M72

Quectel Cellular Engine

Hardware Design

M72_HD_V1.0

Document Title	M72 Hardware Design
Revision	1.0
Date	2011-02-22
Status	Release
Document Control ID	M72_HD_V1.0

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0 Revision History

Revision	Date	Author	Description of change
V1.0	2011-02-22	Crystal He	Initial

1 Introduction

This document defines M72 module and describes the hardware interface of Quectel's M72 module that connects to the customer application and the air interface.

This document can help customers quickly understand module interface specifications, electrical and mechanical details. With the help of this document, associated application notes and user guide, customer can use M72 module to design and set up mobile applications quickly.

1.1 Related documents

Table 1: Related documents

SN	Document name	Remark
[1]	M72_ATC	AT command set
[2]	GSM_UART_AN	UART port application notes
[3]	GSM_FW_Upgrade_AN01	GSM Firmware upgrade application note
[4]	M72_EVB_UGD	M72 EVB user guide application notes

1.2 Terms and Abbreviations

Table 2: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
ARP	Antenna Reference Point
ASIC	Application Specific Integrated Circuit
BER	Bit Error Rate
BOM	Bill Of Material
BTS	Base Transceiver Station
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear To Send
DAC	Digital-to-Analog Converter
DRX	Discontinuous Reception
DSP	Digital Signal Processor
DCE	Data Communications Equipment (typically module)

Abbreviation	Description
DTE	Data Terminal Equipment (typically computer, external controller)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
Imax	Maximum Load Current
Inorm	Normal Current
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
MO	Mobile Originated
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
RX	Receive Direction
SIM	Subscriber Identification Module
SMS	Short Message Service
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter

Abbreviation	Description
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio
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

1.3 Safety caution

The following safety precautions must be observed during all phases of the operation, such as usage, service or repair of any cellular terminal or mobile incorporating M72 module. Manufactures of the cellular terminal should send the following safety information to users and operating personnel and to incorporate these guidelines into all manuals supplied with the product. If not so, Quectel does not take on any liability for customer failure to comply with these precautions.

When in a hospital or other health care facility, observe the restrictions about the use of mobile. Switch the cellular terminal or mobile off. Medical equipment may be sensitive to not operate normally for RF energy interference.

Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it switched off. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. Forget to think much of these instructions may lead to the flight safety or offend against local legal action, or both.

Do not operate the cellular terminal or mobile in the presence of flammable gas or fume. Switch off the cellular terminal when you are near petrol station, fuel depot, chemical plant or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmosphere 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 set, radio, computer or other electric equipment.

Road safety comes first! Do not use a hand-held cellular terminal or mobile while 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 signal and cellular network and cannot be guaranteed to connect in all conditions, for example no mobile fee or an invalid SIM card. While you are in this condition and need emergent help, Please Remember using emergency call. In order to make or receive call, 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 cellular terminal or mobile.

2 Product Concept

M72 is a Dual-band GSM/GPRS engine that works at frequencies GSM900MHz, DCS1800MHz. M72 features GPRS multi-slot class 12 and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. For more details about GPRS multi-slot classes and coding schemes, please refer to ***Appendix A.***

With a tiny profile of 27.5mm x 24mm x 3.6 mm, the module can meet almost all the requirements for data transfer applications.

M72 is an SMD type module, which can be embedded in customer application through its 30-pin pads. It provides all hardware interfaces between the module and customer's host board.

The module is designed with power saving technique so that the current consumption is as low as 0.9mA in SLEEP mode when DRX is 5.

M72 is integrated with protocols which are TCP/IP, PPP and UDP. Extended AT commands have been developed for customers to use these service protocols easily.

The modules are fully RoHS compliant to EU regulation.

Table 3: Module key features

Feature	Implementation
Power supply	Single supply voltage 3.4V ~ 4.5V
Power saving	Typical power consumption in SLEEP mode to 0.9 mA@ DRX=5 0.7 mA@ DRX=9
Frequency bands	● Dual-band: GSM900, DCS1800 ● The module can search these frequency bands automatically ● The frequency bands can be set by AT command ● Compliant to GSM Phase 2/2+
Transmitting power	● Class 4 (2W) at GSM900 ● Class 1 (1W) at DCS1800
GPRS connectivity	● GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● GPRS mobile station class B
Temperature range	● Normal operation: -35°C ~ +75°C ● Restricted operation: -40°C ~ -35°C and +75°C ~ +80°C [1)] ● Storage temperature: -45°C ~ +85°C
DATA GPRS:	● GPRS data downlink transfer: max. 85.6 kbps ● GPRS data uplink transfer: max. 85.6 kbps ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Support the protocols PAP (Password Authentication Protocol)

CSD:	usually used for PPP connections ● Internet service protocols TCP/UDP/PPP ● CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps non-transparent ● Unstructured Supplementary Services Data (USSD) support
SMS	● MT, MO, CB, Text and PDU mode ● SMS storage: SIM card
SIM interface	Support SIM card: 1.8V, 3V
Antenna interface	Connected via 50 Ohm antenna pad
Alarm function	Programmable via AT command
Physical characteristics	Size: 27.5±0.15 x 24±0.15 x 3.6±0.3mm Weight: 4.5g
Firmware upgrade	Firmware upgrade over Main Serial Port

1) When the module works in this temperature range, the deviations from the GSM specification might occur. For example, the frequency error or the phase error could increase.

Table 4: Coding schemes and maximum net data rates over air interface

Coding scheme	1 Timeslot	2 Timeslot	4 Timeslot
CS-1:	9.05kbps	18.1kbps	36.2kbps
CS-2:	13.4kbps	26.8kbps	53.6kbps
CS-3:	15.6kbps	31.2kbps	62.4kbps
CS-4:	21.4kbps	42.8kbps	85.6kbps

2.1 PIN assignment of the module

The following shows the pin assignment and interface definition of M72.

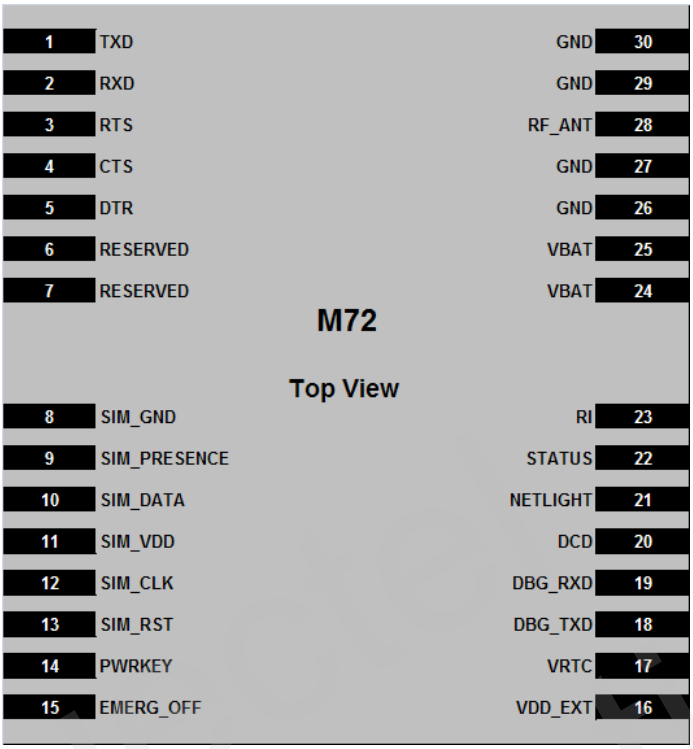


Figure 1: Pin assignment of M72

The following figure shows a block diagram of M72.

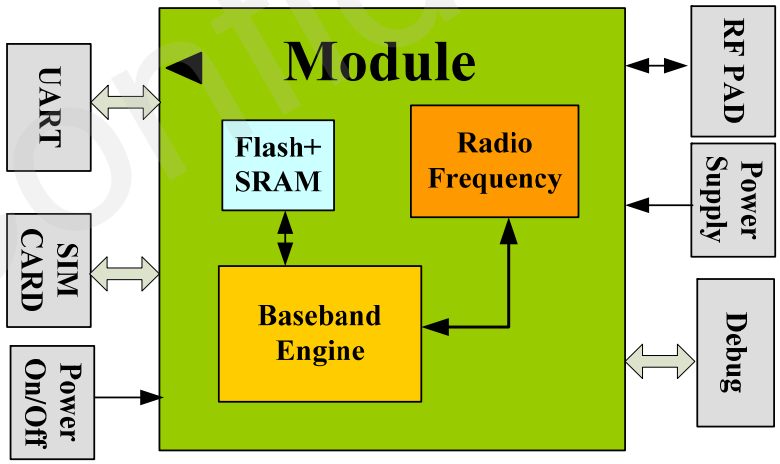


Figure 2: Module functional diagram

2.2 Evaluation board

In order to help customer on the application of M72, Quectel supplies an Evaluation Board (EVB) that hosts the module directly with appropriate power supply, SIM card holder, RS-232 serial interface, antenna and other peripherals to control or test the module. For details, please refer to the ***document [4].***

3 Module interface

The module is equipped with a 30-pin 1.3mm pitch SMT pad that connects to the cellular application platform. Sub-interfaces included in these pads are described in details in the following chapters:

- Power supply ***(refer to Chapter 3.3)***
- Serial interfaces ***(refer to Chapter 3.8)***
- SIM interface ***(refer to Chapter 3.9)***

Electrical and mechanical characteristics of the SMT pad are specified in ***Chapter 5&Chapter6.***

3.1 Pin description

Table 5: Pin description

Power supply					
PIN No.	PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
24,25	VBAT	I	Module main power supply VBAT=3.4V~4.5V	Vmax= 4.5V Vmin=3.4V Vnorm=4.0V	It must be able to provide sufficient current in a transmitting burst which typically rises to 1.6A.
17	VRTC	I/O	Power supply for RTC when VBAT is not supplied for the system. Charging for backup battery or a Large-capacitance Capacitor when the VBAT is supplied.	VImax=VBAT VImin=2.6V VInorm=2.75V VOmax=2.85V VOmin=2.6V VOnorm=2.75V Iout(max)= 730uA Iin=2.6~5 uA	Recommend to connect to a backup battery or a Large-capacitance Capacitor If unused, keep this pin open.
16	VDD_EXT	O	Supply 2.8V voltage for external circuit.	Vmax=2.9V Vmin=2.7V Vnorm=2.8V Imax=20mA	1. If unused, keep this pin open. 2. Recommend to add a 2.2~4.7uF bypass capacitor, when using this pin for power supply.
26,27,	GND		Digital ground		

29,30					
Power on or Power off					
PIN No.	PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
14	PWRKEY	I	Power on/off key. PWRKEY should be pulled down for a moment to turn on or turn off the system.	VILmax=0.3*VBAT VIHmin=0.7*VBAT VImax=VBAT	Pull up to VBAT Internally.
15	EMERG_ OFF	I	Emergency off. Pulled down for at least 20ms will turn off the module in case of emergency. Use it only when normal shutdown through PWRKEY or AT command can't perform well.	VILmax=0.4V VIHmin=2.2V V_{open}max=2.8V	Open drain/collector driver required in cellular device application. If unused, keep this pin open.
Module status indication					
PIN No.	PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
22	STATUS	O	Used to indicate module operating status. High level indicates module power-on and low level indicates power-down.	VOLmin=GND VOLmax=0.34V VOHmin=2.0V VOHmax= VDD_EXT	If unused, keep this pin open.
21	NETLIGHT	O	Network status indication		If unused, keep this pin open.
Main serial port/Debug port					
PIN No.	PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
5	DTR	I	Data terminal ready	VILmin=0V VILmax=0.67V VIHmin=1.7V VIHmax= VDD_EXT+0.3 VOLmin=GND VOLmax=0.34V VOHmin=2.0V VOHmax= VDD_EXT	If only use TXD, RXD and GND to communicate, recommend keeping other pins open.
2	RXD	I	Receiving data		
1	TXD	O	Transmitting data		
3	RTS	I	Request to send		
4	CTS	O	Clear to send		
23	RI	O	Ring indicator		
20	DCD	O	Data carrier detection		

18	DBG_TXD	O	Serial interface for debugging only.	VILmin=0V VILmax=0.67V VIHmin=1.7V VIHmax= VDD_EXT+0.3 VOLmin=GND VOLmax=0.34V VOHmin=2.0V VOHmax= VDD_EXT	If unused, keep this pin open.
19	DBG_RXD	I			
SIM interface					
PIN No.	PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
8	SIM_GND		Specified ground for SIM card		
11	SIM_VDD	O	Voltage supply for SIM card	The voltage can be selected by software automatically. Either 1.8V or 3V.	All signals of SIM interface should be protected against ESD with a Zener diode array. Maximum cable length from the module pad to SIM card holder is recommended no longer than 200mm.
10	SIM_DATA	I/O	SIM data, Pulled up to SIM_VDD through 10K resistor internally	VIHmin=0.7*SIM_VDD VOHmin=0.8*SIM_VDD VOLmax=0.4V When SIM_VDD=3V VILmax=0.4V When SIM_VDD=1.8V VILmax=0.2* SIM_VDD VOHmin=0.9*SIM_VDD When SIM_VDD=3V VOLmax=0.4V When SIM_VDD=1.8V VOLmax=0.2* SIM_VDD	
12	SIM_CLK	O	SIM clock		
13	SIM_RST	O	SIM reset		
9	SIM_ PRESENCE	I	SIM card detect	VILmax=0.67V VIHmin=1.7V	If unused, keep this pin open.
RF interface					
PIN No.	PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
28	RF_ANT	I/O	RF antenna pad	impedance of 50Ω	Refer to ***Chapter 4***

3.2 Operating modes

The table below briefly summarizes the various operating modes referred to in the following chapters.

Table 6: Overview of operating modes

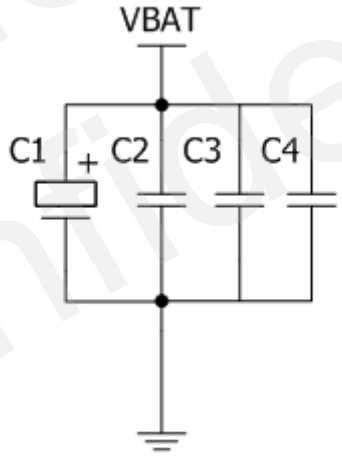
Mode	Function	
Normal operation	GSM/GPRS SLEEP	The module will automatically go into SLEEP mode if DTR is set to high level and there is no interrupt (such as GPIO interrupt or data on serial port). In this case, the current consumption of module will reduce to the minimal level. During SLEEP mode, the module can still receive paging message and SMS from the system normally.
	GSM IDLE	Software is active. The module has registered to the GSM network, and the module is ready to send and receive.
	GSM TALK	GSM connection is going. In this mode, the power consumption is decided by the configuration of Power Control Level (PCL), dynamic DTX control and the working RF band.
	GPRS IDLE	The module is not registered to GPRS network. The module is not reachable through GPRS channel.
	GPRS STANDBY	The module is registered to GPRS network, but no GPRS PDP context is active. The SGSN knows the Routing Area where the module is located at.
	GPRS READY	The PDP context is active, but no data transfer is going on. The module is ready to receive or send GPRS data. The SGSN knows the cell where the module is located at.
	GPRS DATA	There is GPRS data in transfer. In this mode, power consumption is decided by the PCL, working RF band and GPRS multi-slot configuration.
POWER DOWN	Normal shutdown by sending the 'AT+QPOWD=1' command, using the PWRKEY or using the EMERG_OFF[1)] pin. The power management ASIC disconnects the power supply from the base band part of the module, and only the power supply for the RTC is remained. Software is not active. The serial interfaces are not accessible. Operating voltage (connected to VBAT) remains applied.	
Minimum functionality mode (without removing power supply)	Use the 'AT+CFUN' command can set the module to a minimum functionality mode without removing the power supply. In this case, the RF part of the module will not work or the SIM card will not be accessible, or both RF part and SIM card will be closed all, but the serial port is still accessible. The power consumption in this case is very low.	

Alarm mode	RTC alert function launches this restricted operation while the module is in POWER DOWN mode. The module will not be registered to GSM network and only parts of AT commands can be available.

1) Use the EMERG_OFF pin only while failing to turn off the module by the command 'AT+QPOWD=1' and the ON/OFF pin. Please refer to ***Chapter 3.4.2.4.***

3.3 Power supply

The power supply of the module is from a single voltage source of VBAT= 3.4V~ 4.5V. The GSM transmitting burst can cause obvious voltage drop at the supply voltage thus the power supply must be carefully designed and is capable of providing sufficient current at least 1.6A. For the VBAT input, a bypass capacitor of about 100 μF with low ESR is recommended. Multi-layer ceramic chip (MLCC) capacitor can provide the best combination of low ESR and small size.Three ceramic capacitors (100nF, 10pF, 33pF, 0603 package size) are recommended to be applied to the VBAT pin.The capacitors should be placed close to the M72 VBAT pins. The following figure is the reference circuit of the VBAT pin.



C1>=100uF; C2=0.1uF~1uF; C3=10pF; C4=33pF

Figure 3: Reference circuit of the VBAT input

The circuit design of the power supply for the module largely depends on the power source. Figure 4 shows a reference design of +5V input power source. The designed output for the power supply is 4.16V, thus a linear regulator can be used. If there's a big voltage difference between the input source and the desired output (VBAT), a switching converter power supply would be preferable for its better efficiency. One thing needs to be noted here is that a 5.1V zener diode should be in parallel with the 100μF capacitor for a much more stable voltage. It can absorb the surge voltage.

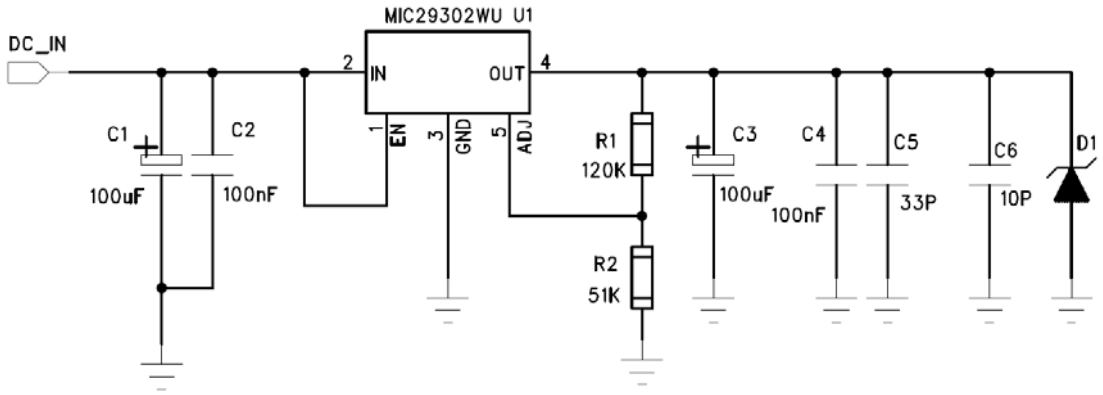


Figure 4: Reference circuit of the source power supply input

The RF Power Amplifier current (1.6A peak in GSM/GPRS mode) flows with a ratio of 1/8 of time, around 577us every 4.615ms, in talking mode. The following figure is the VBAT voltage and current ripple at the maximum power transmitting phase, the test condition is VBAT=4.16V, VBAT maximum output current =2A, C1=100μF tantalum capacitor (ESR=0.7Ω)

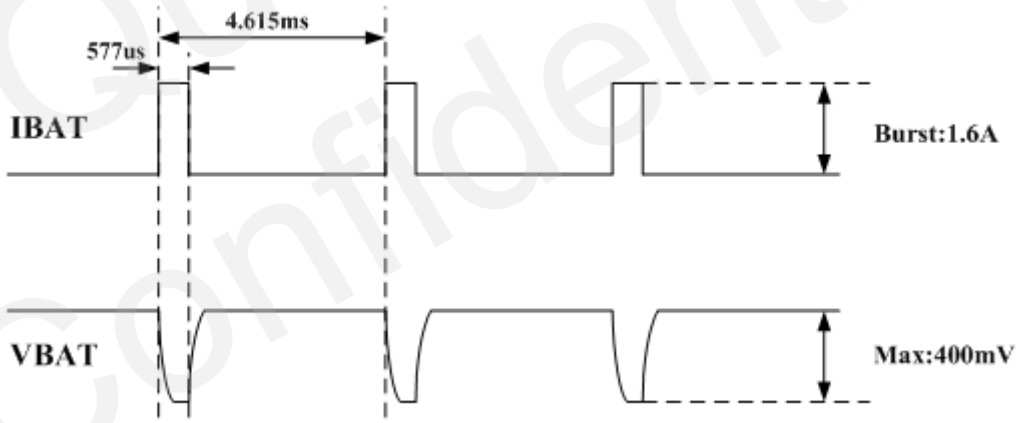


Figure 5: Ripple in supply voltage during transmitting burst

Please pay special attention to the power supply design for your applications. Please make sure that the input voltage will never drop below 3.4V even in a transmitting burst during which the current consumption may rise up to 1.6A. If the power voltage drops below 3.4V, the module could turn off automatically. The PCB traces from the VBAT pads to the power source must be wide enough to ensure that there is no too much voltage drop occurs in the transmitting burst mode. The width of trace should be no less than 2mm and the principle of the VBAT trace is the longer, the wider.

3.3.1 Power supply pins

The VBAT pins are dedicated to connect the module supply voltage. VRTC pin can be used to

connect a rechargeable coin battery or a Large-capacitance Capacitor which can help to maintain the system clock when VBAT supply is not applied.

3.3.2 Monitoring power supply

To monitor the supply voltage, you can use the 'AT+CBC' command which includes three parameters: charging status, remaining battery capacity and voltage value (in mV). It returns the 0-100 percent of battery capacity and actual value measured between VBAT and GND. The voltage is continuously measured at an interval depending on the operating mode. The displayed voltage (in mV) is averaged over the last measuring period before the 'AT+CBC' command is executed.

For details please refer to ***document [1]***

3.4 Power up and power down scenarios

3.4.1 Power on

The module can be turned on by various ways, which are described in following chapters:

- Via PWRKEY pin: start normal operating mode ***(please refer to chapter 3.4.1.1)*;**
- Via RTC interrupt: start ALARM modes ***(please refer to chapter 3.4.1.2)***

Note: The module is set to autobauding mode (AT+IPR=0) in default configuration. In the autobauding mode, the URC 'RDY' after powering on is not sent to host controller. AT command can be sent to the module 2-3 seconds after the module is powered on. Host controller should firstly send an 'AT' or 'at' string in order that the module can detect baud rate of host controller, and it should send the second or the third 'AT' or 'at' string until receiving 'OK' string from module. Then an 'AT+IPR=x;&W' should be sent to set a fixed baud rate for module and save the configuration to flash memory of module. After these configurations, the URC 'RDY' would be received from the Serial Port of module every time when the module is powered on. Refer to Chapter 'AT+IPR' in document [1].

3.4.1.1 Power on module using the PWRKEY pin

Customer's application can turn on the module by driving the pin PWRKEY to a low level voltage and after STATUS pin outputs a high level, PWRKEY pin can be released. Customer may monitor the level of the STATUS pin to judge whether the module is power-on or not. An open collector driver circuit is suggested to control the PWRKEY. A simple reference circuit is illustrated in Figure 6.

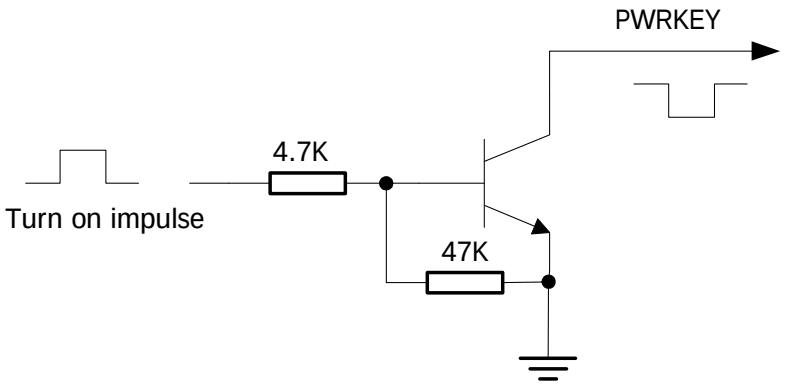


Figure 6: Turn on the module using driving circuit

The other way to control the PWRKEY is using a button directly. A TVS component is indispensable to be placed nearby the button for ESD protection. When pressing the key, electrostatic strike may generate from finger. A reference circuit is showed in Figure 7.

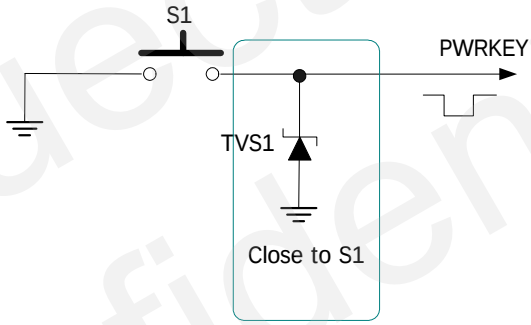


Figure 7: Turn on the module using keystroke

The power on scenarios is illustrated as following figure.

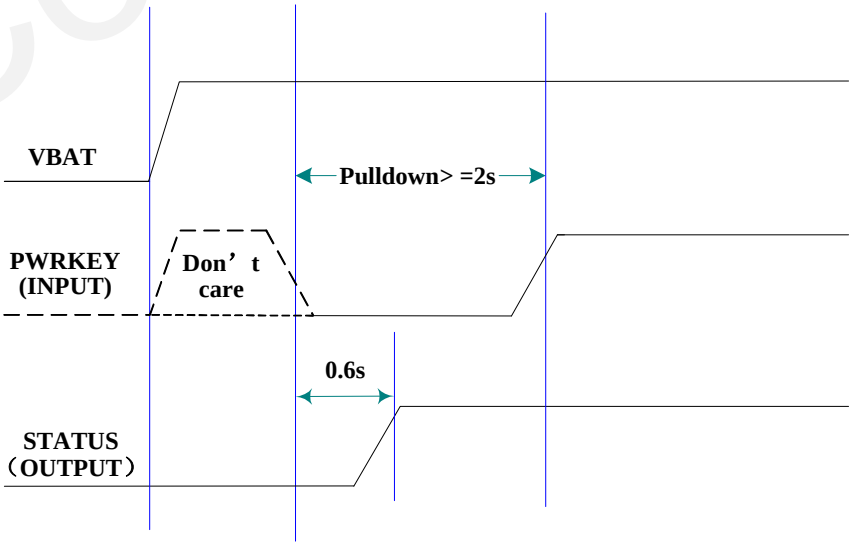


Figure 8: Timing of turn on system

Note: Customer can monitor the voltage level of the STATUS pin to judge whether the module

is power-on. After the STATUS pin goes to high level, PWRKEY may be released. If the STATUS pin is ignored, pull the PWRKEY pin to low level for more than 2 seconds to turn on the module.

3.4.1.2 Power on module using the RTC (Alarm mode)

Alarm mode is a power-on approach by using the RTC. The alert function of RTC can wake-up the module while it is in power-off state. In alarm mode, the module will not register to GSM network and the GSM protocol stack software is closed. Thus the part of AT commands related with SIM card and the protocol stack will not be accessible, and the others can be used.

Use the 'AT+QALARM' command to set the alarm time. The RTC remains the alarm time if the module is powered off by 'AT+QPOWD=1' or by PWRKEY pin. Once the alarm time is expired, the module will go into the alarm mode. In this case, the module will send out an Unsolicited Result Code (URC) when the baud rate of the Serial Port is set to fixed.

RDY

ALARM MODE

+CFUN:0

Note: This result code does not appear when autobauding is active because a valid baud rate is not available immediately after powering up the module. Therefore, the module is recommended to set to a fixed baud rate.

During alarm mode, use 'AT+CFUN' command to query the status of software protocol stack; it will return 0 which indicates that the protocol stack is closed. After 90 seconds, the module will power down automatically. However, if the GSM protocol stack is started by 'AT+CFUN=1' command during the alarm mode, the process of automatic power-off will not be executed. In alarm mode, driving the PWRKEY to a low level voltage for a period will cause the module to power down.

Table 7 briefly summarizes the AT commands that are frequently used during alarm mode, for details of these instructions please refer to ***document [1].***

Table 7: AT commands used in alarm mode

AT command	Function
AT+QALARM	Set alarm time
AT+CCLK	Set data and time of RTC
AT+QPOWD	Power down the module
AT+CFUN	Start or close the protocol stack

3.4.2 Power down

The following procedures can be used to turn off the module:

- Normal power down procedure: Turn off module using the PWRKEY pin
- Normal power down procedure: Turn off module using command 'AT+QPOWD'
- Over-voltage or under-voltage automatic shutdown: Take effect when over-voltage or under-voltage is detected
- Emergent power down procedure: Turn off module using the EMERG_OFF pin

3.4.2.1 Power down module using the PWRKEY pin

Customer's application can turn off the module by driving the PWRKEY to a low level voltage for certain time. The power-down scenario is illustrated as in Figure 9.

The power-down procedure causes the module to log off from the network and allows the software to save important data before completely disconnecting the power supply, thus it is a safe way.

Before the completion of the power-down procedure the module sends out the result code shown below:

NORMAL POWER DOWN

Note: This result code does not appear when autobauding is active and DTE and DCE are not correctly synchronized after start-up. The module is recommended to set a fixed baud rate.

After this moment, no further AT command can be executed. And then the module enters the POWER DOWN mode, only the RTC is still active. The POWER DOWN mode can also be indicated by the STATUS pin, which is a low level voltage in this mode.

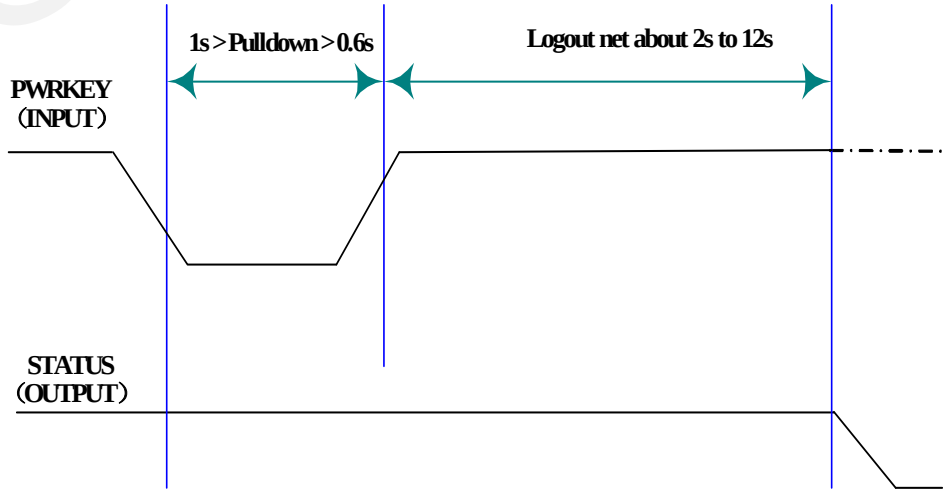


Figure 9: Timing of turn off the module

3.4.2.2 Power down module using AT command

Customer's application can use an AT command 'AT+QPOWD=1' to turn off the module. This command will let the module to log off from the network and allow the software to save important data before completely disconnecting the power supply, thus it is a safe way.

Before the completion of the power-down procedure the module sends out the result code shown below:

NORMAL POWER DOWN

After this moment, no further AT command can be executed. And then the module enters the POWER DOWN mode, only the RTC is still active. The POWER DOWN mode can also be indicated by STATUS pin, which is a low level voltage in this mode.

Please refer to ***document [1]*** for details about the AT command of 'AT+QPOWD'.

3.4.2.3 Over-voltage or under-voltage automatic shutdown

The module will constantly monitor the voltage applied on the VBAT, if the voltage ≤ 3.5V, the following URC will be presented:

UNDER_VOLTAGE WARNNING

If the voltage ≥ 4.5V, the following URC will be presented:

OVER_VOLTAGE WARNNING

The uncritical voltage range is 3.4V to 4.6V. If the voltage > 4.6V or <3.4V, the module would automatically shutdown itself.

If the voltage <3.4V, the following URC will be presented:

UNDER_VOLTAGE POWER DOWN

If the voltage >4.6V, the following URC will be presented:

OVER_VOLTAGE POWER DOWN

Note: These result codes don't appear when autobauding is active and DTE and DCE are not correctly synchronized after start-up. The module is recommended to set to a fixed baud rate.

After this moment, no further AT command can be executed. The module logoff from network and enters POWER DOWN mode, and only RTC is still active. The POWER DOWN mode can also be indicated by the pin STATUS, which is a low level voltage in this mode.

3.4.2.4 Emergency shutdown

The module can be shut down by driving the pin EMERG_OFF to a low level voltage for over 20ms and then releasing it. The EMERG_OFF line can be driven by an Open Drain/Collector driver or a button. The circuit is illustrated as the following figures.

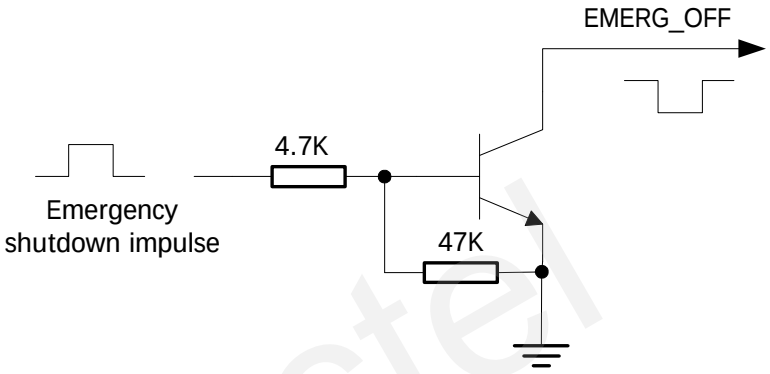


Figure 10: Reference circuit for EMERG_OFF by using driving circuit

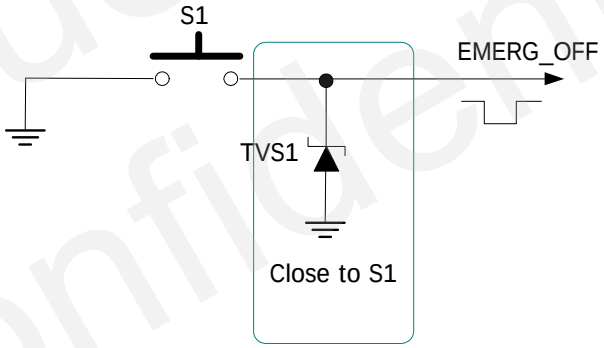


Figure 11: Reference circuit for EMERG_OFF by using button

Be cautious to use the pin EMERG_OFF. It should only be used under emergent situation. For instance, if the module is unresponsive or abnormal, the pin EMERG_OFF could be used to shutdown the system. Although turning off the module by EMERG_OFF is fully tested and nothing wrong detected, this operation is still a big risk as it could cause destroying of the code or data area of the NOR flash memory in the module. Therefore, it is recommended that PWRKEY or AT command should always be the preferential way to turn off the system.

3.4.3 Restart module using the PWRKEY pin

Customer's application can restart the module by driving the PWRKEY to a low level voltage for certain time, which is similar to the way to turn on module. Before restarting the module, at least 500ms should be delayed after detecting the low level of STATUS. The restart scenario is illustrated as the following figure.

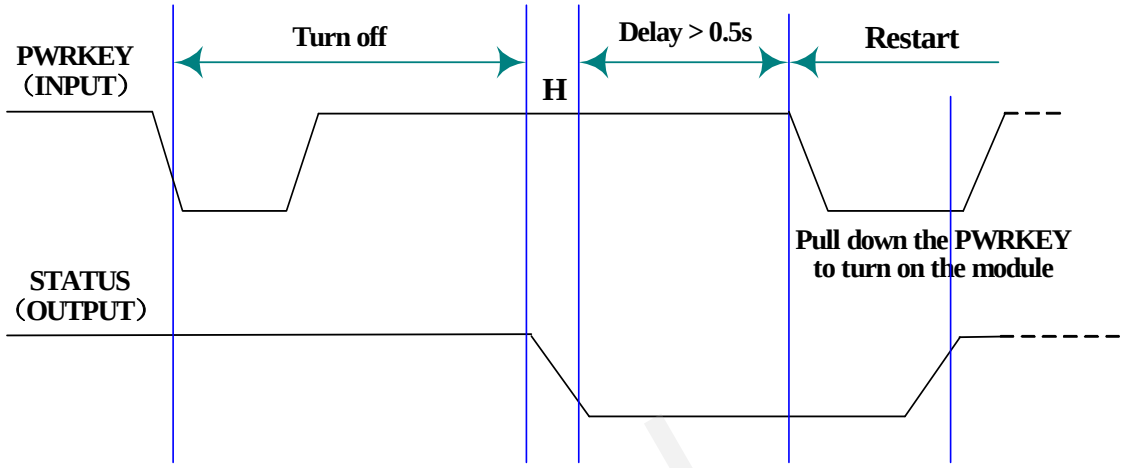


Figure 12: Timing of restart system

The module can also be restarted by the PWRKEY after emergency shutdown.

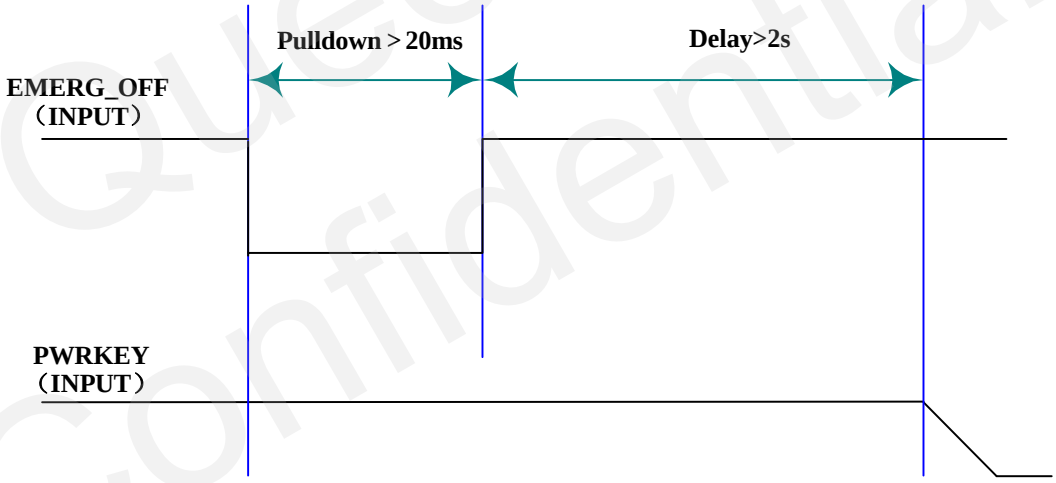


Figure 13: Timing of restart system after emergency shutdown

3.5 Power saving

Upon system requirement, there are several actions to drive the module to enter low current consumption status. For example, 'AT+CFUN' can be used to set module into minimum functionality mode and DTR hardware interface signal can be used to lead system to SLEEP mode.

3.5.1 Minimum functionality mode

Minimum functionality mode reduces the functionality of the module to minimum level, thus minimizes the current consumption when the slow clocking mode is activated at the same time.

This mode is set with the 'AT+CFUN' command which provides the choice of the functionality levels <fun>=0，1，4.

- 0: minimum functionality;
- 1: full functionality (default);
- 4: disable both transmitting and receiving of RF part;

If the module is set to minimum functionality by 'AT+CFUN=0', the RF function and SIM card function would be closed. In this case, the serial port is still accessible, but all AT commands correlative with RF function or SIM card function will not be accessible.

If the module has been set by 'AT+CFUN=4', the RF function will be closed, the serial port is still active. In this case, all AT commands correlative with RF function will not be accessible.

After the module is set by 'AT+CFUN=0' or 'AT+CFUN=4', it can return to full functionality by 'AT+CFUN=1'.

For detailed information about 'AT+CFUN', please refer to ***document [1].***

3.5.2 SLEEP mode (slow clock mode)

The SLEEP mode is disabled in default software configuration. Customer's application can enable this mode by 'AT+QSCLK=1'. On the other hand, the default setting is 'AT+QSCLK=0' and in this mode, the module can't enter SLEEP mode.

When 'AT+QSCLK=1' is set to the module, customer's application can control the module to enter or exit from the SLEEP mode through pin DTR. When DTR is set to high level, and there is no on-air or hardware interrupt such as GPIO interrupt or data on serial port, the module will enter SLEEP mode automatically. In this mode, the module can still receive voice, SMS or GPRS paging from network but the serial port is not accessible.

3.5.3 Wake up module from SLEEP mode

When the module is in the SLEEP mode, the following methods can wake up the module.

- If the DTR Pin is pulled down to a low level, it would wake up the module from the SLEEP mode. The serial port will be active about 20ms after DTR changed to low level.
- Receiving a voice or data call from network to wake up module.
- Receiving an SMS from network to wake up module.
- RTC alarm expired to wake up module.

Note: DTR pin should be held low level during communicating between the module and DTE.

3.6 Summary of state transitions (except SLEEP mode)

Table 8: Summary of state transition

Current mode	Next mode		
	POWER DOWN	**Normal mode**	**Alarm mode**
POWER DOWN		Use PWRKEY	Turn on the module by RTC alarm
Normal mode	AT+QPOWD, use PWRKEY pin, or use EMERG_OFF pin		Set alarm by 'AT+QALARM', and then turn off the module. When the timer expires, the module turns on automatically and enters Alarm mode.
Alarm mode	Use PWRKEY pin or wait module turning off automatically	Use AT+CFUN	

3.7 RTC backup

The RTC (Real Time Clock) can be supplied by an external capacitor or battery (rechargeable or non-chargeable) through the pin VRTC. A 3.9 K resistor has been integrated in the module for current limiting. A coin-cell battery or a Large-capacitance Capacitor can be used to backup power supply for RTC.

The following figures show various sample circuits for RTC backup.

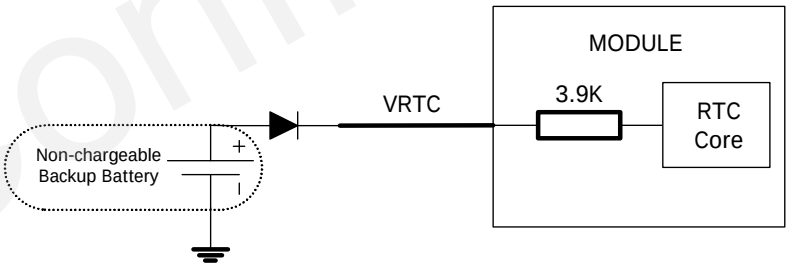


Figure 14: RTC supply from non-chargeable battery

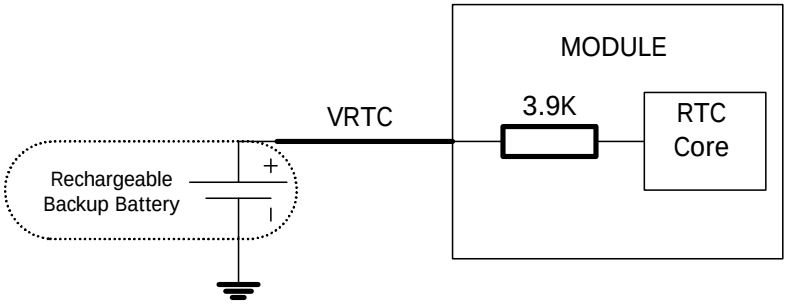


Figure 15: RTC supply from rechargeable battery

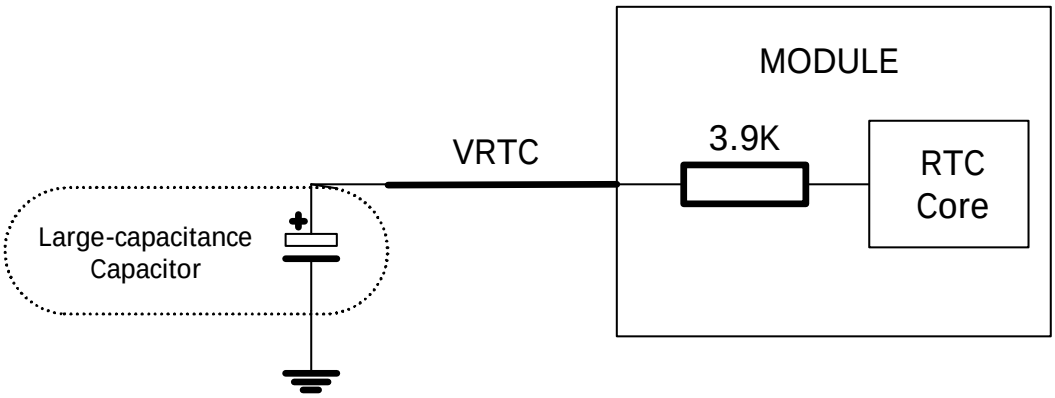


Figure 16: RTC supply from capacitor

Coin-type rechargeable capacitor such as XH414H-IV01E from Seiko can be used.

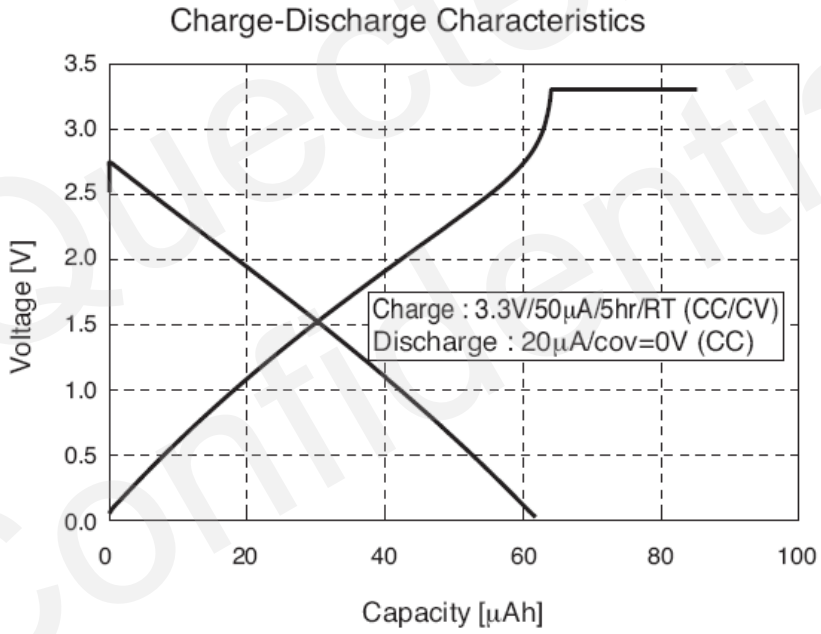


Figure 17: Seiko XH414H-IV01E Charge Characteristic

3.8 Serial interfaces

The module provides two unbalanced asynchronous serial ports including Main Serial Port and Debug Port.The module is designed as a DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. Autobauding function supports baud rate from 4800bps to 115200bps.

The Main Serial Port

- TXD: Send data to RXD of DTE
- RXD: Receive data from TXD of DTE

When hardware flow control is required, RTS and CTS should be connected. The module supports hardware flow control in default. When the module is used as a modem, DCD and RI should be connected. Furthermore, RI could indicate the host controller when an event happens such as an incoming voice call, a URC data export.

The Debug Port:

- DBG_TXD: Send data to the COM port of a debugging DTE
- DBG_RXD: Receive data from the COM port of a debugging DTE

The logic levels are described in the following table.

Table 9: Logic levels of the serial interface

Parameter	Min	Max	Unit
V_{IL}	0	0.67	V
V_{IH}	1.67	VDD_EXT +0.3	V
V_{OL}	GND	0.34	V
V_{OH}	2.0	VDD_EXT	V

Table 10: Pin definition of the serial interfaces

Interface	Name	Pin	Function
Debug Port	DBG_RXD	18	Receive data of the debug port
	DBG_TXD	19	Transmit data of the debug port
Main Serial Port	RI	23	Ring indicator
	RTS	3	Request to send
	CTS	4	Clear to send
	RXD	2	Receiving data of the serial port
	TXD	1	Transmitting data of the serial port
	DTR	5	Data terminal ready
	DCD	20	Data carrier detection

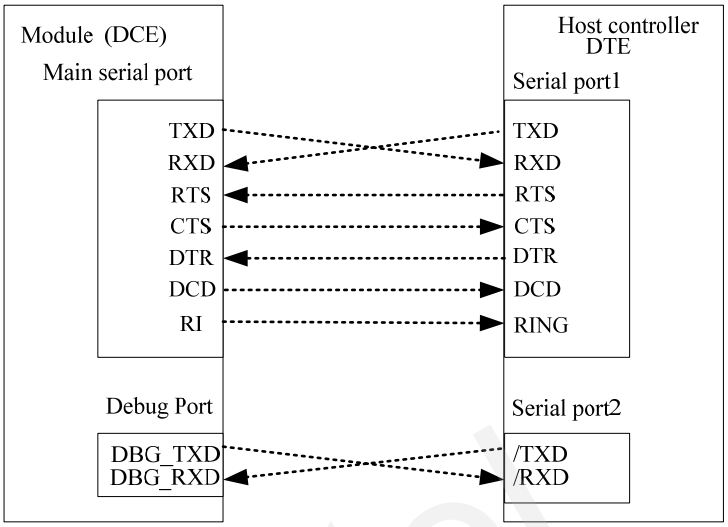


Figure 18: Connection of serial interfaces

3.8.1 Feature of serial interfaces

Main Serial Port:

- Seven lines on serial interface.
- Contain data lines TXD and RXD, hardware flow control lines RTS and CTS, other control lines DTR, DCD and RI.For more details about RI signal, please refer to Chapter 3.10.
- Used for AT command, GPRS data, CSD FAX, etc. Multiplexing function is supported on the Serial Port. So far only the basic mode of multiplexing is available.
- Support the communication baud rates as the following:
  75,150,300,600,1200,2400,4800,9600,14400,19200,28800,38400,57600,115200.
  The default setting is autobauding mode. Support the following baud rates for Autobauding function: 4800, 9600, 19200, 38400, 57600, 115200bps.

After setting a fixed baud rate or Autobauding, please send ‘AT’ string at that rate, the serial port is ready when it responds ‘OK’.

Autobauding allows the module to automatically detect the baud rate of the string ‘AT’ or ‘at’ sent by the host controller, which gives the flexibility to put the module into operation without considering which baud rate is used by the host controller. Autobauding is enabled in default. To take advantage of the autobauding mode, special attention should be paid to the following requirements:

Synchronization between DTE and DCE:
When DCE (the module) powers on with the autobauding enabled, it is recommended to wait 2 to 3 seconds before sending the first AT character. After receiving the 'OK’ response, DTE and DCE are correctly synchronized.

If the host controller needs URC in the mode of autobauding, it must be synchronized firstly.

Otherwise the URC will be discarded.

Restrictions on autobauding operation

- The serial port has to be operated at 8 data bits, no parity and 1 stop bit (factory setting).
- The A/ and a/ commands can't be used.
- Only the strings 'AT' or 'at' can be detected (neither 'At' nor 'aT').
- The Unsolicited Result Codes like 'RDY', '+CFUN: 1' and '+CPIN: READY' will not be indicated when the module is turned on with autobauding enabled and not be synchronized.
- Any other Unsolicited Result Codes will be sent at the previous baud rate before the module detects the new baud rate by receiving the first 'AT' or 'at' string. The DTE may receive unknown characters after switching to new baud rate.
- It is not recommended to switch to autobauding from a fixed baud rate.
- If autobauding is active it is not recommended to switch to multiplex mode

Note: To assure reliable communication and avoid any problems caused by undetermined baud rate between DCE and DTE, it is strongly recommended to configure a fixed baud rate and save instead of using autobauding after start-up. For more details, please refer to Chapter 'AT+IPR' in document [1].

Debug Port

- Two lines: DBG_TXD and DBG_RXD
- Debug Port is only used for software debugging and its baud rate must be configured as 460800bps.

3.8.2 Software upgrade and software debug

- The TXD、RXD can be used to upgrade software. The PWRKEY pin must be pulled down during the software upgrade process. Please refer to the following figures for software upgrade.

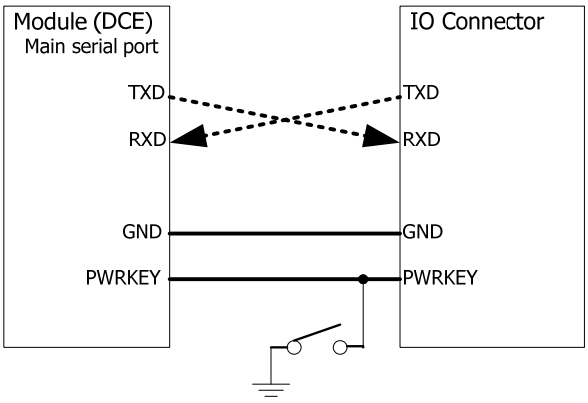


Figure 19: Connection of software upgrade

Note: To help upgrade firmware in the host board system, Quectel develops a special upgrade fixture and release an upgrade design application document. For more details, please refer to document [3].

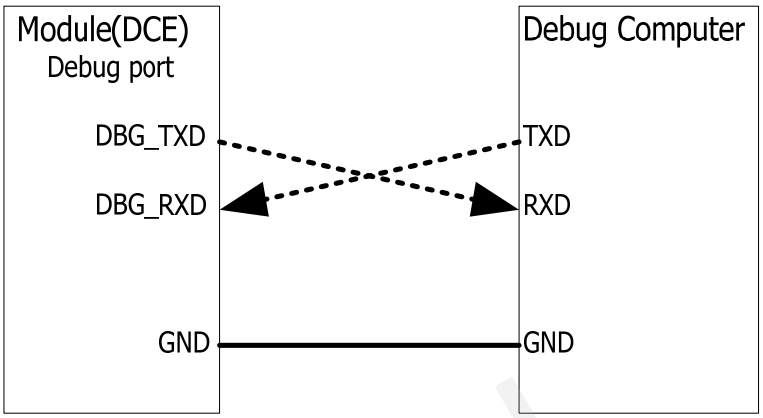


Figure 20: Connection of software debug

The main serial port and the debug port don't support the RS_232 level, but only support the CMOS level. A RS_232 level shifter IC or circuit must be inserted between module and PC. ***Figure 21*** shows a reference level shifter circuit when the module is connected to a PC.

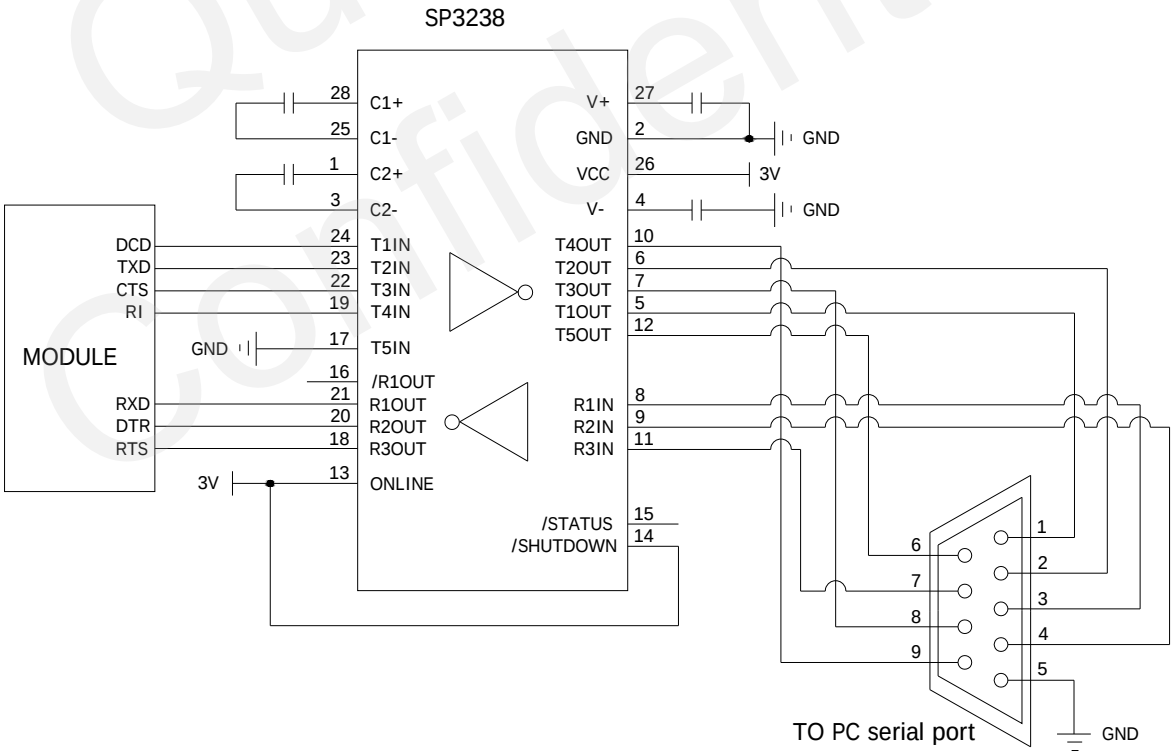


Figure 21: RS232 level converter circuit

Note 1：For details information about serial port application, please refer to document [2]

3.9 SIM card interface

3.9.1 SIM card application

The SIM interface supports the functionality of the GSM Phase 1 specification and also supports the functionality of the new GSM Phase 2+ specification for FAST 64 kbps SIM card, which is intended for use with a SIM application Tool-kit.

The SIM interface is powered from an internal regulator in the module. Both 1.8V and 3.0V SIM Cards are supported.

Table 11: Pin definition of the SIM interface

Name	Pin	Function
SIM_VDD	11	Supply power for SIM Card. Automatic detection of SIM card voltage. 3.0V±10% and 1.8V±10%. Maximum supply current is around 10mA.
SIM_DATA	10	SIM Card data I/O
SIM_CLK	12	SIM Card Clock
SIM_PRESENCE	9	SIM Card Presence
SIM_RST	13	SIM Card Reset
SIM_GND	8	SIM Card Ground

Figure 22 is the reference circuit for SIM interface, and here an 8-pin SIM card holder is used. In order to offer good ESD protection, it is recommended to add TVS such as ST (www.st.com) ESDA6V1W5 or ON SEMI (www.onsemi.com) SMF05C. The 22Ω resistors should be added in series between the module and the SIM card so as to suppress the EMI spurious transmission and enhance the ESD protection. Note that the SIM peripheral circuit should be close to the SIM card socket.

To avoid possible cross-talk from the SIM_CLK signal to the SIM_DATA signal be careful that both lines are not placed closely next to each other. A useful approach is to use GND line to shield the SIM_DATA line from the SIM_CLK line.

The pin SIM_PRESENCE is used to detect whether the tray of the Molex SIM socket, which is used for holding SIM card, is present in the card socket. When the tray is inserted in the socket, SIM_PRESENCE is at low level. Regardless of whether the SIM card is in the tray or not, the change of SIM_PRESENCE level from high to low level inspires the module to reinitialize SIM card. In default configuration, SIM card detection function is disabled. Customer's application can use 'AT+QSIMDET=1, 0' to switch on and 'AT+QSIMDET=0, 0' to switch off the SIM card detection function. For details of this AT command, please refer to ***document [1]***. When 'AT+QSIMDET=1, 0' is set and the tray with SIM card is removed from SIM socket, the

following URC will be presented.

+CPIN: NOT READY

When the tray with SIM card is inserted into SIM socket again and the module finishes re-initialization SIM card, the following URC will be presented.

Call Ready

Reference circuits of the 6 pins and 8pins SIM card show below:

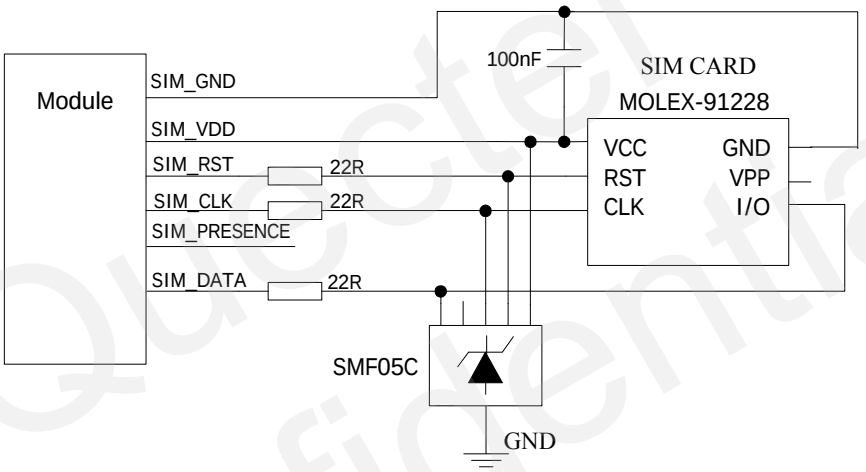


Figure 22: Reference circuit of the 6 pins SIM card

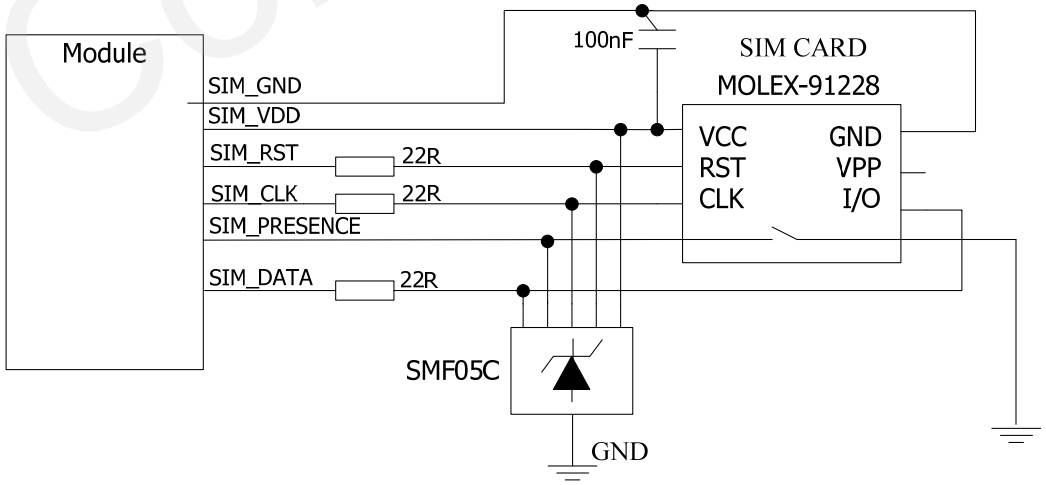


Figure 23: Reference circuit of the 8 pins SIM card

Note: Please do not use 'AT+QSIMDET=1, 1'to enable when Figure23 circuit is adopted.

3.9.2 Design considerations for SIM card holder

For 6-pin SIM card holder, it is recommended to use Amphenol C707 10M006 512 2. Please visit http://www.amphenol.com for more information.

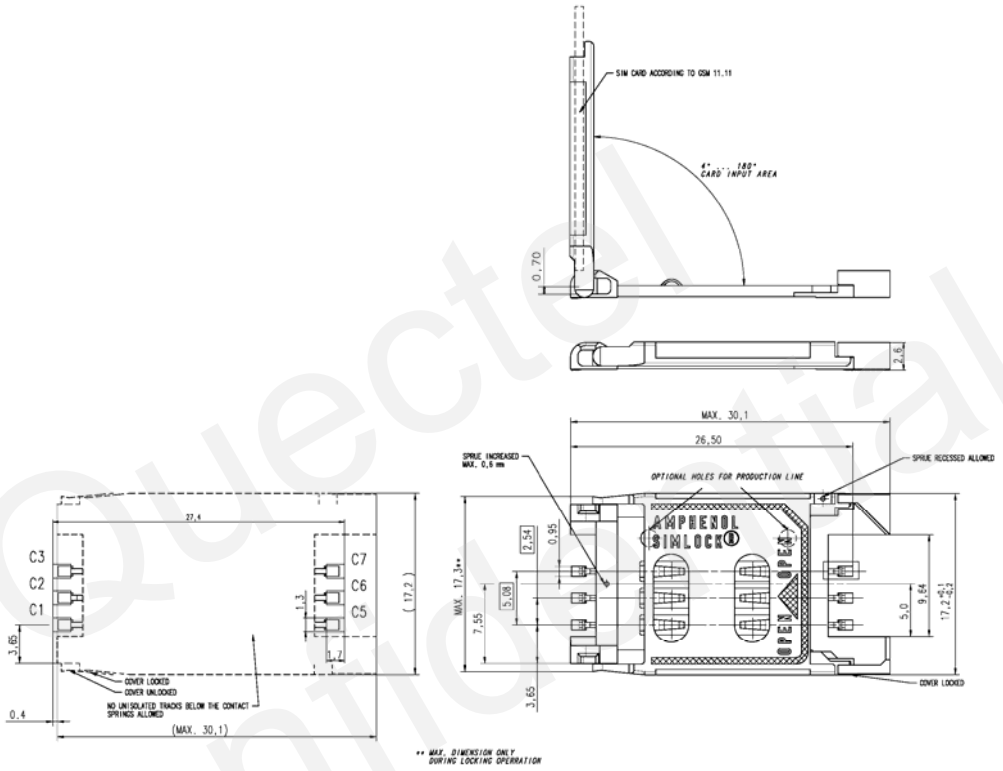


Figure 24: Amphenol C707 10M006 512 2 SIM card holder

Table 12: Pin description of Amphenol SIM card holder

Name	Pin	Function
SIM_VDD	C1	SIM Card Power supply
SIM_RST	C2	SIM Card Reset
SIM_CLK	C3	SIM Card Clock
GND	C5	Ground
VPP	C6	Not Connect
SIM_DATA	C7	SIM Card data I/O

For 8-pin SIM card holder, it is recommended to use Molex 91228. Please visit http://www.molex.com for more information.

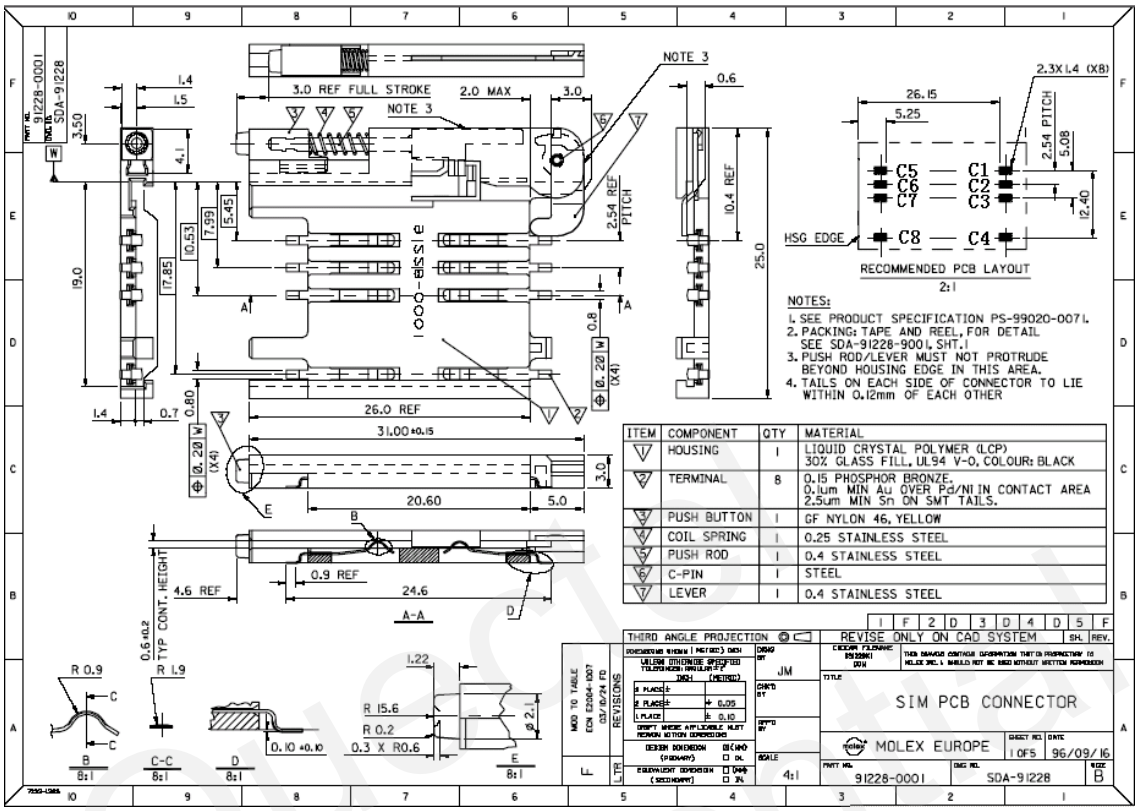


Figure 25: Molex 91228 SIM card holder

Table 13: Pin description of Molex SIM card holder

Name	Pin	Function
SIM_VDD	C1	SIM Card Power supply
SIM_RST	C2	SIM Card Reset
SIM_CLK	C3	SIM Card Clock
SIM_PRESENCE	C4	SIM Card Presence Detection
GND	C5	Ground
VPP	C6	Not Connect
SIM_DATA	C7	SIM Card Data I/O
SIM_DETECT	C8	Pulled down GND with external circuit. When the tray is present, C4 is connected to C8.

3.10 Behaviors of the RI

Table 14: Behaviors of the RI

State	RI respond
Standby	HIGH
Voice calling	Change to LOW, then: （1）Change to HIGH when call is established. （2）Use ATH to hang up the call, change to HIGH. （3）Calling part hangs up, change to HIGH first, and change to LOW for 120ms indicating 'NO CARRIER' as an URC, then change to HIGH again. （4）Change to HIGH when SMS is received.
Data calling	Change to LOW, then： （1）Change to HIGH when data connection is established. （2）Use ATH to hang up the data calling, change to HIGH. （3）Calling part hangs up, change to HIGH first, and change to LOW for 120ms indicating 'NO CARRIER' as an URC, then change to HIGH again. （4）Change to HIGH when SMS is received.
SMS	When a new SMS comes, The RI changes to LOW and holds low level for about 120 ms, then changes to HIGH.
URC	Certain URCs can trigger 120ms low level on RI. For more details, please refer to the ***document [2]***

If the module is used as a caller, the RI would maintain high except the URC or SMS is received. On the other hand, when it is used as a receiver, the timing of the RI is shown below.

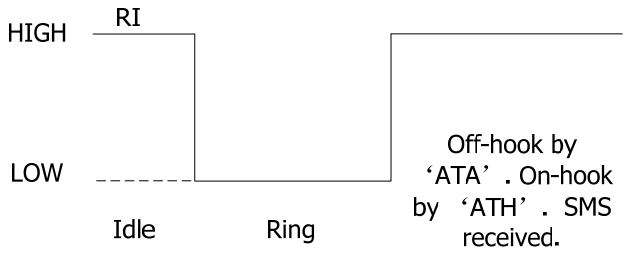


Figure 26: RI behaviours of voice calling as a receiver

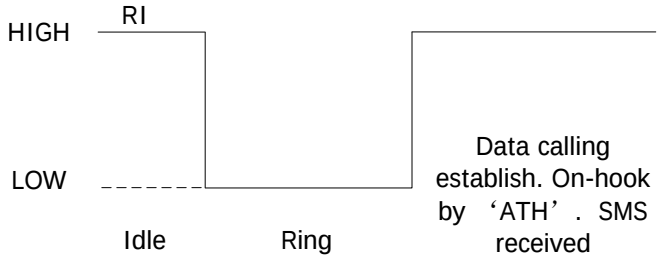


Figure 27: RI behaviour of data calling as a receiver

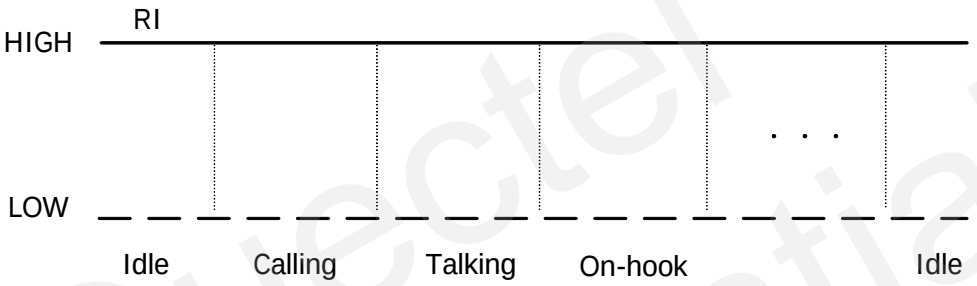


Figure 28: RI behaviours as a caller

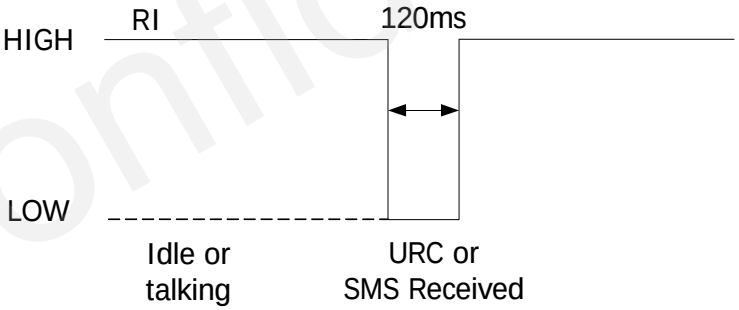


Figure 29: RI behaviours of URC or SMS received

3.11 Network status indication

The NETLIGHT signal can be used to drive a network status indication LED. The working state of this pin is listed in Table 15.

Table 15: Working state of the NETLIGHT

State	Module function
Off	The module is not running.
64ms On/ 800ms Off	The module is not synchronized with network.
64ms On/ 2000ms Off	The module is synchronized with network.
64ms On/ 600ms Off	GPRS data transfer is ongoing.

A reference circuit is shown in ***Figure 30***

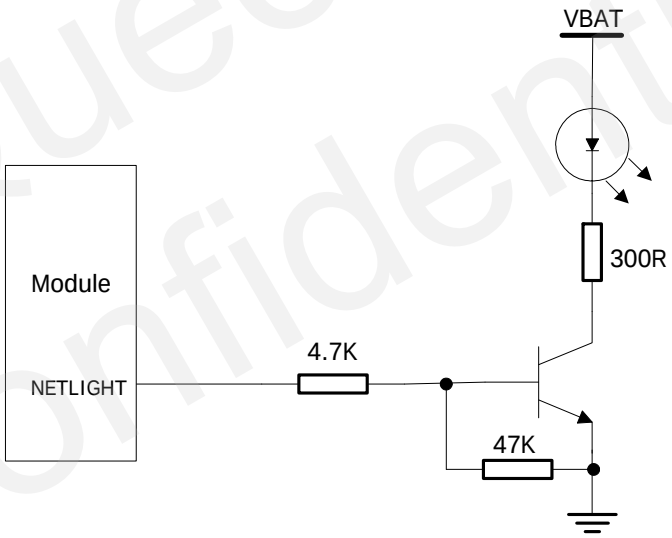


Figure 30: Reference circuit of the NETLIGHT

3.12 Operating status indication

The STATUS pin is set as an output pin and can be used to judge whether module is power-on, please refer to ***Chapter 3.4.*** In customer design, this pin can be connected to a GPIO of DTE or be used to drive an LED in order to judge module operation status. A reference circuit is shown in Figure 31.

Table 16: Pin definition of the STATUS

Name	Pin	Function
STATUS	22	Indication of module operating status

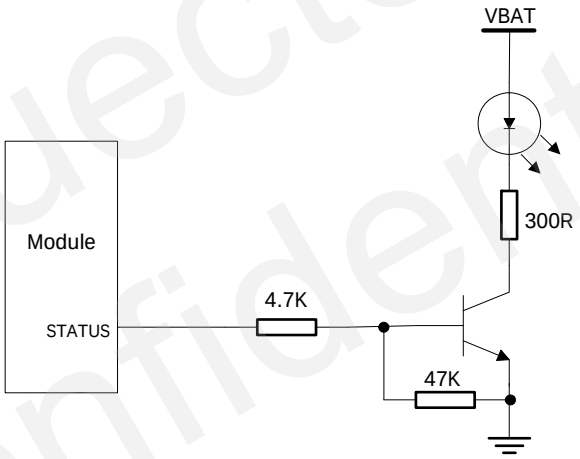


Figure 31: Reference circuit of the STATUS

4 Antenna interface

The Pin 28 is the RF antenna pad. The RF interface has an impedance of 50Ω.

4.1 Antenna installation

M72 provides an RF antenna PAD for customer's antenna connection. The RF trace in host PCB connecting to the module RF antenna pad should be micro-strip line or other types of RF trace, whose characteristic resistance should be close to 50Ω. M72 comes with 2 grounding pads which are next to the antenna pad in order to give a better grounding.

Table 17: Pin definition of the RF_ANT

Name	Pin	Function
GND	26	Ground
GND	27	Ground
RF_ANT	28	RF antenna pad
GND	29	Ground
GND	30	Ground

To minimize the loss on the RF trace and RF cable, they should be designed carefully. It is recommended that the insertion loss should try to meet the following requirements:

- EGSM900<1dB
- DCS1800<1.5dB

4.2 RF output power

Table 18: The module conducted RF output power

Frequency	Max	Min
EGSM900	33dBm ±2dB	5dBm±5dB
DCS1800	30dBm ±2dB	0dBm±5dB

Note: In GPRS 4 slots TX mode, the max output power is reduced by 2.5dB. This design conforms to the GSM specification as described in chapter 13.16 of 3GPP TS 51.010-1.

4.3 RF receiving sensitivity

Table 19: The module conducted RF receiving sensitivity

Frequency	Receive sensitivity
EGSM900	< -108.5dBm
DCS1800	< -108dBm

4.4 Operating frequencies

Table 20: The module operating frequencies

Frequency	Receive	Transmit	ARFCH
EGSM900	925~960MHz	880~915MHz	0~124, 975~1023
DCS1800	1805~1880MHz	1710~1785MHz	512~885

4.5 Recommendation of RF pad welding

If external antenna is connected with RF cable welded on the RF pads, please refer to Figure 32. Any incorrect welding type may cause poor performance both in transmitting power and receiving sensitivity.

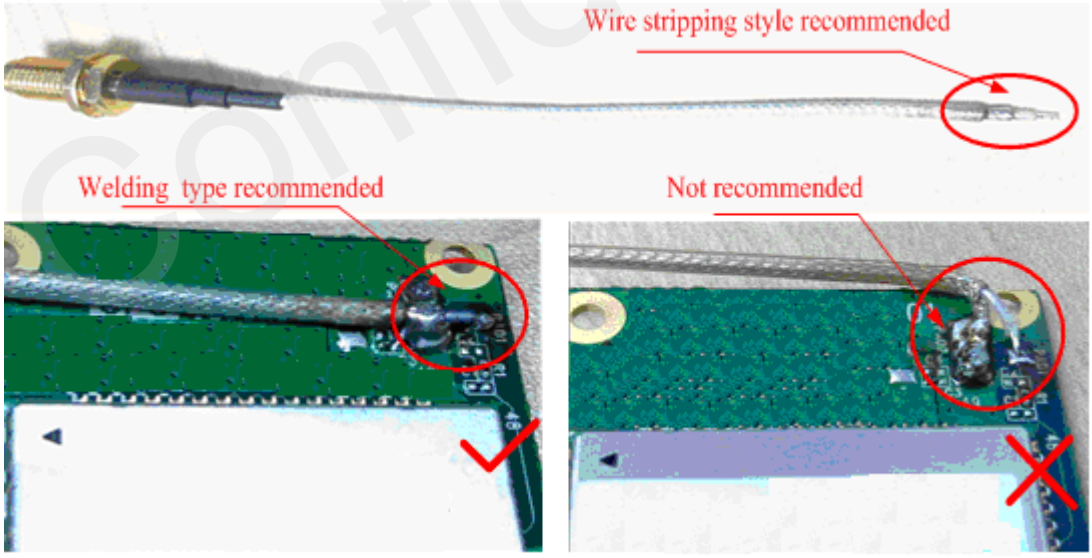


Figure 32: Recommendation of RF pad welding

5 Electrical, reliability

5.1 Absolute maximum ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of module are listed in the following table:

Table 21: Absolute maximum ratings

Parameter	Min	Max	Unit
VBAT	0	4.7	V
Peak current of power supply	0	2	A
RMS current of power supply (during one TDMA- frame)	0	0.7	A
Voltage at digital pins	-0.3	3.3	V
Voltage at analog pins	-0.3	3.0	V
Voltage at digital/analog pins in POWER DOWN mode	-0.25	0.25	V

5.2 Operating temperature

The operating temperature is listed in the following table:

Table 22: Operating temperature

Parameter	Min	Typ	Max	Unit
Normal temperature	-35	+25	+75	℃
Restricted operation[1)]	-40 to -35		+75 to+ 80	℃
Storage temperature	-45		+90	℃

[1)] When the module works in this temperature range, the deviations from the GSM specification may occur. For example, the frequency error or the phase error could increase.

5.3 Power supply ratings

Table 23: The module power supply ratings

Parameter	Description	Conditions	Min	Typ	Max	Unit
VBAT	Supply voltage	Voltage must stay within the min/max values, including voltage drop, ripple, and spikes.	3.4	4.0	4.5	V

	Voltage drop during transmitting burst	Maximum power control level on GSM900			400	mV
	Voltage ripple	Maximum power control level on GSM900 @ f<200kHz @ f>200kHz			 50 2	 mV mV
I_{VBAT}	Average supply current	POWER DOWN mode SLEEP mode @ DRX=5		65 0.9		uA mA
		Minimum functionality mode AT+CFUN=0 IDLE mode SLEEP mode AT+CFUN=4 IDLE mode SLEEP mode		 12 500 15 600		 mA uA mA uA
		IDLE mode EGSM 900 DCS1800		 12 12		 mA mA
		DATA mode, GPRS (3 Rx,2Tx) EGSM 900[1)] DCS1800[2)]		 390 320		 mA mA
		DATA mode, GPRS(2 Rx,3Tx) EGSM 900[1)] DCS1800[2)]		 500 400		 mA mA
		DATA mode, GPRS (4 Rx,1Tx) EGSM 900[1)] DCS1800[2)]		 260 220		 mA mA
		DATA mode, GPRS (1Rx,4Tx) EGSM 900[1)] DCS1800[2)]		 500 400		 mA mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM900		1.6	2	A

[1)] Power control level PCL 5

[2)] Power control level PCL 0

Note: GPRS Class 12 is the default setting. The module can be configured from GPRS Class 1 to Class 12 by 'AT+QGPCLASS'. Setting to lower GPRS class would make it easier to design the power supply for the module.

5.4 Electro-static discharge

Although the GSM engine is generally protected against Electrostatic Discharge (ESD), ESD protection precautions should still be emphasized. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any applications using the module.

The measured ESD values of module are shown as the following table:

Table 24: The ESD endurance (Temperature: 25℃, Humidity: 45 %)

Tested point	Contact discharge	Air discharge
VBAT,GND	±5KV	±10KV
RF_ANT	±5KV	±10KV

6 Mechanical dimension

This chapter describes the mechanical dimensions of the module.

6.1 Mechanical dimensions of module

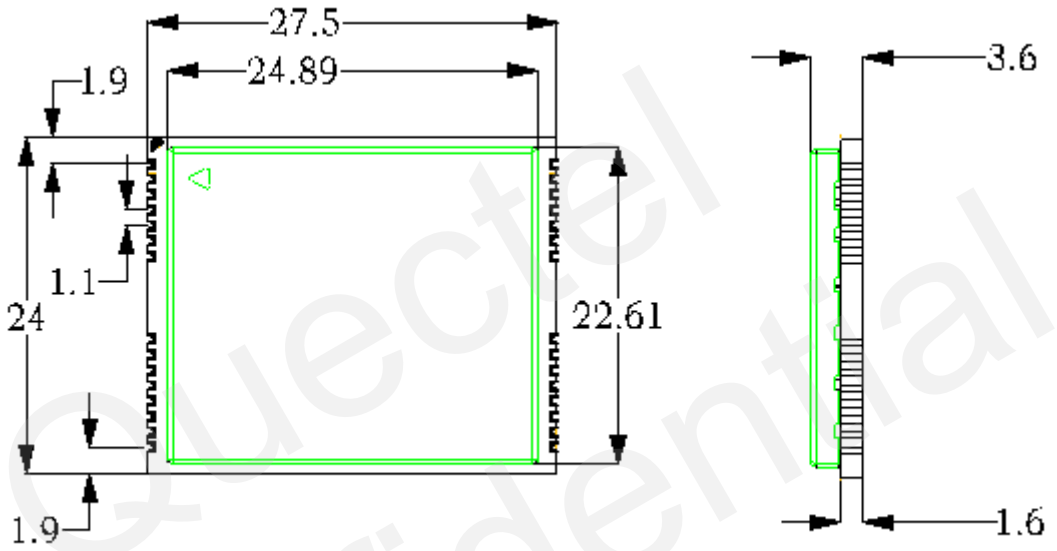


Figure 33: M72 top and side dimensions（Unit: mm）

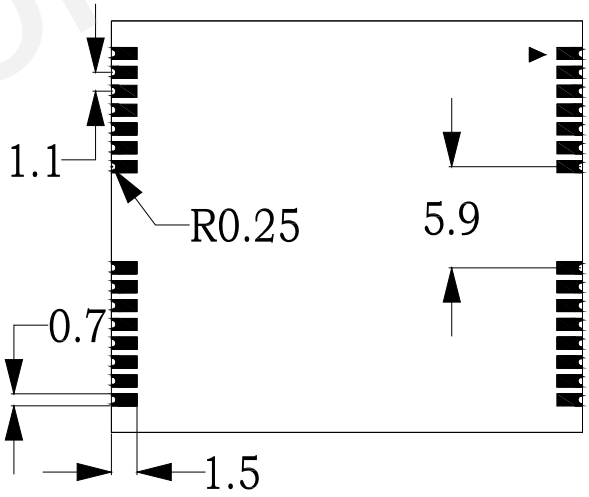


Figure 34: M72 bottom dimensions（Unit: mm）

6.2 Footprint of recommendation

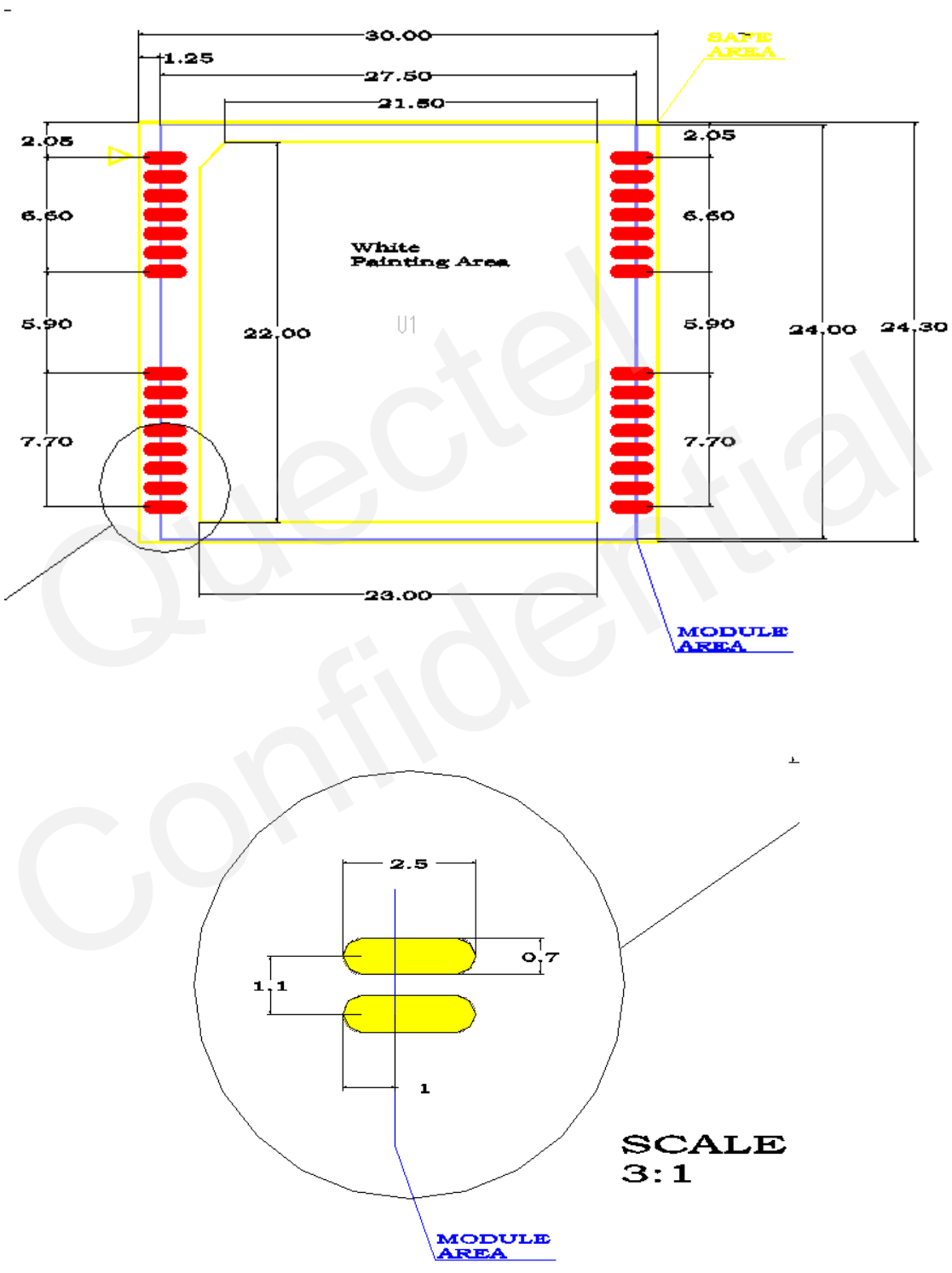


Figure 35: Footprint of recommendation（Unit: mm）

6.3 Top view of the module

Figure 36: Top view of the module

6.4 Bottom view of the module

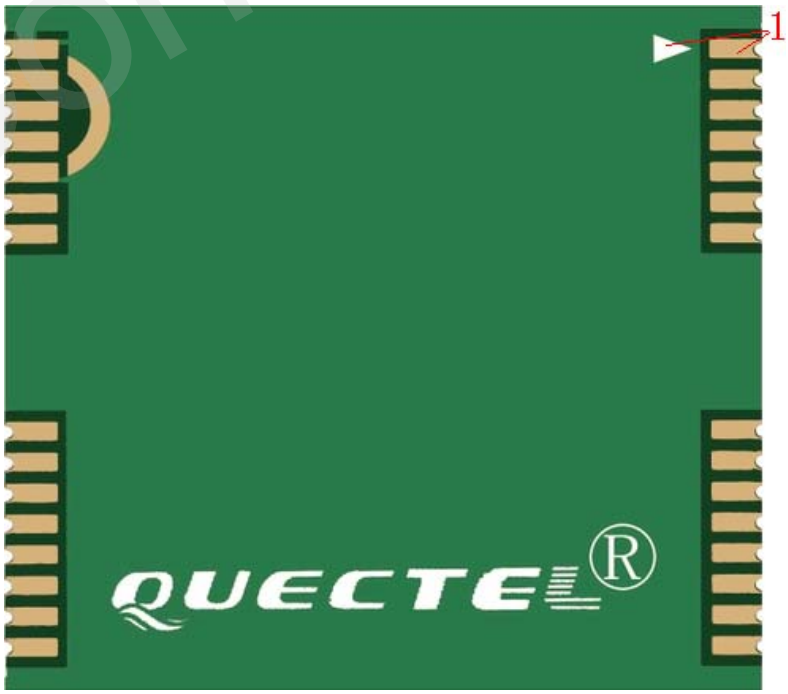


Figure 37: Bottom view of the module

Appendix A: GPRS multi-slot classes

Twenty-nine classes of GPRS multi-slot modes are defined for MS in GPRS specification. Multi-slot classes are product dependant, and determine the maximum achievable data rates in both the uplink and downlink directions. Written as 3+1 or 2+2, the first number indicates the amount of downlink timeslots, while the second number indicates the amount of uplink timeslots. The active slots determine the total number of slots the GPRS device can use simultaneously for both uplink and downlink communications. The description of different multi-slot classes is shown in Table 25.

Table 25: GPRS multi-slot classes

Multislot class	Downlink slots	Uplink slots	Active slots
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
9	3	2	5
10	4	2	5
11	4	3	5
12	4	4	5
13	3	3	NA
14	4	4	NA
15	5	5	NA
16	6	6	NA
17	7	7	NA
18	8	8	NA
19	6	2	NA
20	6	3	NA
21	6	4	NA
22	6	4	NA
23	6	6	NA
24	8	2	NA
25	8	3	NA
26	8	4	NA
27	8	4	NA
28	8	6	NA
29	8	8	NA

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