System Control				
RESET	28	DI，PU	System reset control input, Vnorm = 1.3 V	Active low.
WAKEUP Control				
WAKEUP	12,39	DI，PU	External interrupt pin; wake up the module from PSM mode. Vnorm = 1.3 V	Active on falling edge.
GPIO level selection				
IO_1833_SEL	20	DI	Module GPIO level selection control pin. When floating: all GPIO levels of the module are 1.8V and the output voltage of VDD_EXT is 1.8V. When connected to GND: all GPIO levels of the module are 3.3V and the output voltage of VDD_EXT is 3.3V.	The default state is floating.
BOOT download control				
BOOT	10	DI	Download control pin, active low. Pull down this pin and then power on the module or press the reset button, the module will enter the download mode.	It cannot be pulled down before normal boot.

SIM interface				
SIM_DATA	15	I/O	SIM Card data I/O	
SIM_RST	17	DO	SIM Reset	
SIM_CLK	16	DO	SIM clock	
SIM_VDD	18	PO	Power output for SIM card, its output Voltage depends on SIM card type automatically.	
UART interface				
UART1_TXD	1	DOH	Transmit Data	The voltage domain is 1.8V/3.3V optional. Default 1.8 V.
UART1_RXD	2	DI，PU	Receive Data	
UART1_RTS	3	DI，PU	Request to send	
UART1_CTS	4	DOH	Clear to Send	
UART1_DCD	5	DOH	Data carrier detect	
UART1_DTR	6	DI，PU	Transmit Data	
UART1_RI	7	DOH	Ring Indicator	
UART0_TXD	22	DOH	Transmit Data	
UART0_RXD	23	DI，PU	Receive Data	
GPIO				
NETLIGHT	41	DOH	LED control output as network status indication. VOLmax = 0.45 V VOHmin = 0.7 x VDD_EXT	The voltage domain is 1.8V/3.3V optional. Default 1.8 V.
STATUS	42	DO	Operating status output. High level: Power on and firmware ready Low level: Power off	
GPIO1	14	IO		
GPIO2	29	IO		
AON_GPIO	11	IO	Controllable level after entering sleep	
RF interface				
ANT	32	AI	antenna	
Other interface				
ADC	38	AI	Analog-digital converter input. Voltage range: 0-3.3V.	If unused, keep them open.
RESERVED	9,24,25,26			Keep it open

NOTE

BOOT is the download control pin, this pin cannot be pulled down before the normal boot. Otherwise, it will enter the download mode.

2.3 Mechanical Information

The following figure shows the package outline drawing of SIM7028.

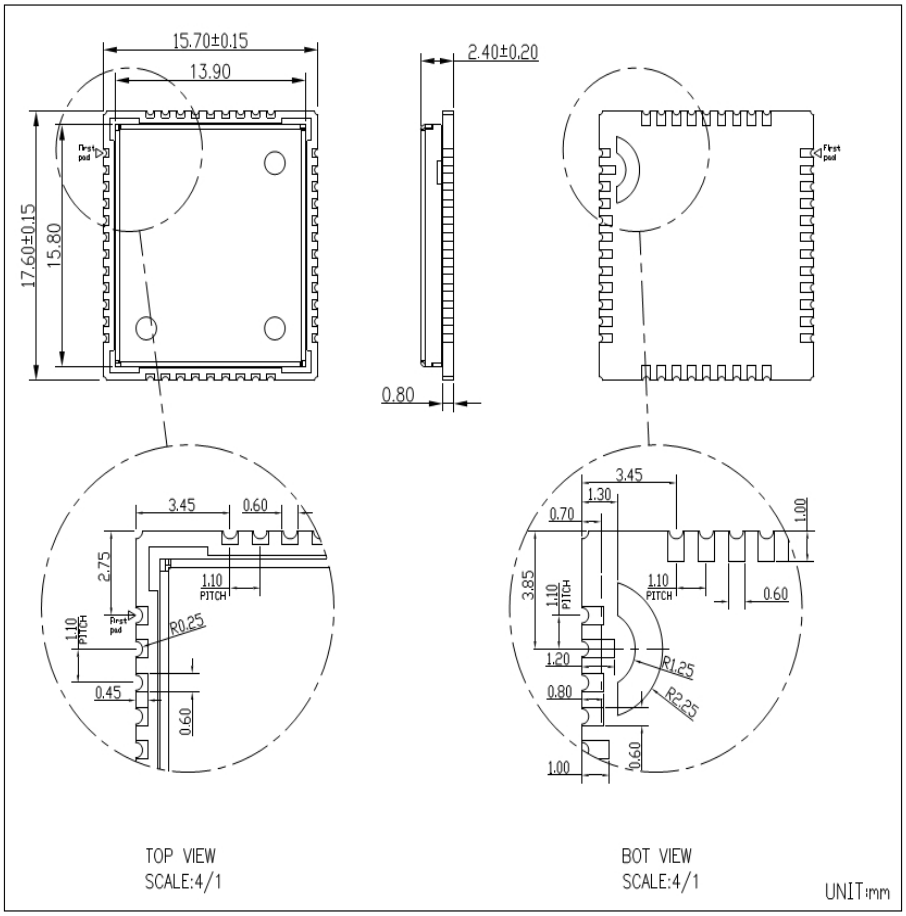

Figure 3: Dimensions (Unit: mm)

2.4 Footprint Recommendation

The following figure shows the Foot printer commended of the SIM7028.

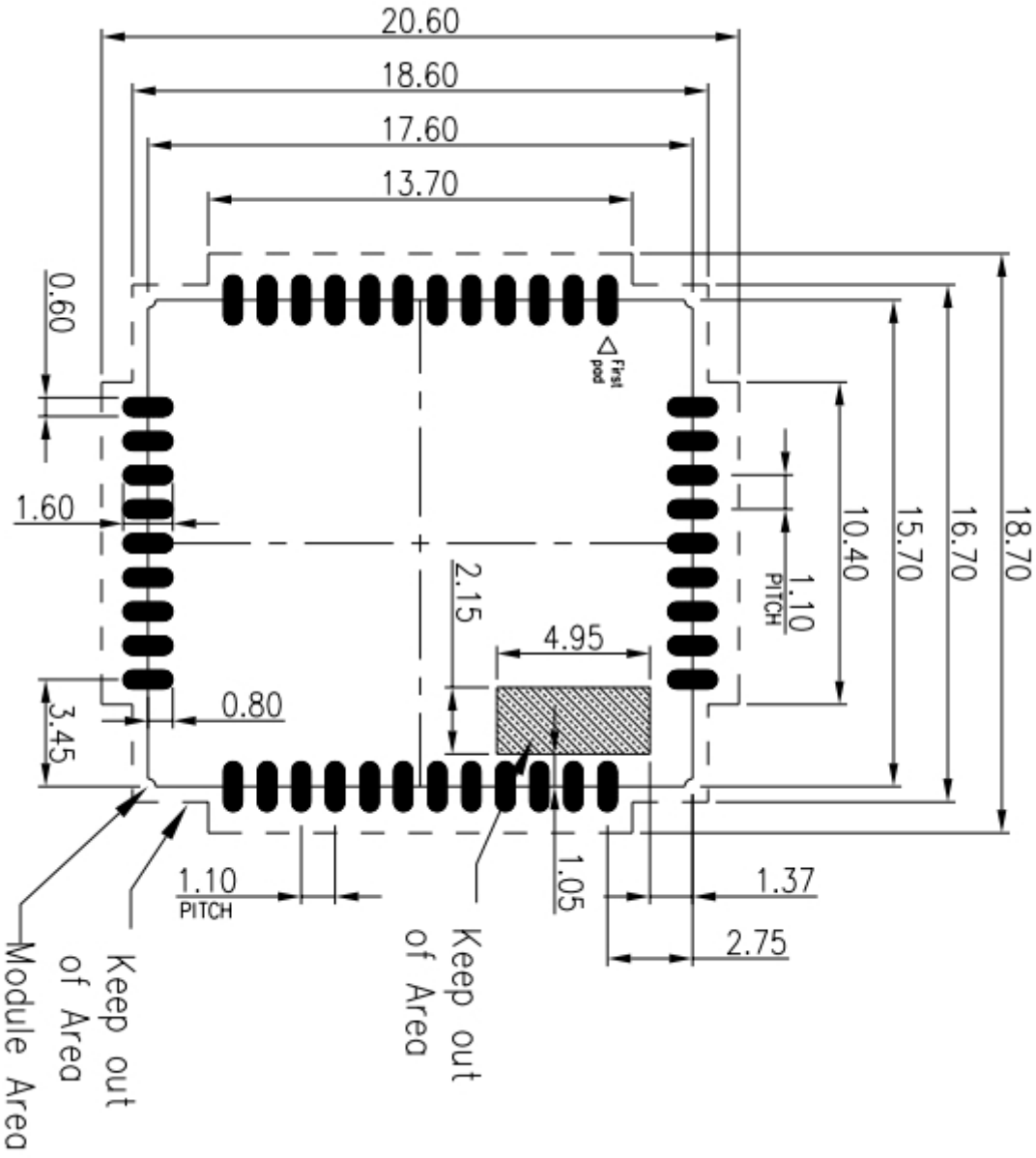

Figure 4: Footprint recommendation (Unit: mm)

3 Interface Application

3.1 Power Supply

Pin 34 and pin 35 are VBAT power input.

The power supply for SIM7028 must be able to provide sufficient current up to more than 500mA in order to satisfy the power supply current for maximum consumption.

The module can use an LDO with a low quiescent current output capability of 1 A as the power supply, or it can be powered by a battery. When the module is working in the digital transmission mode, it must be ensured that the power drop does not fall below the minimum working voltage of the module 2.2 V, otherwise the module will be abnormal.

At the VBAT pin of the module, you can refer to the following devices, where CA is a low ESR 100μF tantalum capacitor. In addition, to prevent surges and static electricity, it is recommended to connect TVS in parallel with the VBAT pin of the module. If you choose a Zener tube, please pay special attention to the static power consumption of the Zener tube. During PCB layout, the capacitor and TVS should be as close as possible to the VBAT pin of the module.

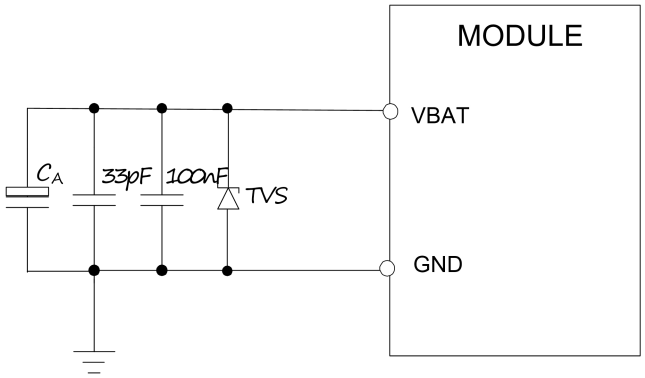

Figure 5: Power supply application circuit

3.2 Power on/Power off/Reset Function

3.2.1 Power on

The module is automatically turned on after power on, without a power button. Under the condition that the RESET pin is not pulled low by the outside, the module will automatically power on after supplying a voltage

of 2.2V to 4.3V to the VBAT pin.

NOTE

1.The voltage of VBAT must be lower than 0.7 V before power-on, and the power supply must rise to above 2.2 V within 10 ms.
2. After VBAT is powered on, RESET automatically rises to a high level due to an internal pull-up.
3. After the VBAT voltage rises above 2.2V, the system will automatically turn on. After turning on the VBAT voltage, the jitter cannot be lower than 2.2V, otherwise the system will be abnormal. The system can be reset via RESET.

3.2.2 Power off

The module can be shut down by disconnecting the VBAT power supply.

3.2.3 Reset Function

SIM7028 can reset the module by keeping the RESET pin low for at least 50ms. The module can also be reset by the AT command "AT+NRB".
The RESET signal has been pulled up inside the chip, and the RESET signal will immediately change to a high level after the module is powered on.

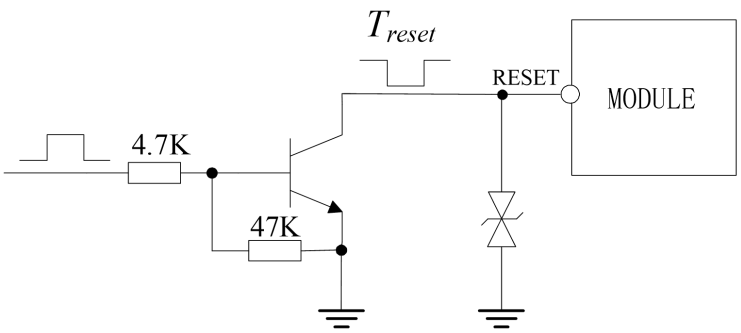

Figure 6:Reference reset circuit

Table 6: RESET pin electronic characteristic

Symbol	Description	Min.	Typ.	Max.	Unit
T_{reset}	The active low level time impulse on RESET pin to reset module	50	-	–	ms
V_{IH}	Input high level voltage	1.1	1.3	1.4	V
V_{IL}	Input high level voltage	-	-	0.3	V

3.3 WAKEUP Description

After SIM7028 enters sleep mode, it can be awakened by pulling down the WAKEUP pin.

WAKEUP is a falling edge wake-up. After the MCU pulls down the WAKEUP pin, it needs to send an AT command to the module within 10ms. If the RXD end of the module does not receive any AT command within 10ms, it will immediately enter the sleep mode. If the RXD end of the module receives data within 10ms, it will execute the corresponding instruction and then enter the sleep mode.

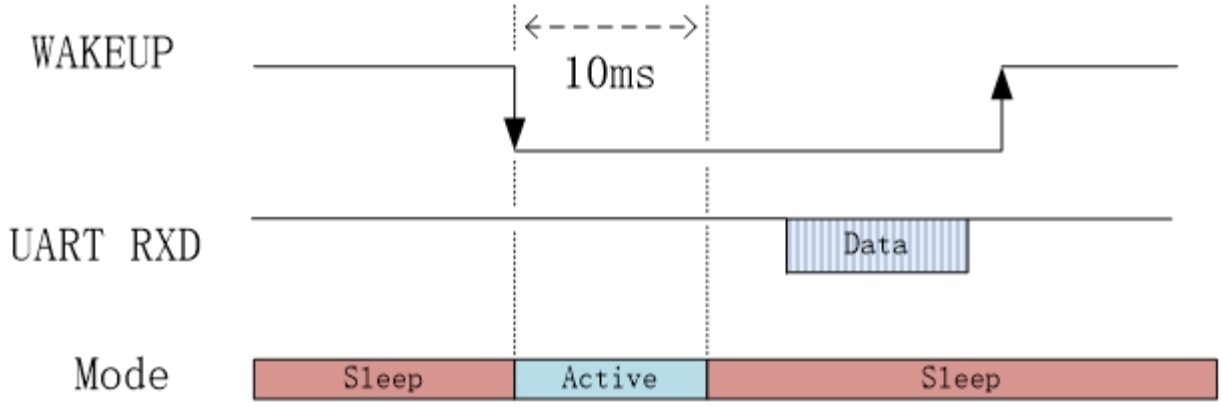

Figure 7: WAKEUP wakes up the serial communication is abnormal

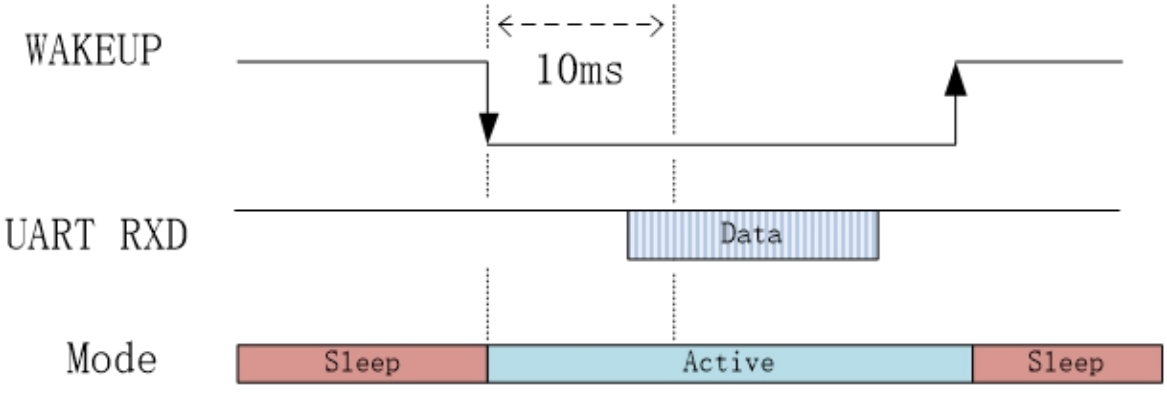

Figure 8: WAKEUP wakes up the serial communication successfully

The recommended circuit for WAKEUP is as follows:

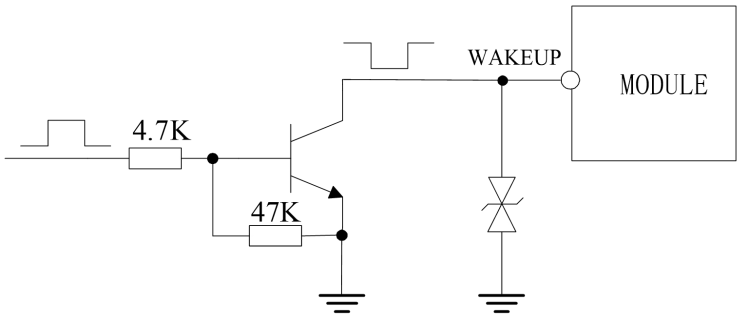

Figure 9: WAKEUP recommended circuit

Table 7: WAKEUP pin electrical parameters

Symbol	Description	Min.	Typ.	Max.	Unit
T	The active low level time impulse	500	-	–	ms
VIH	Input high level voltage	1.1	1.3	1.4	V
VIL	Input low level voltage	-	-	0.3	V

NOTE

When the serial port baud rate is less than or equal to 9600bps, there is no need to wake up by WAKEUP, and the module can be waked up directly by sending an AT command through UART1. When the baud rate is greater than 9600bps, the module wake-up needs to be realized by pulling down the WAKEUP pin.

3.4 GPIO power domain 1.8V/3.3V selection

The GPIO power domain of SIM7028 has two configurations of 1.8V and 3.3V. The default power domain is 1.8V. The two GPIO levels can be switched by setting the state of the pin IO_1833_SEL. The user can flexibly select the GPIO port level of the module according to the GPIO level of the external single-chip microcomputer to achieve the purpose of level matching, without adding an additional IO level conversion circuit between the single-chip microcomputer and the module.

Table 8: Pin definition

Pin name	Pin number	I/O direction	Description	Comment
IO_1833_SEL	20	I	GPIO level control input	When floating, the pin level is 1.1V

When the IO_1833_SEL pin is floating, after setting "AT+VIOSET=1", the power domain of the module's GPIO is 1.8V. When "AT+VIOSET" is not set, its default value is "1".

When the IO_1833_SEL pin is grounded, after setting "AT+VIOSET=3", the power domain of the GPIO port of the module will be set to 3.3V.

NOTE

The voltage of the GPIO of the module will not exceed the voltage of VBAT. When VBAT<3.3V, even if the IO_1833_SEL pin is grounded, the level of the GPIO port will be lower than 3.3V.
The GPIO of the module includes three UART ports, RI, SPI, NETLIGHT, SWDIO/SWDCLK.
When the module's GPIO level selection is switched, VDD_EXT will also follow the switch.

3.5 UART Interface

SIM7028 provides two serial ports: UART1 and UART0.

Table 9: UART electrical parameters

Symbol	Description	Min.	Typ.	Max.	Unit
VIH	Input high level voltage	0.7 x VDD_EXT	VDD_EXT	VDD_EXT	V
VIL	Input low level voltage	-0.3	0	0.2 x VDD_EXT	V
VOH	Output high level voltage	0.7 x VDD_EXT	VDD_EXT	VDD_EXT	V
VOL	Output low level voltage	0	0	0.45	V

3.5.1 UART1 is used for serial communication

UART1 is the main serial port, which can be used for AT command communication. UART1 supports adaptive baud rate and can be configured as 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400, 460800 bps. It can be set by AT command "AT+IPR".

3.5.2 UART1 is used for firmware upgrade and calibration

SIM7028 download baud rate defaults to 115200bps. Download steps: first trigger the module to enter the download mode: to ensure that the module is successfully powered on, first pull down BOOT, then pull down RESET to reset the module. After the module is successfully reset, release RESET first, and then release it. BOOT, so the module will enter the download mode and wait for the data transmitted by the download tool. After the module enters the download mode, set the port, baud rate and software version on the download tool, and click the "Download" button to start downloading data.

3.5.3 Debug serial port UART0

UART0 is the debug serial port. Customers can view the underlying log information through the debug serial port for software debugging.

Need to use a special EPAT log tool.

The baud rate that needs to be set when capturing EPAT log cannot be less than 3Mbps, otherwise the log will be lost.

The default baud rate of DBG_UART is 3 Mbps.

NOTE

When using EPAT log tool to capture log, you need to select a serial cable with a baud rate greater than 3Mbps.

3.5.4 Serial Port Voltage Level Matching

1.8V as default voltage for the serial port of the module. Costumer can also configure the voltage of the serial port to 3.3V upon the requirements, to match the IO level of MCU.

When serial port of the module and serial port of MCU have the same voltage level, the serial port and GPIO of module can connect to the MCU directly, the voltage level translator circuit is not needed, as shown below:

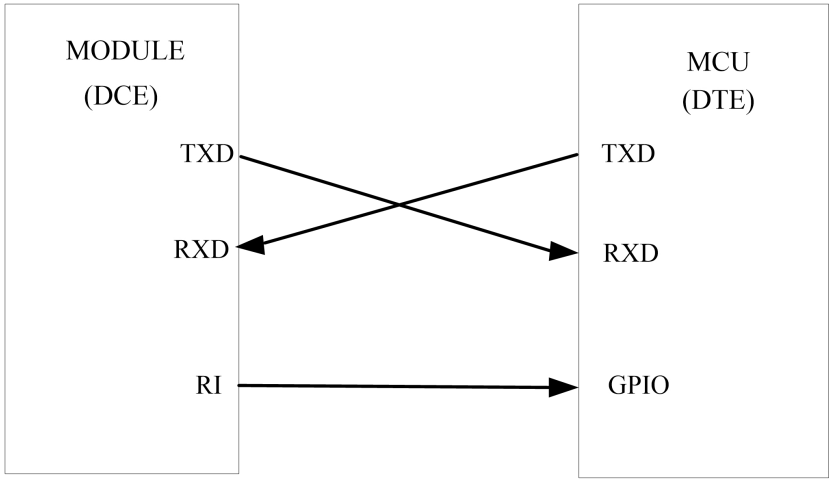

Figure 10: Connection of serial port with level matching

When serial port of MCU does not match the serial port of the module, the voltage level translator circuit is recommended between them to let the voltage level match.

The following figure is the reference design circuit with translator IC:

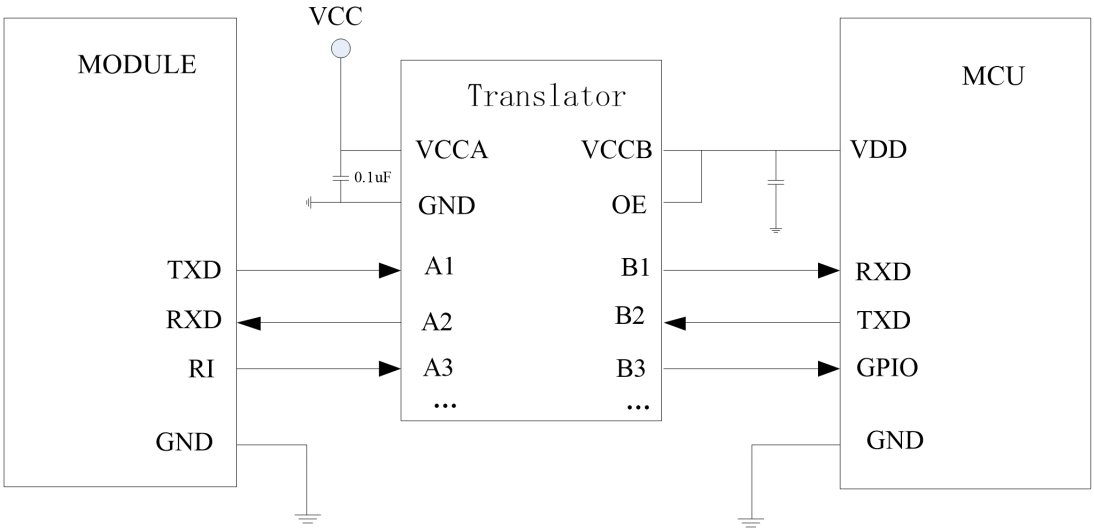

Figure 11: The recommended circuit with the translator IC

The second level translator circuit as shown in the figure below:

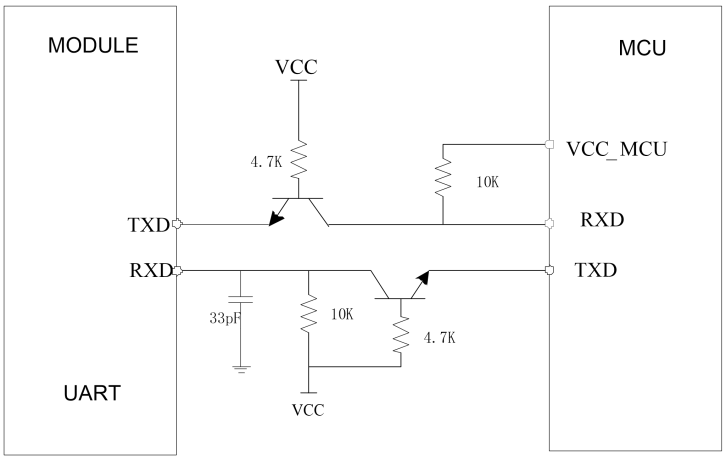

Figure 12: The recommended circuit with MOSFET

※ Note

Using pin of IO_1833_SEL to configure the power domain of serial port is recommended to match the serial port of MCU to simplify the hardware design and to have the optimum cost.

The pin of VDD_EXT is not recommended as power supply of the VCC, because VCC will be shut

down as the module goes to sleep, which cannot be awake by AT command through the serial port, only can be awake by WAKEUP pin. The external LDO as the power supply is recommended.

3.6 RI signal behaviors

RI always keep at the high level, when SMS received or URC outputs, the module will inform DTE through RI pin.

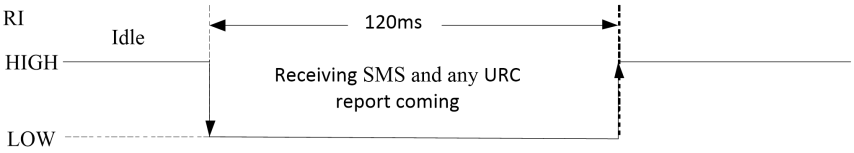

Figure 13: RI signal behaviors(SMS, URC)

※ Note

For details of this AT command, please refer to document [1].

3.7 ADC

SIM7028 provides one ADC, the electrical characteristics shown as below:

Table 10: ADC electrical characteristics

Characteristics	Min	Typ	Max	Unit
ADC resolution	-	12	-	bits
Voltage range	0	-	3.3	V

※ Note

Customer can use AT command “AT+CADC?” to read the voltage value. For details of this AT command, please refer to document [1].

3.8 SIM Card Interface

SIM7028 supports 1.8V and 3.0V SIM card. The power supply of SIM card provides by the internal LDO.

Table 11: SIM card pin definition

Pin name	Pin number	I/O	Description	Comment
SIM_DATA	15	I/O	SIM data input/output	
SIM_RST	16	DO	SIM reset	
SIM_CLK	17	DO	SIM clock	
SIM_VDD	18	PO	Voltage supply for SIM card. Support 1.8V or 3V SIM card depends on SIM card type	

※ Note

3.0 V < VBAT ≤ 4.5 V, 1.8/3.0 V SIM card is supported;
2.2 V ≤ VBAT ≤ 3 V, only 1.8 V SIM card is supported.

The following figure is the reference circuit for SIM card. The component of circuit should be placed as close as possible to the SIM card holder.

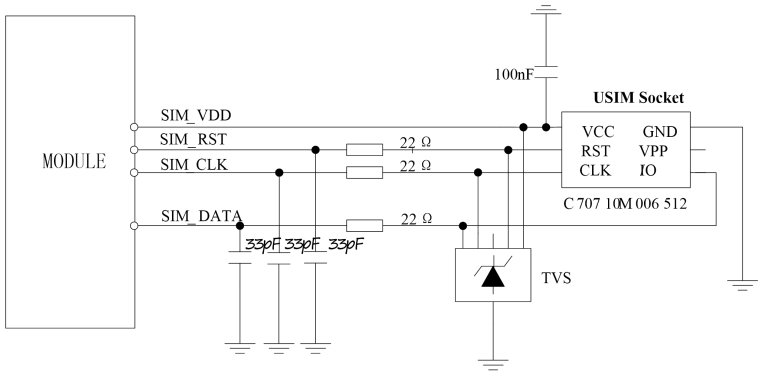

Figure 14: Reference circuit of SIM card interface

SIM card signal could be interference by some high frequency signal, it is strongly recommended to follow these guidelines while designing:

- Add some TVS which parasitic capacitance should not exceed 50pF
- SIM card holder should be far away from GSM antenna
- SIM traces should keep away from RF lines, VBAT and high-speed signal lines, the traces should be as short as possible
- Keep SIM card holder's GND connect to main ground directly
- Shielding the SIM_CLK to prevent the interference to other signals

3.9 Network Status

NETLIGHT pin to indicate the current network status, which is used to control Network Status LED, its reference circuit is shown in the following figure.

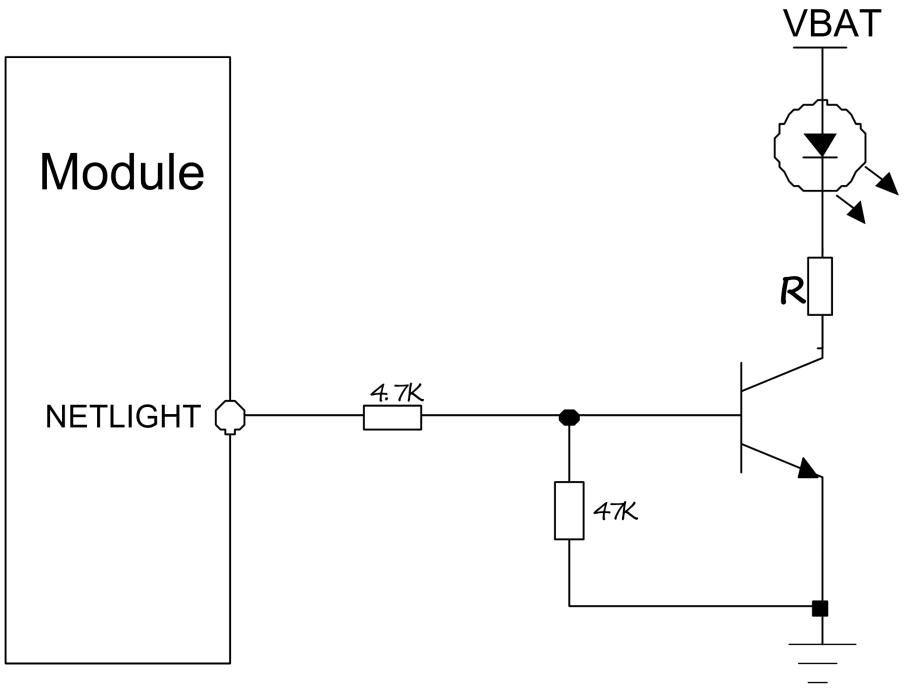

Figure 15: NETLIGHT reference circuit

NETLIGHT signal to control the network status LED, the pin status shown in the below table:

Table 12: NETLIGHT pin status

NETLIGHT pin status	Module status
64ms ON, 800ms OFF	No registered network
64ms ON, 2000ms OFF	Registered network (PS domain registration success)
OFF	Power off or PSM mode

4 Operation Mode

4.1 Operating mode

SIM7028 module has modes which are listed below:

Table 13: Module operating mode

Mode function		Description
Normal operating mode	Active	Power saving mode is not active, the system will stay in loop-waiting status, even has no tasks, high power consumption. All the function work properly for data transmitting and receiving.
	Idle	The core clock will be shut down when the system has no tasks, any interrupt could wake up the system and restart the core clock. IDLE mode only receive the paging message, which means monitor the network paging, if the data detected, the module will switch to ACTIVE mode from IDLE mode.
	Sleep	The module will shut down all the peripherals and part of registers based on the IDLE mode, the interrupt of the peripherals cannot wake up the system. The paging message cannot be received in SLEEP mode. When the module needs to receive the paging message, it will switch to IDLE mode to receive the network paging message, then switch to SLEEP mode.
	PSM	CPU will be shut down, only RTC function works; the network is disconnect and the module cannot receive the download data; the module can exist PSM mode by setting the timer of RTC and switch to ACTIVE mode.

The module can be configured to different sleep mode, which the system shuts down the different number of the internal power supply, to has different power consumption. The sleep mode can be set by AT command "AT+ECPMUCFG" and "AT+ECPMUCFG=1,4" as default.

The detailed information is listed below:

Table 14: Sleep mode

AT command	Setting mode	Description
AT+ECPMUCFG=0	Active	Power saving mode is not active, the system will stay in loop-waiting status, even has no tasks, high power consumption.
AT+ECPMUCFG=1,1	Idle	The core clock will be shut down when the system has no tasks, any interrupt

		could wake up the system and restart the core clock.
AT+ECPMUCFG=1,2	Sleep1	The module will shut down all the peripherals and part of registers based on the IDLE mode, the interrupt of the peripherals cannot wake up the system.
AT+ECPMUCFG=1,3	Sleep2	The 256KB memory will be shut down based on SLEEP1 mode, only 16KB Retention Memory is kept.
AT+ECPMUCFG=1,4	Hibernate	The 16KB Retention Memory will be shut down based on SLEEP2 mode.

The paging message cannot be received in SLEEP1 mode, SLEEP2 mode and Hibernate mode. When the module needs to receive the paging message, it will switch to IDLE mode to receive the network paging message, then switch back. The interrupt of the peripherals cannot wake up the system in SLEEP1 mode, SLEEP2 mode and Hibernate mode. The module could be wake up by sending AT command of LPUART function in UART1, and also pull down the pin of WAKEUP.

SLEEP1, SLEEP2, HIBERATE mode has difference with PSM mode. In the SLEEP1, SLEEP2, HIBERATE mode, the system will shut down the internal power supply of module to reduce the power consumption. When the communication with the networks is required, the module will switch to the IDLE mode. In PSM mode, the module will enable the PSM function and the network send the timer of T3324 and T3412, the module will enter the low power consumption when all the conditions are met.

4.2 PSM

The PSM function of SIM7028 could be opened by AT command "AT+CPSMS=1", when the conditions are met, the module will switch to PSM automatically. The module in PSM has low current(typically: 800nA). PSM aims to reduce the power consumption of module and extend the power-on time of battery.

The following figure shows the power consumption of module in different mode:

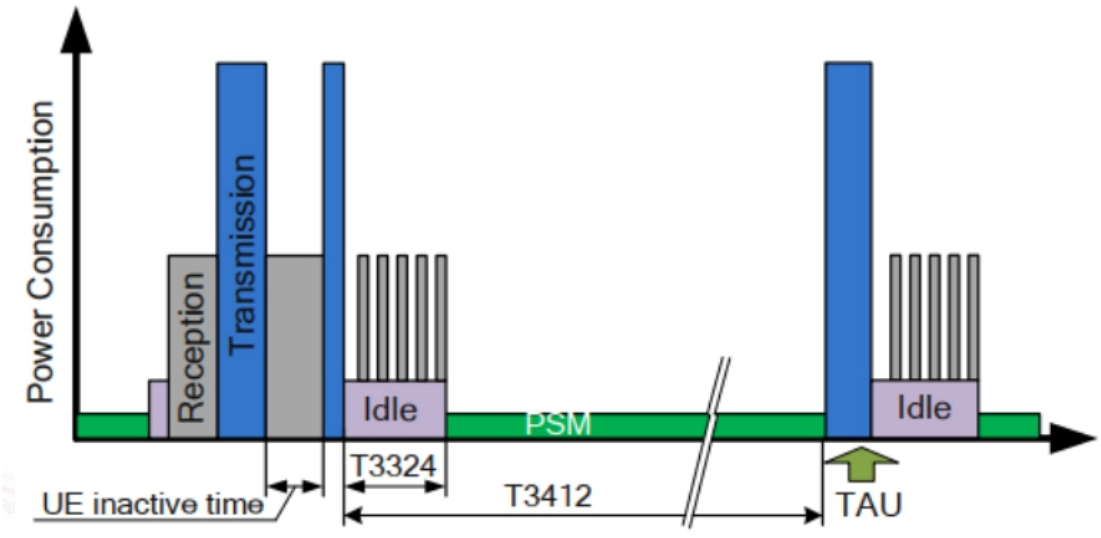

Figure 16: Power consumption of module in different mode

PSM will start after the data connection terminated or TAU updated. When the module connects to the network or update TAU, the network will send timer of T3324 and T3412 to the module, then the module will enter IDLE mode. In this mode, the module will transfer data with network(DRX status). When the timer of T3324 over time, the module will enter PSM.

In PSM, the module in power saving status, terminate the connection of network, shut down the most of power supply, only RTC function is kept, the module cannot be awake. When the timer of T3412 over time, the module will wake up.

4.3 PSM wake up

In PSM, the network connection of SIM7028 will terminated, the module cannot respond to the request of user.
If the customer want to use AT command by UART, they need to wake up the module first.

The following methods will wake up the module from PSM:

- When the timer T3412 expires, the module will automatically woken up.
- Communicate by LPUART(UART1) with baud rate 9600, send AT command to the module and RXD has data receiving, the module will automatically woken up
- Pulling WAKEUP pin to low level to wake up the module. When the module detects the falling edge, AT command must be send in 10ms to wake up the module.
- Pulling RESET pin to low level to wake up the module. The module will restart in network registration, network searching, some settings will lost.

5 RF Specifications

5.1 LTE RF Specifications

Table 15: Conducted transmission power

Frequency	Power	Min.
LTE-FDD B1	23dBm +/-2.7dB	<-40dBm
LTE-FDD B2	23dBm +/-2.7dB	<-40dBm
LTE-FDD B3	23dBm +/-2.7dB	<-40dBm
LTE-FDD B4	23dBm +/-2.7dB	<-40dBm
LTE-FDD B5	23dBm +/-2.7dB	<-40dBm
LTE-FDD B8	23dBm +/-2.7dB	<-40dBm
LTE-FDD B12	23dBm +/-2.7dB	<-40dBm
LTE-FDD B13	23dBm +/-2.7dB	<-40dBm
LTE-FDD B14	23dBm +/-2.7dB	<-40dBm
LTE-FDD B17	23dBm +/-2.7dB	<-40dBm
LTE-FDD B18	23dBm +/-2.7dB	<-40dBm
LTE-FDD B19	23dBm +/-2.7dB	<-40dBm
LTE-FDD B20	23dBm +/-2.7dB	<-40dBm
LTE-FDD B25	23dBm +/-2.7dB	<-40dBm
LTE-FDD B26	23dBm +/-2.7dB	<-40dBm
LTE-FDD B28	23dBm +/-2.7dB	<-40dBm
LTE-FDD B66	23dBm +/-2.7dB	<-40dBm
LTE-FDD B70	23dBm +/-2.7dB	<-40dBm
LTE-FDD B85	23dBm +/-2.7dB	<-40dBm

NOTE

The max power is tested result for single-tone in CAT-NB2. Multi-tone test results please refer to 3GPP, Maximum power reduction please refer to part 6.2.3F.3.

Table 16: Maximum Power Reduction (MPR) for UE CAT NB2

Modulation	QPSK		
Tone positions for 3 Tones allocation	0-2	3-5 and 6-8	9-11

MPR	≤ 0.5 dB	0 dB	≤ 0.5 dB
Tone positions for 3 Tones allocation	0-5 and 6-11		
MPR	≤ 1 dB	≤ 1 dB	
Tone positions for 3 Tones allocation	0-11		
MPR	≤ 2 dB		

Table 17: E-UTRA operating bands

E-UTRA	UL Freq.	DL Freq.	Duplex Mode
1	1920 ~1980 MHz	2110 ~2170 MHz	HD-FDD
2	1850 ~1910 MHz	1930 ~1990 MHz	HD-FDD
3	1710 ~1785 MHz	1805 ~1880 MHz	HD-FDD
4	1710 ~1755 MHz	2110 ~2155 MHz	HD-FDD
5	824 ~849 MHz	869 ~894 MHz	HD-FDD
8	880 ~915 MHz	925 ~960 MHz	HD-FDD
12	699 ~716 MHz	729 ~746 MHz	HD-FDD
13	777 ~787 MHz	746 ~756 MHz	HD-FDD
14	788 ~798 MHz	758 ~768 MHz	HD-FDD
17	704 ~716 MHz	734 ~746 MHz	HD-FDD
18	815 ~830 MHz	860 ~875 MHz	HD-FDD
19	830 ~845 MHz	875 ~890 MHz	HD-FDD
20	832 ~862 MHz	791 ~821 MHz	HD-FDD
25	1850~1915MHz	1930~1995MHz	HD-FDD
26	814 ~849 MHz	859 ~894 MHz	HD-FDD
28	703 ~748 MHz	758 ~803 MHz	HD-FDD
66	1710 ~1780 MHz	2110 ~2200 MHz	HD-FDD
70	1695 ~1710 MHz	1995 ~2020 MHz	HD-FDD
85	698~716MHz	728~746MHz	HD-FDD

Table 18: CAT-NB2 Reference sensitivity (QPSK)

Operating bands	REFSENS MAX(dBm) 3GPP Request
1	<-108.2
2	<-108.2
3	<-108.2
4	<-108.2
5	<-108.2
8	<-108.2
12	<-108.2

13	<-108.2
14	<-108.2
17	<-108.2
18	<-108.2
19	<-108.2
20	<-108.2
25	<-108.2
26	<-108.2
28	<-108.2
66	<-108.2
70	<-108.2
85	<-108.2

5.2 LTE Antenna Design Guide

Users should connect antennas to SIM7028 antenna pads through micro-strip line or other types of RF trace and the trace impedance must be controlled in 50Ω. It recommends that the total insertion loss between the antenna pads and antennas should meet the following requirements:

Table 19: Trace loss

Frequency	Loss
700MHz-960MHz	<0.5dB
1710MHz-2170MHz	<0.9dB
2300MHz-2650MHz	<1.2dB

To facilitate the antenna tuning and certification test, a RF connector and an antenna matching circuit should be added. The following figure is the recommended circuit.

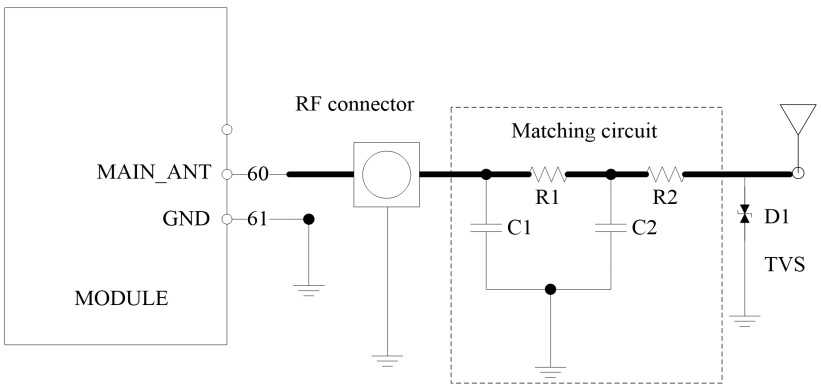

Figure 17: Antenna matching circuit (MAIN_ANT)

In above figure, the components R1, C1, C2 and R2 are used for antenna matching, the values of components can only be achieved after the antenna tuning and usually provided by antenna vendor. By

default, the R1, R2 are 0Ω resistors, and the C1, C2 are reserved for tuning. The component D1 is a TVS for ESD protection, and it is optional for users according to application environment.

The RF test connector is used for the conducted RF performance test, and should be placed as close as to the module's MAIN_ANT pin. The traces impedance between SIM7028 and antenna must be controlled in 50Ω.

Two TVS are recommended in the table below.

Table 20: Recommended TVS

Package	Part Number	Vender
0201	LXES03AAA1-154	Murata
0402	LXES15AAA1-153	Murata

5.3 RF Layout Design Guide

5.3.1 RF layout

- The length of RF trace between module and antenna should be as short as possible upon the antenna position and trace loss, the module should be placed as close as possible to the main board edge.
- The RF trace(micro-strip trace on top or strip trace in the inner layer) should be shielded by ground and 50Ω impedance.
- RF trace should avoid right angle and acute angle.
- RF trace should be shielded around GND.
- RF trace examples shown in the following figure, which isolated from other high-speed signal and shielded by GND.

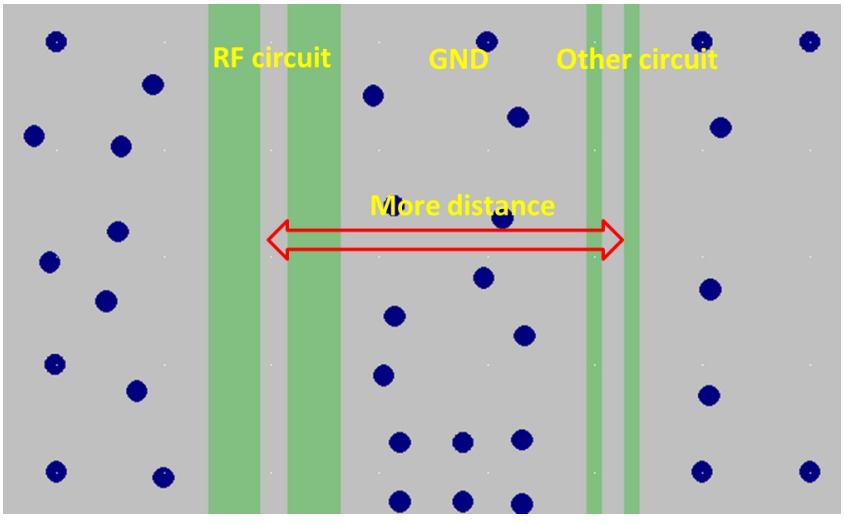

Figure 18: RF trace should be isolated from other signal trace

- Do not trace RF signal across or parallel with other signals
- If the interface of RF is SMA, GND should has some distance away from RF pads. Do not lay the copper in all the layers on PCB

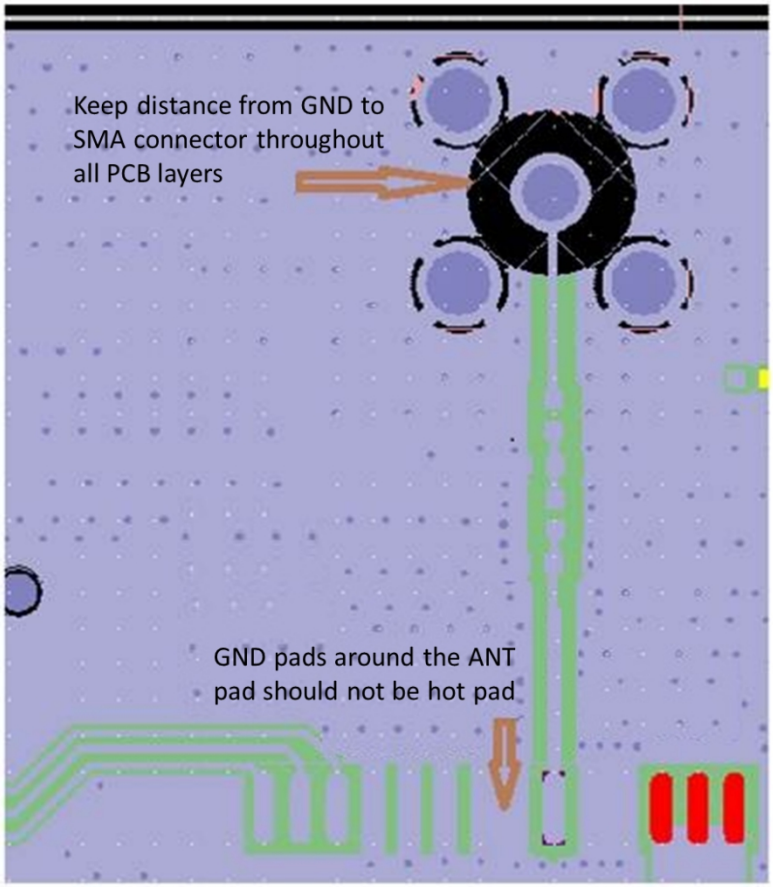

Figure 19: Distance between RF trace and GND

- GND around the ANT pin of RF do not make pads to ensure the integration of the ground.

5.3.2 LTE antenna and other communication system isolation notice

- Efficiency of LTE main antenna in free space should be more than 40%
- If WLAN supported, isolation of LTE main antenna and WLAN antenna should more than 15dB
- If GNSS supported, isolation of LTE main antenna and GNSS antenna should more than 30dB

※ Note

The isolation of different antennas should be decided by the manufacture. For more details, please refer to the ANTENNA DESIGN GUIDELINES FOR DIVERSITY RECEIVER SYSTEM V1.01.pdf.

6 Electrical Specifications

6.1 Normal Operating Conditions

Table 21: Recommended operating ratings

Parameter	Min.	Typ.	Max.	Unit
Voltage at VBAT	2.2	-	4.3	V

Table 22: Operating temperature

Parameter	Min.	Typ.	Max.	Unit
Normal operating temperature	-30	25	80	℃
Extreme operating temperature	-40	25	85	℃
Storage temperature	-45	25	90	℃

NOTE

The performance will be reduced slightly from the 3GPP specifications if the temperature in the extreme operating temperature range.

6.2 Current Consumption

The current consumption is listed in the table below.

Table 23: VBAT current consumption(VBAT=3.3V)

IMAX	
Peak current (Maximum transient current)	Data transmission at maximum output power Typical: 500mA
Idle mode	
LTE supply current (AT$QCPMUCFG=1,1)	NB-IoT Idle mode Typical: 5mA
Power Saving Mode	
PSM supply current	T3324=20S,T3412=600S,DRX=2.56S, PSM mode Typical: 0.8uA
e-DRX	

e-DRX mode supply current （Tested in sleep mode）	@ PTW=40.96s；eDRX=81.92s；DRX=2.56s, Typical：0.15mA @ PTW=25.6s；eDRX=163.84s；DRX=2.56s, Typical：0.02mA

LTE Cat-NB data transmission

	15KHz single tone	15KHz 3 tones	15KHz 12 tones	3.75KHz single tone
B1	@23dbm : 101mA @10dbm: 34mA @0dbm: 25mA	@23dbm : 65mA @10dbm: 25mA @0dbm: 19mA	@23dbm : 26mA @10dbm: 15mA @0dbm: 14mA	@23dbm : 192mA @10dbm: 63mA @0dbm: 37mA
B2	@23dbm : 101mA @10dbm: 35mA @0dbm: 25mA	@23dbm : 63mA @10dbm: 25mA @0dbm: 19mA	@23dbm : 25mA @10dbm: 15mA @0dbm: 16mA	@23dbm : 191mA @10dbm: 59mA @0dbm: 37mA
B3	@23dbm : 99mA @10dbm: 35mA @0dbm: 24mA	@23dbm : 62mA @10dbm: 25mA @0dbm: 19mA	@23dbm : 25mA @10dbm: 15mA @0dbm: 16mA	@23dbm : 187mA @10dbm: 59mA @0dbm: 37mA
B4	@23dbm : 100mA @10dbm: 34mA @0dbm: 24mA	@23dbm : 64mA @10dbm: 25mA @0dbm: 19mA	@23dbm : 25mA @10dbm: 15mA @0dbm: 14mA	@23dbm : 189mA @10dbm: 62mA @0dbm: 38mA
B5	@23dbm : 91mA @10dbm: 28mA @0dbm: 19mA	@23dbm : 56mA @10dbm: 21mA @0dbm: 16mA	@23dbm : 24mA @10dbm: 13mA @0dbm: 13mA	@23dbm : 167mA @10dbm: 46mA @0dbm: 30mA
B8	@23dbm : 94mA @10dbm: 29mA @0dbm: 20mA	@23dbm : 58mA @10dbm: 21mA @0dbm: 16mA	@23dbm : 25mA @10dbm: 14mA @0dbm: 13mA	@23dbm : 172mA @10dbm: 47mA @0dbm: 29mA
B12	@23dbm : 109mA @10dbm: 32mA @0dbm: 19mA	@23dbm : 70mA @10dbm: 23mA @0dbm: 16mA	@23dbm : 28mA @10dbm: 14mA @0dbm: 13mA	@23dbm : 207mA @10dbm: 54mA @0dbm: 30mA
B13	@23dbm : 97mA @10dbm: 27mA @0dbm: 21mA	@23dbm : 62mA @10dbm: 20mA @0dbm: 16mA	@23dbm : 26mA @10dbm: 13mA @0dbm: 13mA	@23dbm : 185mA @10dbm: 46mA @0dbm: 30mA
B14	@23dbm : 98mA @10dbm: 28mA @0dbm: 21mA	@23dbm : 62mA @10dbm: 21mA @0dbm: 16mA	@23dbm : 26mA @10dbm: 14mA @0dbm: 13mA	@23dbm : 185mA @10dbm: 47mA @0dbm: 30mA
B17	@23dbm : 109mA @10dbm: 32mA @0dbm: 20mA	@23dbm : 67mA @10dbm: 23mA @0dbm: 16mA	@23dbm : 28mA @10dbm: 14mA @0dbm: 13mA	@23dbm : 207mA @10dbm: 54mA @0dbm: 30mA
B18	@23dbm : 91mA @10dbm: 28mA @0dbm: 20mA	@23dbm : 57mA @10dbm: 21mA @0dbm: 17mA	@23dbm : 23mA @10dbm: 14mA @0dbm: 12mA	@23dbm : 171mA @10dbm: 46mA @0dbm: 30mA
B19	@23dbm : 91mA @10dbm: 28mA @0dbm: 19mA	@23dbm : 56mA @10dbm: 21mA @0dbm: 17mA	@23dbm : 23mA @10dbm: 14mA @0dbm: 14mA	@23dbm : 167mA @10dbm: 45mA @0dbm: 29mA
B20	@23dbm : 89mA @10dbm: 27mA @0dbm: 20mA	@23dbm : 56mA @10dbm: 21mA @0dbm: 16mA	@23dbm : 24mA @10dbm: 14mA @0dbm: 12mA	@23dbm : 167mA @10dbm: 46mA @0dbm: 30mA
B25	@23dbm : 101mA @10dbm: 35mA @0dbm: 24mA	@23dbm : 64mA @10dbm: 25mA @0dbm: 18mA	@23dbm : 25mA @10dbm: 15mA @0dbm: 13mA	@23dbm : 191mA @10dbm: 59mA @0dbm: 38mA
B26	@23dbm : 90mA @10dbm: 28mA @0dbm: 20mA	@23dbm : 57mA @10dbm: 21mA @0dbm: 17mA	@23dbm : 23mA @10dbm: 14mA @0dbm: 13mA	@23dbm : 169mA @10dbm: 45mA @0dbm: 29mA
B28	@23dbm : 106mA @10dbm: 30mA @0dbm: 20mA	@23dbm : 67mA @10dbm: 21mA @0dbm: 16mA	@23dbm : 26mA @10dbm: 14mA @0dbm: 12mA	@23dbm : 203mA @10dbm: 54mA @0dbm: 30mA
B66	@23dbm : 100mA	@23dbm : 63mA	@23dbm : 26mA	@23dbm : 189mA

	@10dbm: 34mA @0dbm: 24mA	@10dbm: 25mA @0dbm: 19mA	@10dbm: 15mA @0dbm: 15mA	@10dbm: 59mA @0dbm: 38mA
B70	@23dbm : 96mA @10dbm: 33mA @0dbm: 24mA	@23dbm : 62mA @10dbm: 24mA @0dbm: 19mA	@23dbm : 25mA @10dbm: 15mA @0dbm: 14mA	@23dbm : 185mA @10dbm: 56mA @0dbm: 37mA
B85	@23dbm : 110mA @10dbm: 32mA @0dbm: 19mA	@23dbm : 70mA @10dbm: 23mA @0dbm: 17mA	@23dbm : 28mA @10dbm: 14mA @0dbm: 12mA	@23dbm : 206mA @10dbm: 54mA @0dbm: 29mA

6.3 ESD Notes

SIM7028 is sensitive to ESD in the process of storage, transporting, and assembling. When SIM7028 is mounted on the users′ mother board, the ESD components should be placed beside the connectors which human body may touch, such as SIM card holder, audio jacks, switches, keys, etc. The following table shows SIM7028 ESD measurement performance without any external ESD component.

Table 24: The ESD performance measurement table (Temperature: 25℃, Humidity: 45%.)

Part	Contact discharge	Air discharge
GND（Shield）	6±KV	12±KV
GND （RF）	6±KV	12±KV
VBAT	5±KV	10±KV
Antenna port	5±KV	10±KV

7 SMT Production Guide

7.1 Top and Bottom View of SIM7028

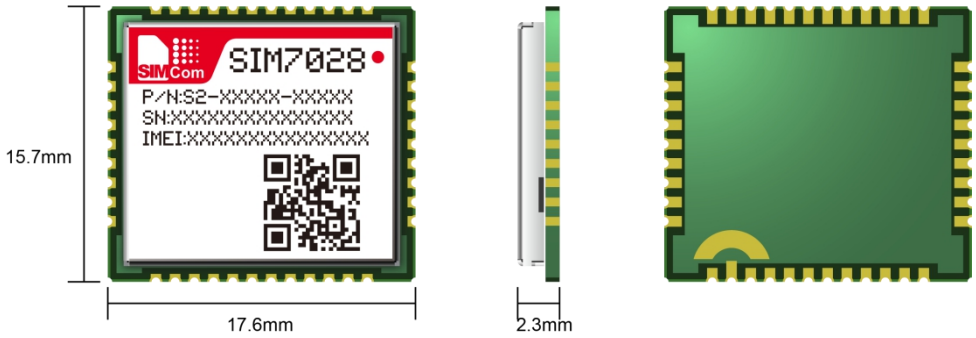

Figure 20: Top and bottom view of SIM7028

7.2 Typical SMT Reflow Profile

SIMCom provides a typical soldering profile. Therefore the soldering profile shown below is only a generic recommendation and should be adjusted to the specific application and manufacturing constraints.

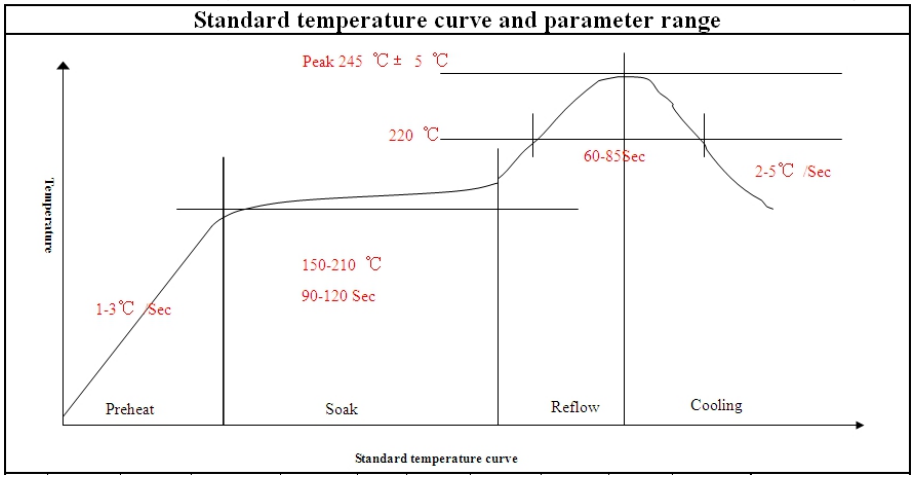

Figure 21: The ramp-soak-spike reflow profile of SIM7028

7.3 Moisture Sensitivity Level (MSL)

SIM7028 is qualified to Moisture Sensitivity Level (MSL) 3 in accordance with JEDEC J-STD-033.

The following table shows the features of Moisture Sensitivity Level (MSL). After seal off, storage conditions must meet the following table. If the storage time was expired, module must be baking before SMT.

Table 25: Moisture Sensitivity Level and Floor Life

Moisture Sensitivity Level (MSL)	Floor Life (out of bag) at factory ambient≤30°C/60% RH or as stated
1	Unlimited at ≦30℃/85% RH
2	1 year at ≦30℃/60% RH
2a	4 weeks at ≦30℃/60% RH
3	168 hours at ≦30℃/60% RH
4	72 hours at ≦30℃/60% RH
5	48 hours at ≦30℃/60% RH
5a	24 hours at ≦30℃/60% RH
6	Mandatory bake before use. After bake, it must be re-flowed within the time limit specified on the label.

7.4 Baking

In order to get better yield, the module need to bake before SMT.

- If the packaging is in perfect condition, the module which dateofproduction is within six months has no use for baking. If the dateofproduction is more than six months, the module must be baking.
- If the packaging had been opened or damaged, the module must be baking.

Table 26: Baking conditions

Conditions	Parameters
Baking temperature	120℃
Baking time	8 hours

NOTE

IPC / JEDEC J-STD-033standard must be followed for production and storage.

8 Packaging

8. 1 Tray packaging

SIM7028 module support tray packaging.

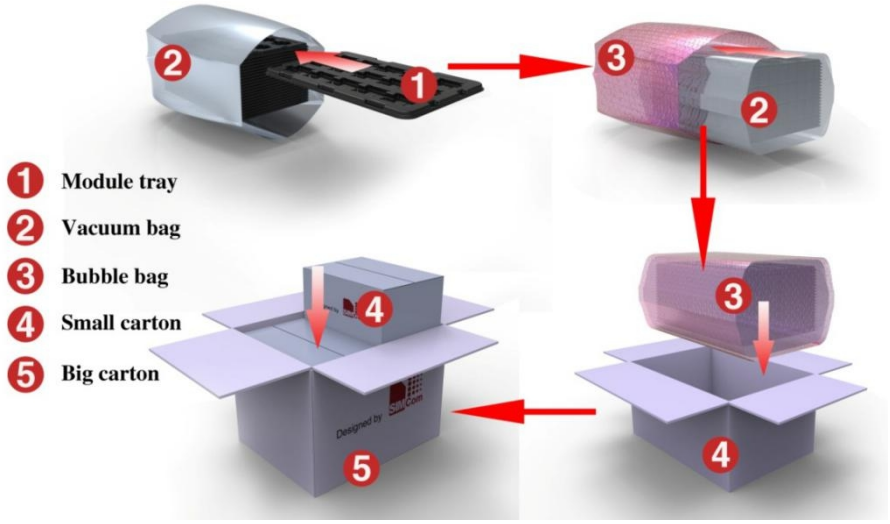

Figure 22: packaging diagram

Module tray drawing：

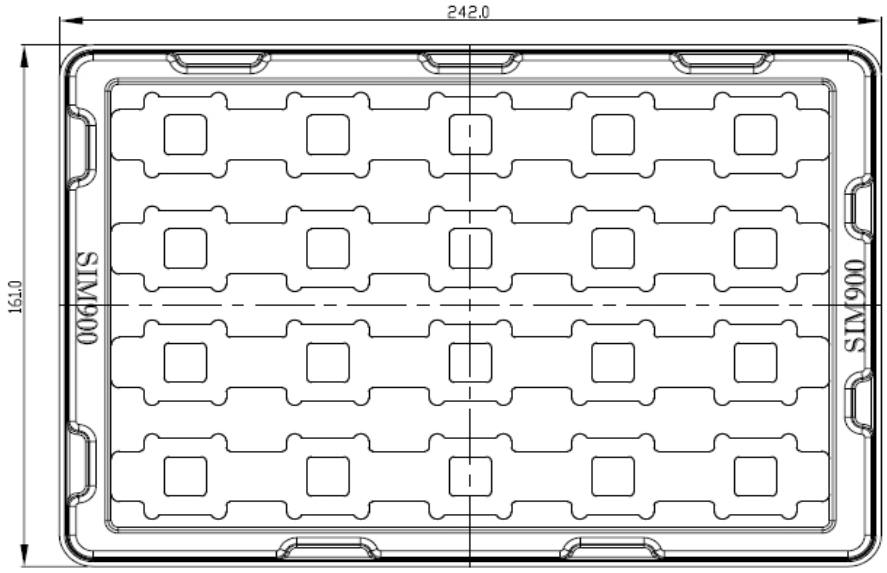

Figure 23: Tray drawing

Table 27: Tray size

Length（±3mm）	Width（±3mm）	Module number
242.0	161.0	50

Small carton drawing：

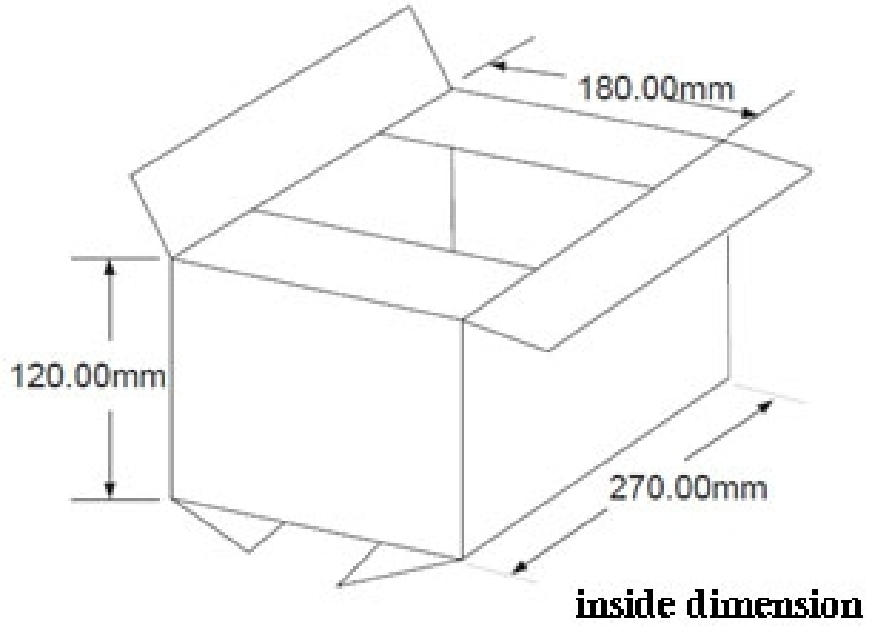

Figure 24: Small carton drawing

Table 28: Small Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module number
270	180	120	50*20=1000

Big carton drawing：

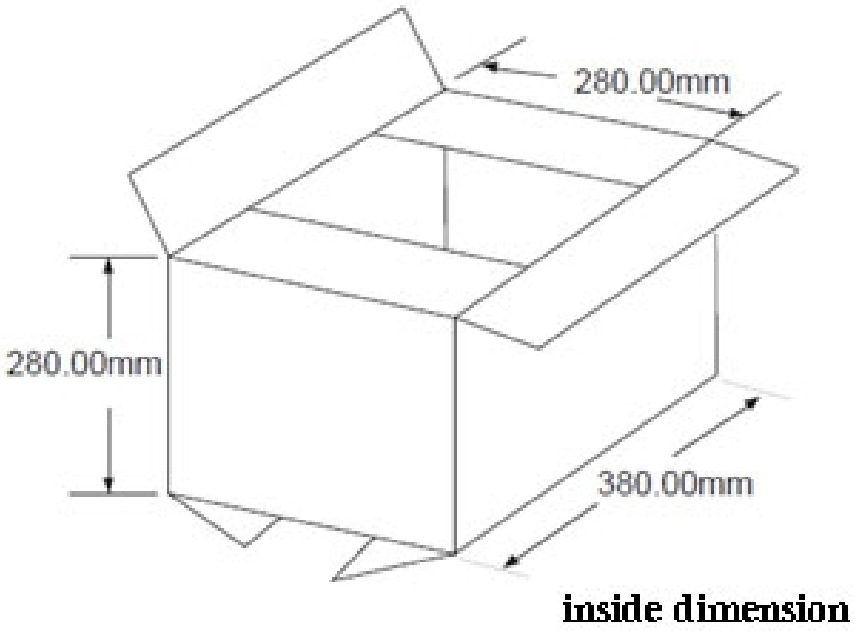

Figure 25: Big carton drawing

Table 29: Big Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module number
380	280	280	1000*4=4000

9 Appendix

9.1 A.Related Documents

Table 30: Related Documents

NO.	Title	Description
[1]		AT Command Manual
[2]	3GPP TS 51.010-1	Digital cellular telecommunications system (Release 5); Mobile Station (MS) conformance specification
[3]	3GPP TS 34.124	Electromagnetic Compatibility (EMC) for mobile terminals and ancillary equipment.
[4]	3GPP TS 34.121	Electromagnetic Compatibility (EMC) for mobile terminals and ancillary equipment.
[5]	3GPP TS 34.123-1	Technical Specification Group Radio Access Network; Terminal conformance specification; Radio transmission and reception (FDD)
[6]	3GPP TS 34.123-3	User Equipment (UE) conformance specification; Part 3: Abstract Test Suites.
[7]	EN 301 908-02 V2.2.1	Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS) and User Equipment (UE) for IMT-2000. Third Generation cellular networks; Part 2: Harmonized EN for IMT-2000, CDMA Direct Spread (UTRA FDD) (UE) covering essential requirements of article 3.2 of the R&TTE Directive
[8]	EN 301 489-24 V1.2.1	Electromagnetic compatibility and Radio Spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 24: Specific conditions for IMT-2000 CDMA Direct Spread (UTRA) for Mobile and portable (UE) radio and ancillary equipment
[9]	IEC/EN60950-1(2001)	Safety of information technology equipment (2000)
[10]	3GPP TS 51.010-1	Digital cellular telecommunications system (Release 5); Mobile Station (MS) conformance specification
[11]	2002/95/EC	Directive of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
[12]	Module secondary-SMT-UGD-V1.xx	Module secondary SMT Guidelines
[13]	HERACLES324G Series UART Application Note_V1.xx	This document describes how to use UART interface of SIMCom modules.
[14]	ETSI EN 301 908-13 (ETSI TS 136521-1 R13.4.0)	IMT cellular networks; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive; Part 13
[15]	ANTENNA DESIGN GUIDELINES FOR MULTI-ANTENNA SYSTEM V1 01	Design notice for multi-antenna.

9.2 B. Terms and Abbreviations

Table 31: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
ARP	Antenna Reference Point
BER	Bit Error Rate
BD	BeiDou
BTS	Base Transceiver Station
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DRX	Discontinuous Reception
DSP	Digital Signal Processor
DTE	Data Terminal Equipment (typically computer, terminal, printer)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
DAM	Downloadable Application Module
DPO	Dynamic Power Optimization
DRX	Discontinuous Reception
e-DRX	Extended Discontinuous Reception
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
EVDO	Evolution Data Only
FCC	Federal Communications Commission (U.S.)
FD	SIM fix dialing phonebook
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global Standard for Mobile Communications
HR	Half Rate

HSPA	High Speed Packet Access
I2C	Inter-Integrated Circuit
IMEI	International Mobile Equipment Identity
LTE	Long Term Evolution
MO	Mobile Originated
MS	Mobile Station (GSM engine), also referred to as TE
MT	Mobile Terminated
NMEA	National Marine Electronics Association
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCS	Personal Communication System, also referred to as GSM 1900
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
SIM	Subscriber Identification Module
SMS	Short Message Service
SMPS	Switched-mode power supply
TDMA	Time Division Multiple Access
TE	Terminal Equipment, also referred to as DTE
TX	Transmit Direction
UART	Universal Asynchronous Receiver & Transmitter
VSWR	Voltage Standing Wave Ratio
SM	SIM phonebook
NC	Not connect
EDGE	Enhanced data rates for GSM evolution
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
ZIF	Zero intermediate frequency
WCDMA	Wideband Code Division Multiple Access
VCTCXO	Voltage control temperature-compensated crystal oscillator
SIM	Universal subscriber identity module
UMTS	Universal mobile telecommunications system
UART	Universal asynchronous receiver transmitter
PSM	Power saving mode
LD	SIM last dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT calls (missed calls)
ON	SIM (or ME) own numbers (MSISDNs) list
RC	Mobile Equipment list of received calls
SM	SIM phonebook
NC	Not connect

9.3 C. Safety Caution

Table 32: Safety Caution

Marks	Requirements
	When in a hospital or other health care facility, observe the restrictions about the use of mobiles. Switch the cellular terminal or mobile off, medical equipment may be sensitive and not operate normally due to RF energy interference.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it is switched off. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. Forgetting to think much of these instructions may impact the flight safety, or offend local legal action, or both.
	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.
	Road safety comes first! Do not use a hand-held cellular terminal or mobile when driving a vehicle, unless it is securely mounted in a holder for hands free operation. Before making a call with a hand-held terminal or mobile, park the vehicle.
	GSM cellular terminals or mobiles operate over radio frequency signals and cellular networks and cannot be guaranteed to connect in all conditions, especially with a mobile fee or an invalid SIM card. While you are in this condition and need emergent help, please remember to use emergency calls. In order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency call if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may have to deactivate those features before you can make an emergency call. Also, some networks require that a valid SIM card be properly inserted in the cellular terminal or mobile.

OEM/Integrators Installation Manual

Important Notice to OEM integrators 1. This module is limited to OEM installation ONLY. 2. This module is limited to installation in mobile or fixed 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 Simcom 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: 2AJYU-8EC0001” “The FCC ID can be used only when all FCC compliance requirements are met.

Antenna

(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.

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 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.

To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed

Test Mode	Antenna Gain (dBi)	Test Mode	Antenna Gain (dBi)
LTE B2	7.30	LTE B14	4.30
LTE B4	4.30	LTE B17	4.30
LTE B5	4.30	LTE B25	7.30
LTE B12	4.30	LTE B26	4.30
LTE B13	4.30	LTE B66	4.30

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 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.