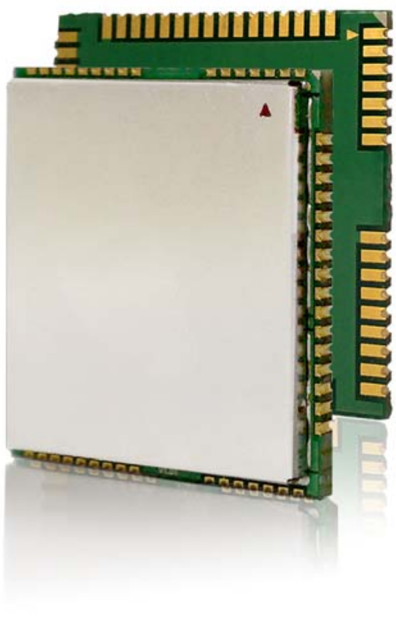
M12

Quectel Cellular Engine



Hardware Design

M12_HD_V1.0

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Contents

Table Index

Figure Index

0 Revision history

Revision	Date	Author	Description of change
1.0	2010-07-20	Yong An	Initial

1 Introduction

This document defines the M12 module and describes the hardware interface of the M12 module that connects to the customer application and the air interface. The M12 module is pin-to-pin fully compatible with the M10 quad-band module from Quectel, therefore some documents of M10 can be referred for application of M12.

This document can help customer quickly understand module interface specifications, electrical and mechanical details. With the help of this document, associated application notes and user guide, customer can use M12 module to design and set up mobile applications quickly.

1.1 Related documents

Table 1: Related documents

SN	Document name	Remark
[1]	M12_ATC	AT command set
[2]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[3]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[4]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[5]	GSM 07.05	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[6]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[7]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[8]	GSM 03.38	Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information
[9]	GSM 11.10	Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification
[10]	GSM_UART_AN	UART port application notes
[11]	M10_HD_AN01	M10 hardware design application notes

[12]	GSM_FW_Upgrade_AN01	GSM Firmware upgrade application note
[13]	M10_EVB_UGD	M10 EVB user guide application notes

1.2 Terms and abbreviations

Table 2: Terms and abbreviations

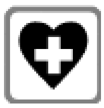
Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
ARP	Antenna Reference Point
ASIC	Application Specific Integrated Circuit
BER	Bit Error Rate
BOM	Bill Of Material
BTS	Base Transceiver Station
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit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

Abbreviation	Description
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
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
Phonebook abbreviations	
FD	SIM Fix Dialing phonebook
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

1.3 Safety caution

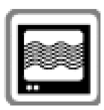
The following safety precautions must be observed during all phases of the operation, such as usage, service or repair of any cellular terminal or mobile incorporating M12 module. Manufactures of the cellular terminal should send the following safety information to users and operating personnel and to 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

The M12 is a Dual-band GSM/GPRS engine that works at frequencies GSM900MHz and DCS1800MHz. The M12 features GPRS multi-slot class 12 and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. For more detail about GPRS multi-slot classes and coding schemes, please refer to Appendix A and Appendix B.

With a tiny profile of 29mm x 29mm x 3.6 mm, the module can meet almost all the requirements for M2M applications, including Tracking and Tracing, Smart Metering, Wireless POS, Security, Telematics, Remote Controlling, etc.

The M12 is an SMD type module, which can be embedded in customer application through its 64-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 1.1 mA in SLEEP mode when DRX is 5.

The M12 is integrated with Internet service protocols, which are TCP/IP, PPP. Extended AT commands have been developed for customer to use these Internet service protocols easily.

The modules are fully RoHS compliant to EU regulation.

2.1 Key features

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 1.1 mA@ DRX=5 0.7 mA@ DRX=9
Frequency bands	● Duad-band: GSM900, DCS1800. ● The module can search two frequency bands automatically ● The frequency bands can be set by AT command. ● Compliant to GSM Phase 2/2+
GSM class	Small MS
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: -30°C ~ +70°C ● Restricted operation: -35°C ~ -30°C and +70°C ~ +75°C [1)]

	● Storage temperature: -40°C ~ +85°C
DATA GPRS: CSD:	● 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) usually used for PPP connections ● Internet service protocols TCP/IP, PPP ● Support Packet Switched Broadcast Control Channel (PBCCH) ● 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
FAX	Group 3 Class 1 and Class 2
SIM interface	Support SIM card: 1.8V, 3V
Antenna interface	Connected via 50 Ohm antenna pad
Audio features	Speech codec modes: ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10) ● Enhanced Full Rate (ETS 06.50 / 06.60 / 06.80) ● Adaptive Multi-Rate (AMR) ● Echo Cancellation ● Echo Suppression ● Noise Reduction
Serial interface	Serial Port: ● Seven lines on serial port interface ● Use for AT command, GPRS data and CSD data ● Multiplexing function ● Support autobauding from 4800 bps to 115200 bps Debug Port: ● Two lines on second serial port interface DBG_TXD and DBG_RXD ● Debug Port only used for software debugging
Phonebook management	Support phonebook types: SM, FD, LD, RC, ON, MC
SIM Application Toolkit	Support SAT class 3, GSM 11.14 Release 99
Real time clock	Implemented
Alarm function	Programmable via AT command
Physical characteristics	Size: 29±0.15 x 29±0.15 x 3.6±0.3mm Weight: 6g
Firmware upgrade	Firmware upgrade over 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

2.2 Functional diagram

The following figure showes a block diagram of the M12 module and illustrates the major functional parts:

- The GSM baseband part
- Flash and SRAM
- The GSM radio frequency part
- The SMT pads interface

  —LCD interface
  —SIM card interface
  —Audio interface
  —Key-board interface
  —UART interface
  —Power supply
  —RF interface

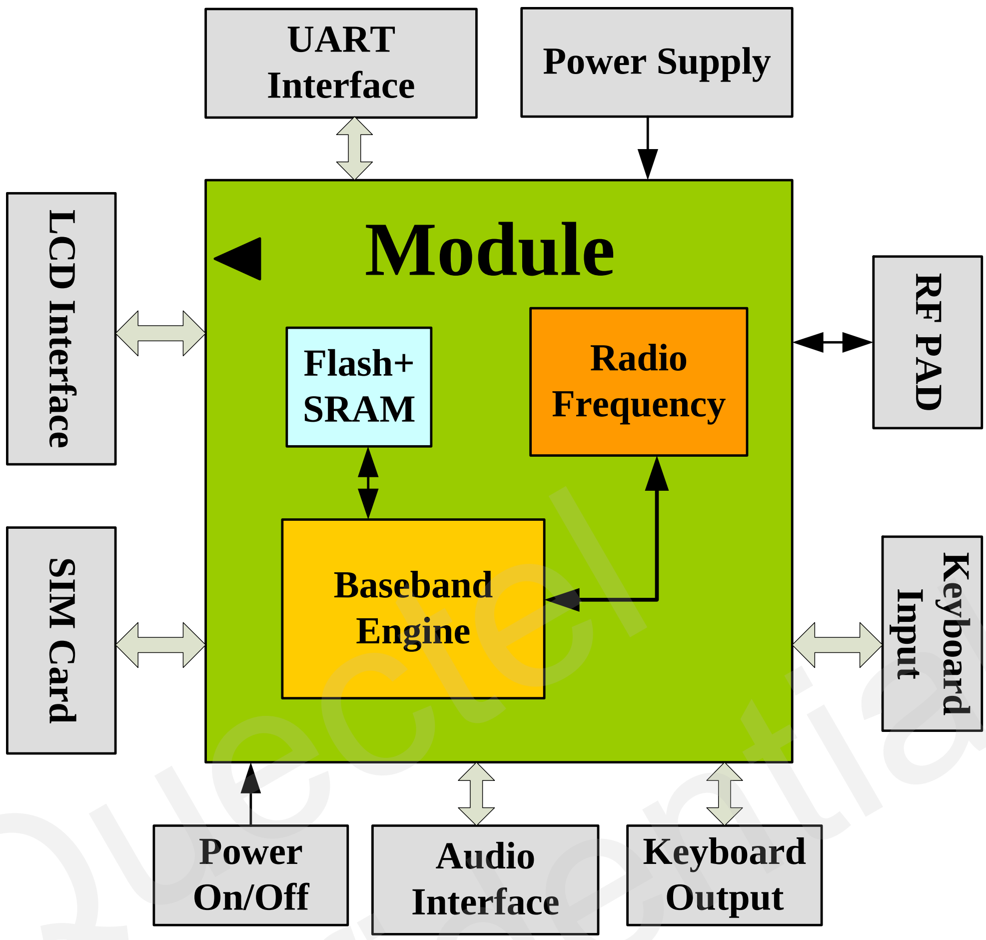


Figure 1: Module functional diagram

2.3 Evaluation board

M12 module is an SMD type module. To test M12 module in M10 EVB, M12-TE-A module should be used. M12-TE-A is pin-to-pin compatible with M10-TE-A module. For details, please refer to *Document [13]*.

3 Application interface

The module is equipped with a 64-pin 1.3mm pitch SMT pad that connects to the cellular application platform. Sub-interfaces included in these pads are described in detail in following chapters:

- Power supply (*refer to Chapter 3.3*)
- Serial interfaces (*refer to Chapter 3.9*)
- Two analog audio interfaces (*refer to Chapter 3.10*)
- SIM interface (*refer to Chapter 3.12*)

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 NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
VBAT	I	Module main power supply. The power supply of module has to be a single voltage source of VBAT=3.4V~4.5V. It must be able to provide sufficient current in a transmitting burst which typically rises to 2A.	Vmax= 4.5V Vmin=3.4V Vnorm=4.0V	
VCHG	I	Voltage input for the charging circuit	Vmax=6.5V Vmin=1.1 * VBAT Vnorm=5.0V	If unused, keep this pin open. Charging function is not supported in default.
VRTC	I/O	Power supply for RTC when VBAT is not supplied for the system. Charging for backup battery or golden 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 golden capacitor.
VDD_EXT	O	Supply 2.8V voltage for	Vmax=2.9V	1. If unused, keep this

		external circuit.	Vmin=2.7V Vnorm=2.8V Imax=20mA	pin open. 2. Recommend to add a 2.2~4.7uF bypass capacitor, when using this pin for power supply.
GND		Digital ground		
Power on or power off				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
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.
Emergency shutdown				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
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 NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
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.
Audio interfaces				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
MIC1P MIC1N	I	Positive and negative voice-band input	Audio DC Characteristics refer to Chapter 3.10.	If unused, keep these pins open
MIC2P MIC2N	I	Auxiliary positive and negative voice-band input		
SPK1P SPK1N	O	Positive and negative voice-band output		If unused, keep these pins open
SPK2P	O	Auxiliary positive voice-band output		If unused, keep this pin open.

AGND		AGND is separate ground connection for external audio circuits.		If unused, keep this pin open.
BUZZER	O	Buzzer output		If unused, keep this pin open
General purpose input/output				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
KBC0~ KBC4	I	Keypad interface	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 these pins open
KBR0~ KBR4	O			Pull up to VDD_EXT, if unused, keep these pins open
DISP_DATA	I/O	LCD display interface		If unused, keep these pins open
DISP_CLK	O			
DISP_CS	O			
DISP_D/C	O			
DISP_RST	O			
NETLIGHT	O	Network status indication		If unused, keep these pins open
GPIO0	I/O	Normal input/output port		
GPIO1_ KBC5	I/O	Normal input/output port/Keypad interface		
LIGHT_ MOS	O	Open drain output port	Imax=100mA	If unused, keep this pin open
Serial port				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
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 to keep other pins open.
RXD	I	Receiving data		
TXD	O	Transmitting data		
RTS	I	Request to send		
CTS	O	Clear to send		
RI	O	Ring indicator		
DCD	O	Data carrier detection		
Debug port				
DBG_TXD	O	Serial interface for debugging only.		If unused, keep these pins open
DBG_RXD	I			

PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
SIM interface				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
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 TVS diode array. Maximum cable length 200mm from the module pad to SIM card holder.
SIM_DATA	I/O	SIM data	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	
SIM_CLK	O	SIM clock		
SIM_RST	O	SIM reset		
SIM_PRESENCE	I	SIM card detection	VILmax=0.67V VIHmin=1.7V	If unused, keep this pin open.
AUXADC				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
ADC0	I	General purpose analog to digital converter.	voltage range: 0V to 2.8V	If unused, keep this pin open
TEMP_BAT	I	ADC input for battery temperature over NTC resistor.	voltage range: 0V to 2.8V	NTC should be installed inside or near battery pack to deliver temperature values. If unused keep this pin open.
RF interface				
PIN NAME	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
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

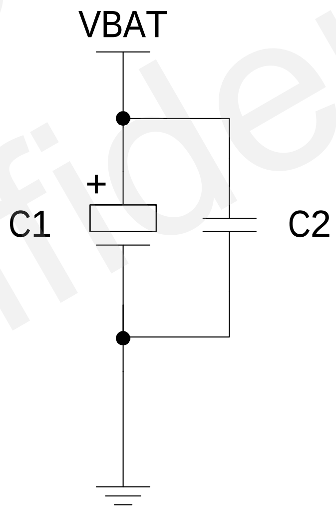
Mode	Function	
Normal operation	GSM/GPRS SLEEP	The module will automatically go into SLEEP mode if DTR is set to high level and there is no interrupt (such as GPIO interrupt or data on serial port). In this case, the current consumption of module will reduce to the minimal level. During SLEEP mode, the 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 up to 2A. 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 but may not be economical. A lower cost choice could be a 100 µF tantalum capacitor with low ESR. A small (0.1µF to 1µF) ceramic capacitor should be in parallel with the 100µF capacitor, which is illustrated in Figure 2. The capacitors should be placed close to the M12 VBAT pins.



C1=100uF, C2=0.1uF~1uF

Figure 2: Reference circuit of the VBAT input

The circuit design of the power supply for the module largely depends on the power source. Figure 3 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 especially with the 2A peak current in burst mode of the module.

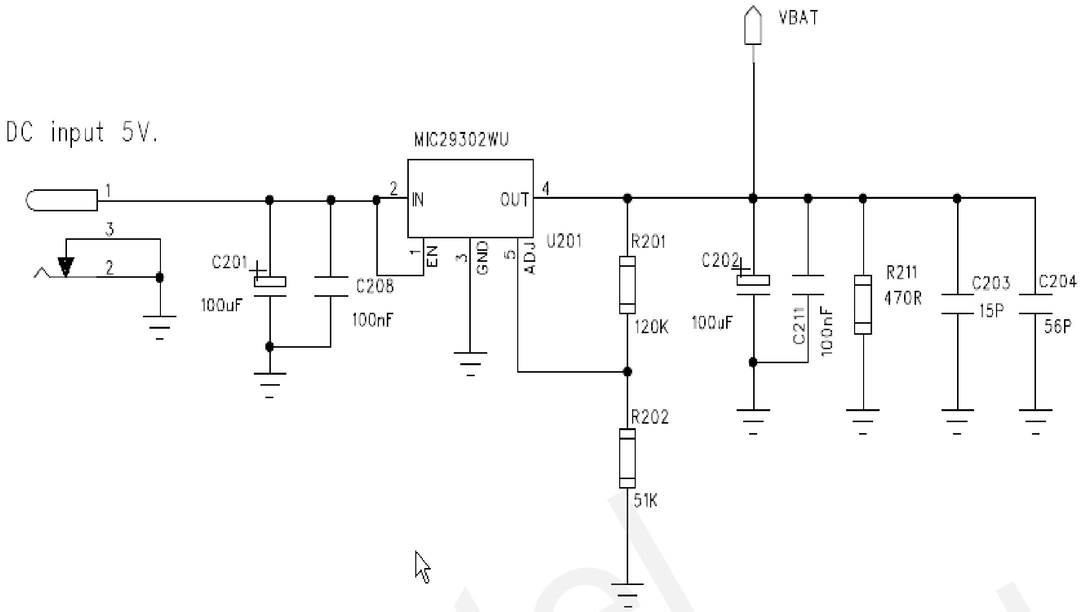


Figure 3: Reference circuit of the source power supply input

When the power supply for the module can't provide current of 2A, proper bigger capacitor is required so as to supply for the current demand during the burst transmission period. Reference capacitors for corresponding limited current supply are listed in Table 7.

Table 7: Recommended bypass capacitors for limited current supply

Maximum current output of power supply	Capacitance	ESR@ +25°C 100KHz (Ω)	Part number	Quantity of application	Vendor
1.5A	1500µF	<=0.045	592D158X06R3R2T20H	1	VISHAY
1A	2200µF	<=0.055	592D228X06R3X2T20H	2	VISHAY

The single 3.6V Li-Ion cell battery type can be connected to the power supply of the module VBAT directly. The Ni_Cd or Ni_MH battery types must be used carefully, because their maximum voltage can rise over the absolute maximum voltage for the module and damage it. The M12 module does not support charging function in the default hardware configuration.

A suitable way to charge battery in M2M application is to use an external charging circuit which can charge the battery and put it into idle mode after fully charged. The VBAT is supplied by external power source instead of the battery, but when the external power source is cut off the battery will supply to the VBAT immediately. A reference block diagram for this design is shown in Figure 4.

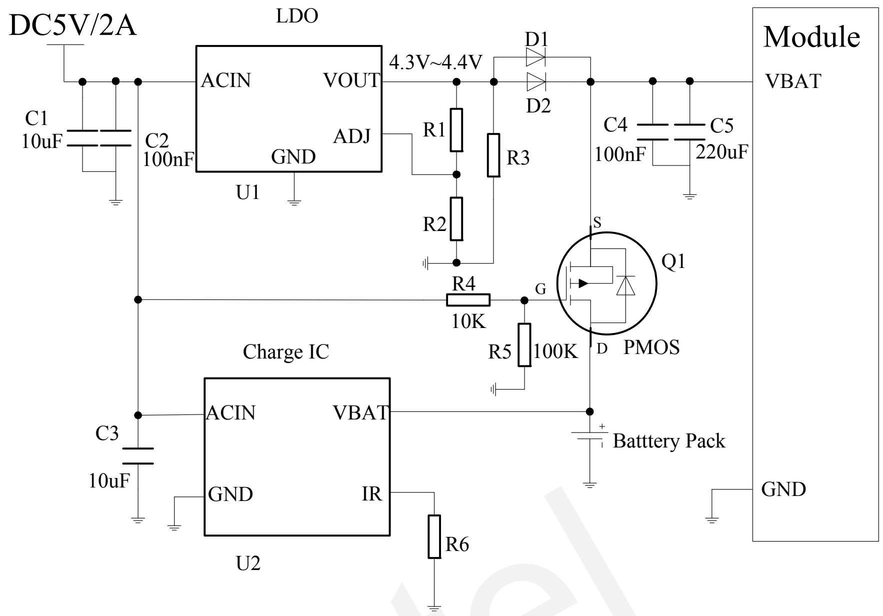


Figure 4: Reference external battery charging circuit

Figure 4 shows the reference battery charging circuit for M2M application. U1 is an LDO which can supply current more than 2A and can output a voltage of 4.3~4.4V through adjusting the resistance of R1 and R2. R3 is the minimum load whose value can usually be found in the datasheet of U1. Both D1 and D2 are Schottky barrier diodes, which is capable of forward current more than 1.5A and has low forward voltage drop and fast switching feature. Q1 is a P-channel MOSFET which acts as a switch between battery supply and external power supply. When the external power supply is present, Q1 is cut off and the module is powered by external supply. Otherwise, Q1 is turned on and the module is supplied by the battery. The Q1 P-channel MOSFET must be able to supply continuous drain current bigger than 2A. Moreover, on-resistance of Drain-to-Source should be as small as possible which means lower thermal power dissipation and voltage drop. U2 is a charging IC, which should be chosen according to the requirements of the application. Since the module is powered by external supply during most of the time in common application, charging current of more than 100mA would be enough. Furthermore, the external 5V DC power supply should be capable of supplying current more than the total sum of maximum charging current and maximum module load current, which is happened in GPRS multi-slot transmission at highest power control level in GSM900MHz band.

The RF Power Amplifier current (2.0A 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=4.0V, VBAT maximum output current =2A, C1=100µF tantalum capacitor (ESR=0.7Ω) and C2=1µF.

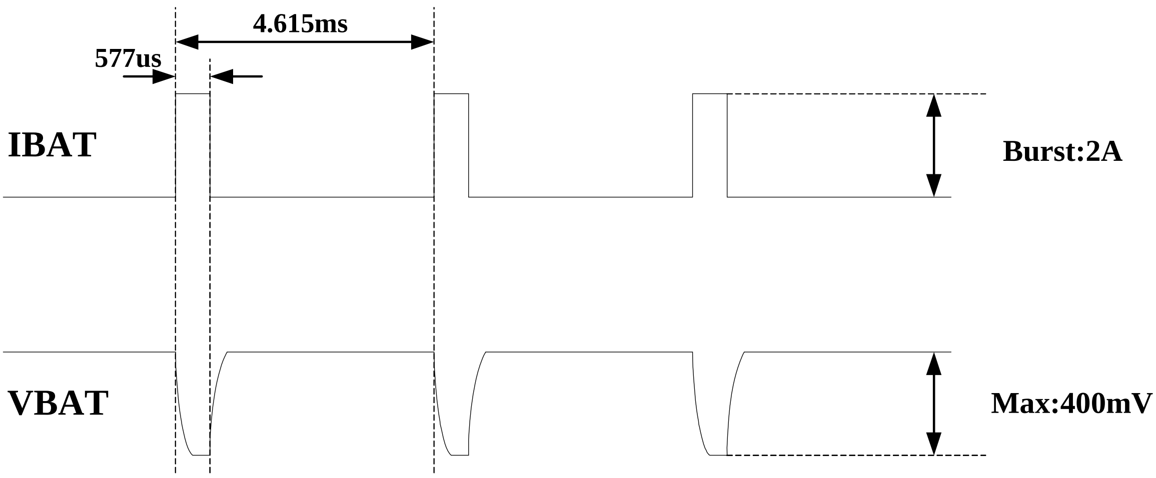


Figure 5: Ripple in supply voltage during transmitting burst

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 golden capacitor which can help to maintain the system clock when VBAT supply is not applied.

3.3.2 Minimizing supply voltage drop

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 1.8A. 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 isn't too much voltage drop occur 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. The VBAT voltage can be measured by oscilloscope.

3.3.3 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.

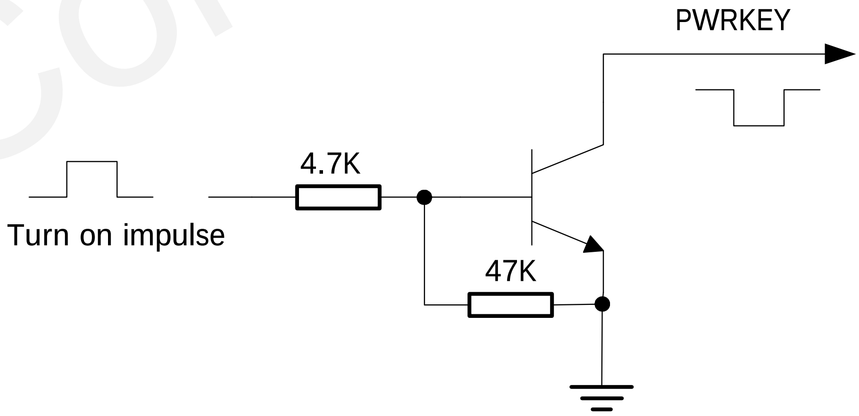


Figure 6: Turn on the module using driving circuit

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.

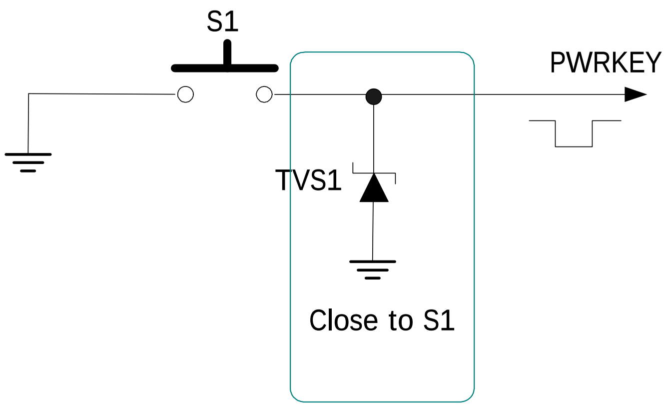


Figure 7: Turn on the module using keystroke

The power on scenarios is illustrated as following figure.

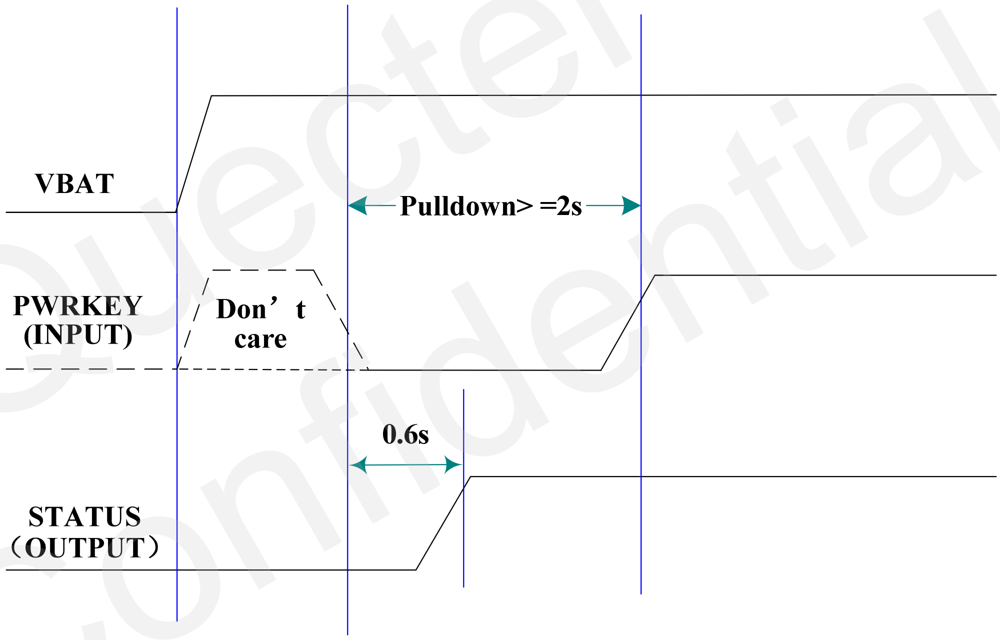


Figure 8: Timing of turn on system

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

Table 8: 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.

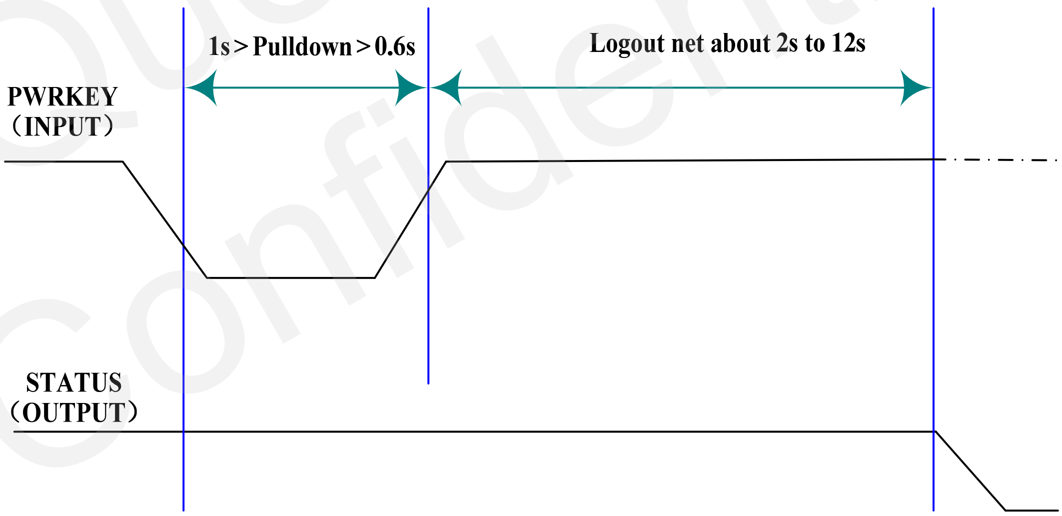


Figure 9: Timing of turn off the module

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 detail 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.

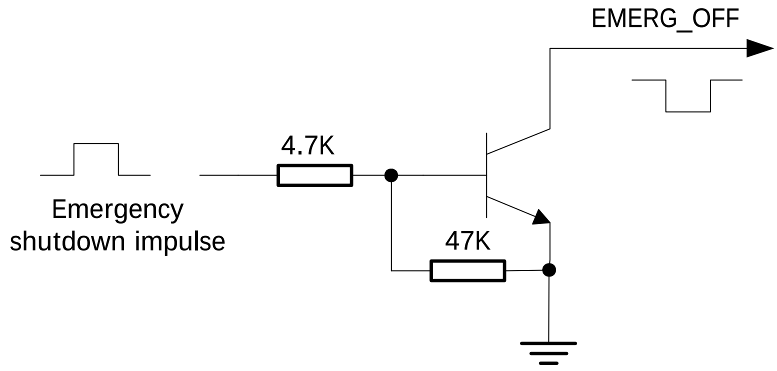


Figure 10: Reference circuit for EMERG_OFF by using driving circuit

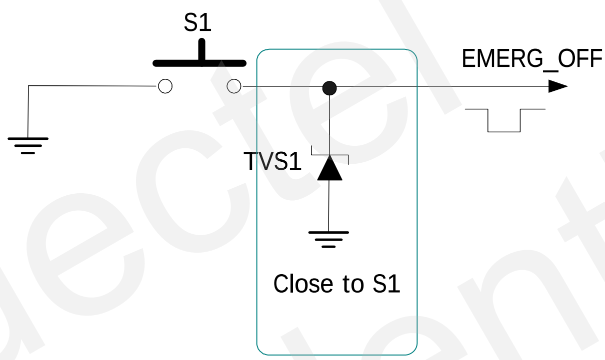


Figure 11: Reference circuit for EMERG_OFF by using button

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.

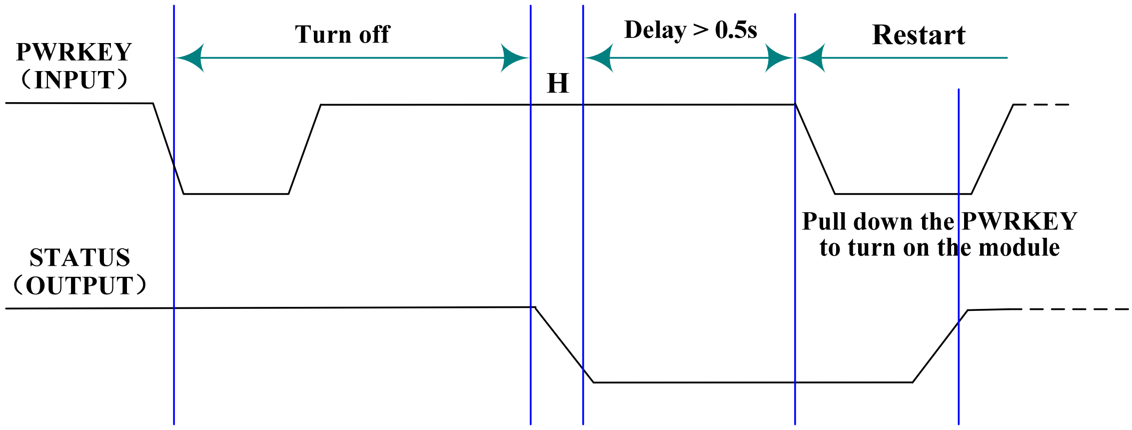


Figure 12: Timing of restart system

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

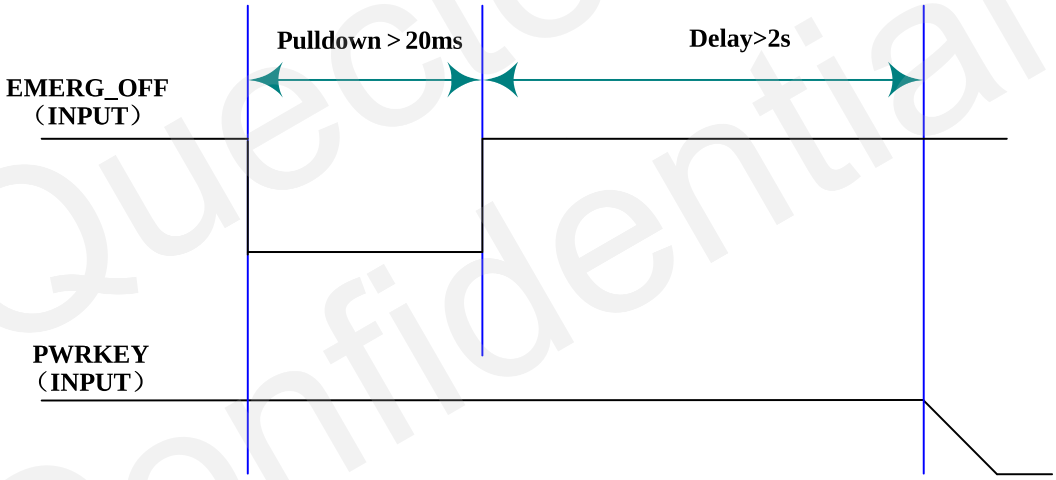


Figure 13: Timing of restart system after emergency shutdown

3.5 Charging interface

The module has OPTIONALLY integrated a charging circuit for rechargeable Li-Ion or Lithium Polymer battery, which makes it very convenient for application to manage its battery charging.

A common connection is shown in Figure 14.

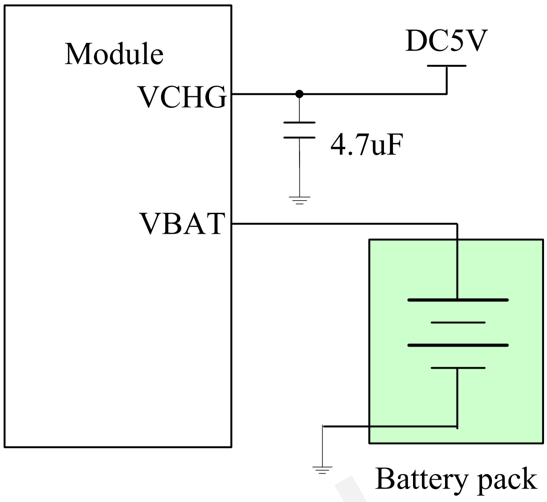


Figure 14: Charging circuit connection

The charging function is not supported in standard M12 module. If customer needs this function, it would be necessary to contact Quectel. Furthermore, when battery charging is done by the charging function supported by the module, the VBAT would be mainly supplied by the battery and the external power source is used to charge the battery. In this case, when the battery is charged full, the charging circuit will stop working, but the charging function would be re-activated when the battery voltage drops to certain level. The battery is either in discharging mode or in charging mode, which could significantly shorten its life cycle. Therefore, it should always be cautious to use the internal charging function in M2M application.

3.5.1 Battery pack characteristics

The module has optimized the charging algorithm for the Li-Ion or Lithium Polymer battery that meets the characteristics listed below. To use the module's charging algorithm properly, it is recommended that the battery pack is compliant with these specifications, as it is important for the AT command "AT+CBC" to monitor the voltage of battery properly, or the "AT+CBC" may return incorrect battery capacity value.

- The maximum charging voltage of the Li-Ion battery pack is 4.2V and the capacity is greater than 500mAh.
- The battery pack should have a protection circuit to avoid overcharging, over-discharging and over-current.
- On the GSM part of the module, the build-in power management chipset monitors the supply voltage constantly. Once the Under-voltage is detected, the module will power down automatically. Under-voltage thresholds are specific to the battery pack.
- The internal resistance of the battery and the protection circuit should be as low as possible. It is recommended that the battery internal resistance should not exceed 70mΩ and the internal resistance include battery and protection circuit of battery pack should not exceed 130mΩ.

- The battery pack must be protected from reverse pole connection.
- The Li-Ion/Polymer battery charging protection parameter is required as the following table

Table 9: Recommended battery protect circuit parameter

Item	Min.	Typ.	Max.
Over-charge protect threshold.(V)	4.25	4.3	4.35
Released Voltage from Over-charge(V)	4.1		4.2
Over-discharge protect threshold(V)	2.2		2.35
Released Voltage from Over-discharge(V)	2.35	2.4	2.45

3.5.2 Recommended battery pack

The following is the specification of the recommended battery pack:

Table 10: Specification of the recommended battery pack

Item	Remark
Product name & type	SCUD Li-Ion, 3.7V, 800mAh
To obtain more information, Please contact :	**SCUD (FU JIAN) Electronic CO., LTD.**
Normal voltage	3.7V
Capacity	Minimum 800mAh
Charging Voltage	4.200~4.23V
Max Charging Current	1.2C
Max Discharge Current	2C
Charging Method	CC / CV (Constant Current / Constant Voltage)
Internal resistance	≤130mΩ
Over-charge protect threshold.(V)	4.28 ± 0.025
Released Voltage from Over-charge(V)	4.08 ± 0.05
Over-discharge protect threshold(V)	2.3± 0.1
Released Voltage from Over-discharge(V)	2.4± 0.1

3.5.3 Implemented charging technique

There are two pins on the connector related with the internal battery charging function: VCHG and VBAT. The VCHG pin is driven by an external voltage, this pin can be used to detect an external charger supply and provide most charging current to external battery when it is in constant current charging stage. The module VBAT pin is connected directly to external battery positive terminal.

It is very simple to implement battery charging. Just connect the charger to the VCHG pin and connect the battery to the VBAT pin. When the module detects the charger supply and the battery are both present, battery charging happens. If there is no charger supply or no battery present, the charging function would not be enabled.

Normally, there are three main states in whole charging procedure.

- DDLO charging and UVLO charging
- CC (constant current) charging or fast charging
- CV (constant voltage) charging

DDLO charging and UVLO charging:

DDLO (deep discharge lock out) is the state of battery when its voltage is under 2.4V. And UVLO (under voltage lock out) is the state of battery when the battery voltage is less than 3.2V and more than 2.4V. The battery is not suitable for CC or CV charging when its condition is DDLO or UVLO. The module provides a small constant current to the battery when the battery is in DDLO or UVLO. The module provides current of about 15mA to the battery in the DDLO charging stage, and about 55mA to the battery in the UVLO charging stage.

DDLO charging terminates when the battery voltage reaches 2.4V. UVLO charging terminates when the battery voltage is up to 3.2V. Both DDLO and UVLO charging are controlled by the module hardware only.

CC charging:

When an external charger supply and battery have been inserted and the battery voltage is higher than 3.2V, the module enters CC charging stage. CC charging controlled by the software. In this charging stage, the module provides a constant current (about 550mA) through VBAT pins to the battery until battery voltage reaches to 4.18±0.02V.

CV charging:

After CC charging ending, the module automatically enters constant voltage charging. When charging current steadily decreases to 50mA, the module begins to carry out 30 minutes charging delay. The CV charging will terminate after this delay.

Charging hold:

The charging hold state is exclusively state. When the charger is applied, a voice call is connected and the battery voltage is above 4.05V, the module would enter Charge Hold state. The charging will pause until the battery voltage falls below 3.8V or the module goes into idle mode.

Note: The module has a maximum charging time threshold, 6 hours. If the battery is not fully charged after 6 hours' constant charging, the module would terminate the charging operation immediately.

The charging process is shown in Figure 15.

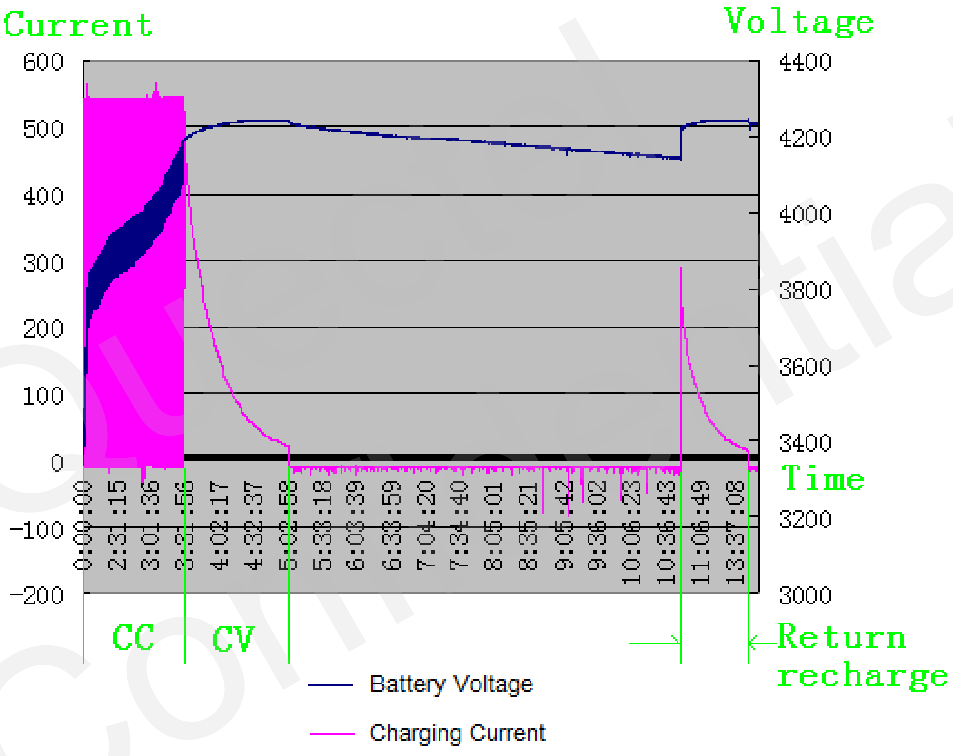


Figure 15: Normal charging process diagram

3.5.4 Operating modes during charging

The battery can be charged in various working modes such as SLEEP, TALK and GPRS DATA. It is named as Charging mode.

When a charger is connected to the module's VCHG pin, the battery is connected to the VBAT pin and the module is in POWER DOWN mode, the module enters the GHOST mode (Off and charging). The following table gives the differences between Charging mode and GHOST mode.

Table 11: Operating modes

	How to activate	Features
Charging Mode	Connect charger to the module's VCHG pin after connecting battery to VBAT pin of module and put the module in one of Normal operating modes, including: SLEEP, IDLE, TALK, GPRS STANDBY, GPRS READY and GPRS DATA mode, etc.	The module can normally operate.
GHOST Mode	Connect charger to module's VCHG pin while the module is in POWER DOWN mode. Or power down from Charging mode.	Battery can be charged in GHOST mode. The module is not registered to GSM network. Only a few AT commands are available as listed in Table 12.

When the module is in the GHOST mode, AT commands listed in Table 12 can be used. For further instruction refer to *document [1]*.

Table 12: AT Commands available in the GHOST mode

AT command	Function
AT+QALARM	Set alarm time
AT+CCLK	Set data and time of RTC
AT+QPOWD	Power down the module
AT+CBC	Indicated charging state and voltage
AT+CFUN	Start or close the protocol Setting AT command "AT+CFUN=1" to the module will transfer it from GHOST mode to Charging mode.

3.5.5 Charger requirements

The requirements of a suitable charger to match with the module internal charging function are listed below:

- Output voltage: 4.6V~6.5V，nominal voltage level is 5.0V.
- Charging current limitation: 650mA

- A 10V peak voltage is allowed for maximum 1ms when charging current is switched off.
- A 1.6A peak current is allowed for maximum 1ms when charging current is switched on.

3.6 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.

3.6.1 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]*.

3.6.2 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.

3.6.3 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.

3.7 Summary of state transitions (except SLEEP mode)

Table 13: 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	

3.8 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 super-cap can be used to backup power supply for RTC.

The following figures show various sample circuits for RTC backup.

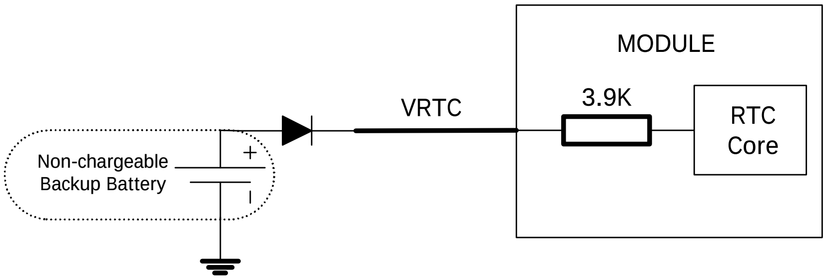


Figure 16: RTC supply from non-chargeable battery

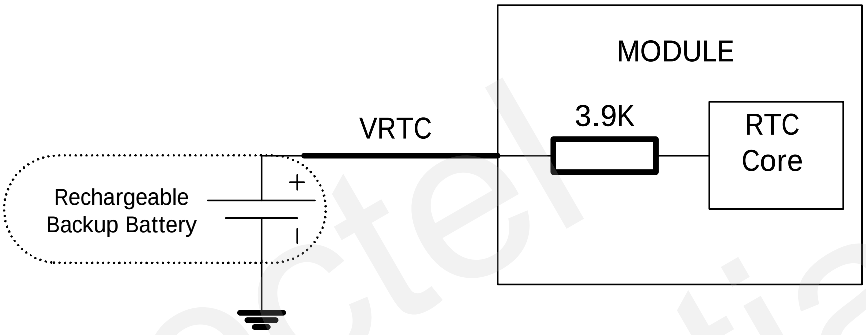


Figure 17: RTC supply from rechargeable battery

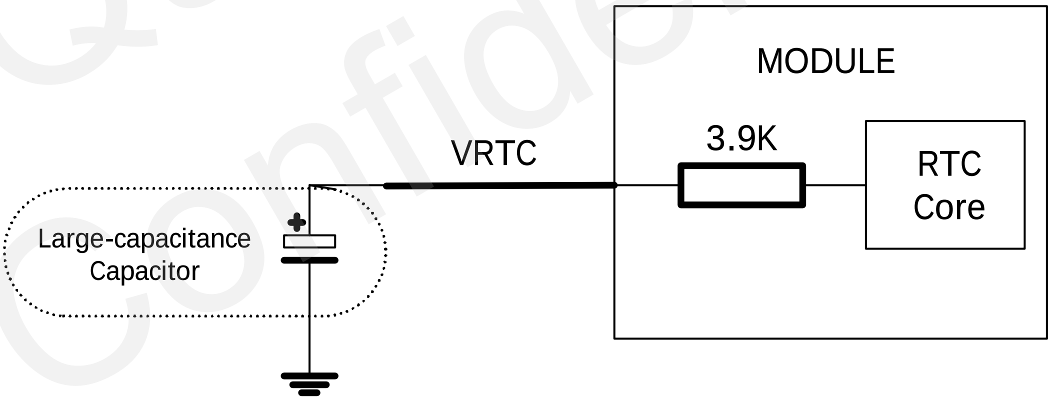


Figure 18: RTC supply from capacitor

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

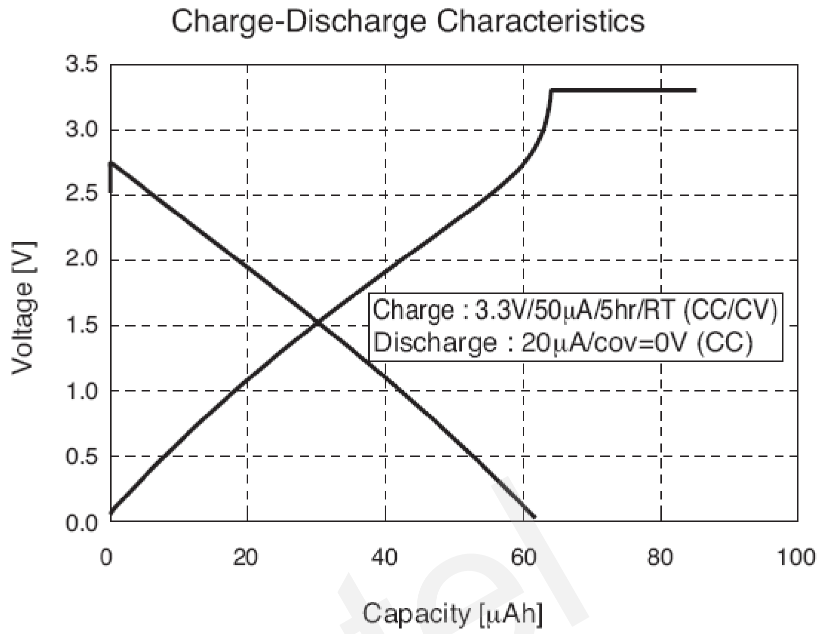


Figure 19: Seiko XH414H-IV01E Charge Characteristic

3.9 Serial interfaces

The module provides two unbalanced asynchronous serial ports including Serial Port, 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 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 computer
- DBG_RXD: Receive data from the COM port of a debugging computer

The logic levels are described in the following table.

Table 14: 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 15: Pin definition of the serial interfaces

Interface	Name	Pin	Function
Debug Port	DBG_RXD	9	Receive data of the debug port
	DBG_TXD	10	Transmit data of the debug port
Serial Port	RI	55	Ring indicator
	RTS	58	Request to send
	CTS	57	Clear to send
	RXD	61	Receiving data of the serial port
	TXD	60	Transmitting data of the serial port
	DTR	59	Data terminal ready
	DCD	56	Data carrier detection

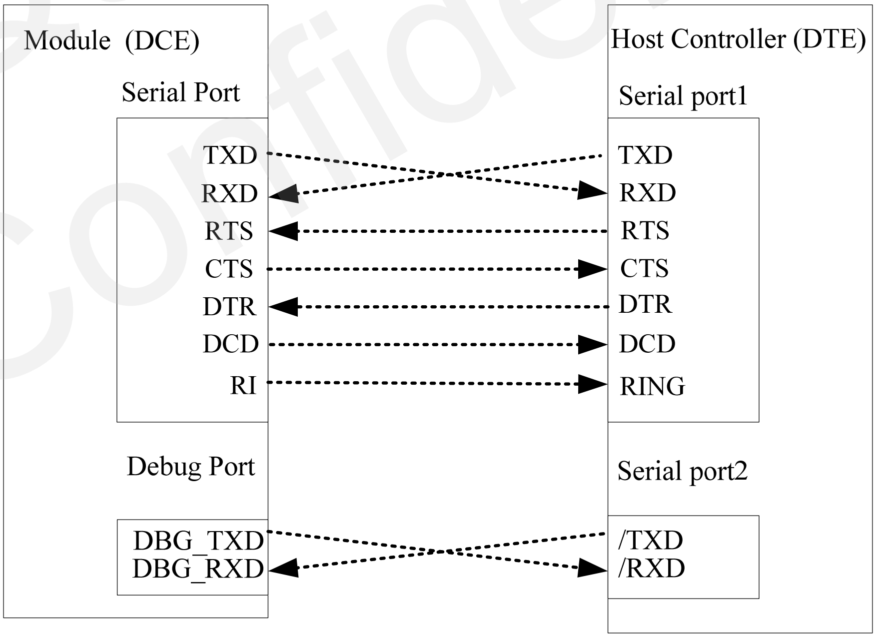


Figure 20: Connection of serial interfaces

3.9.1 Feature of serial interfaces

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.
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.

3.9.2 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.

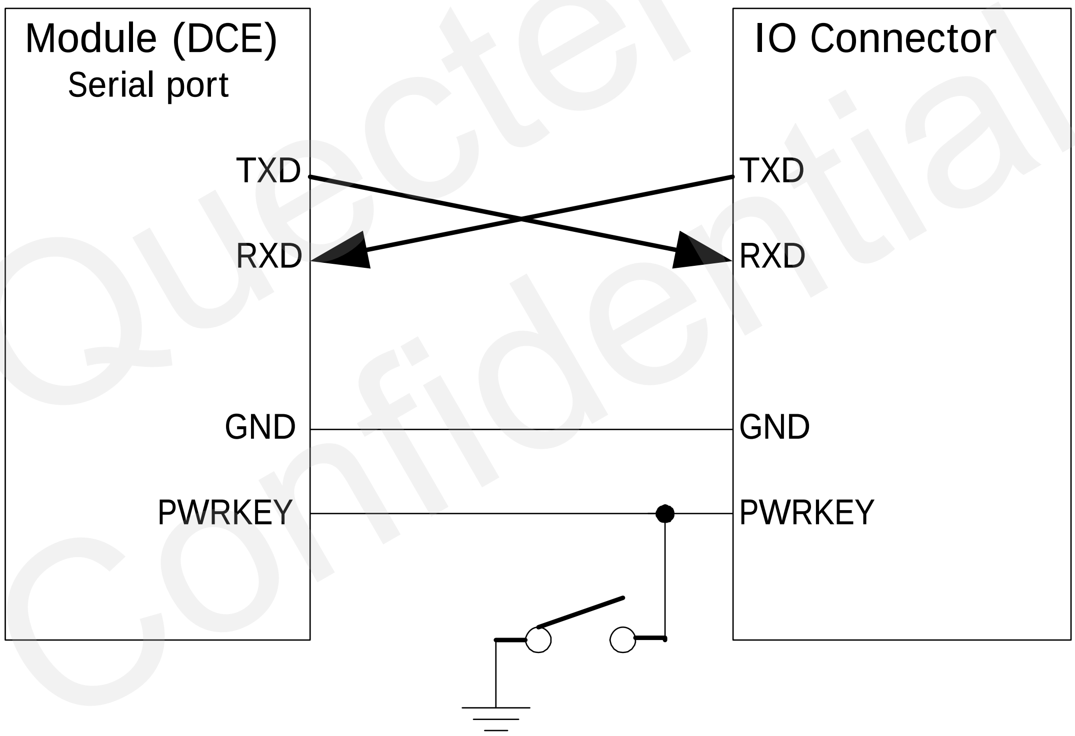


Figure 21: Connection of software upgrade

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 [12].

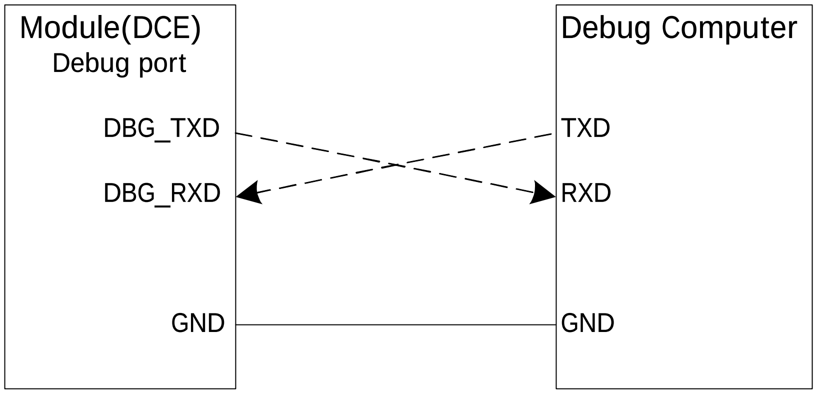


Figure 22: Connection of software debug

The 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 23 shows a reference level shifter circuit when the module is connected to a PC.

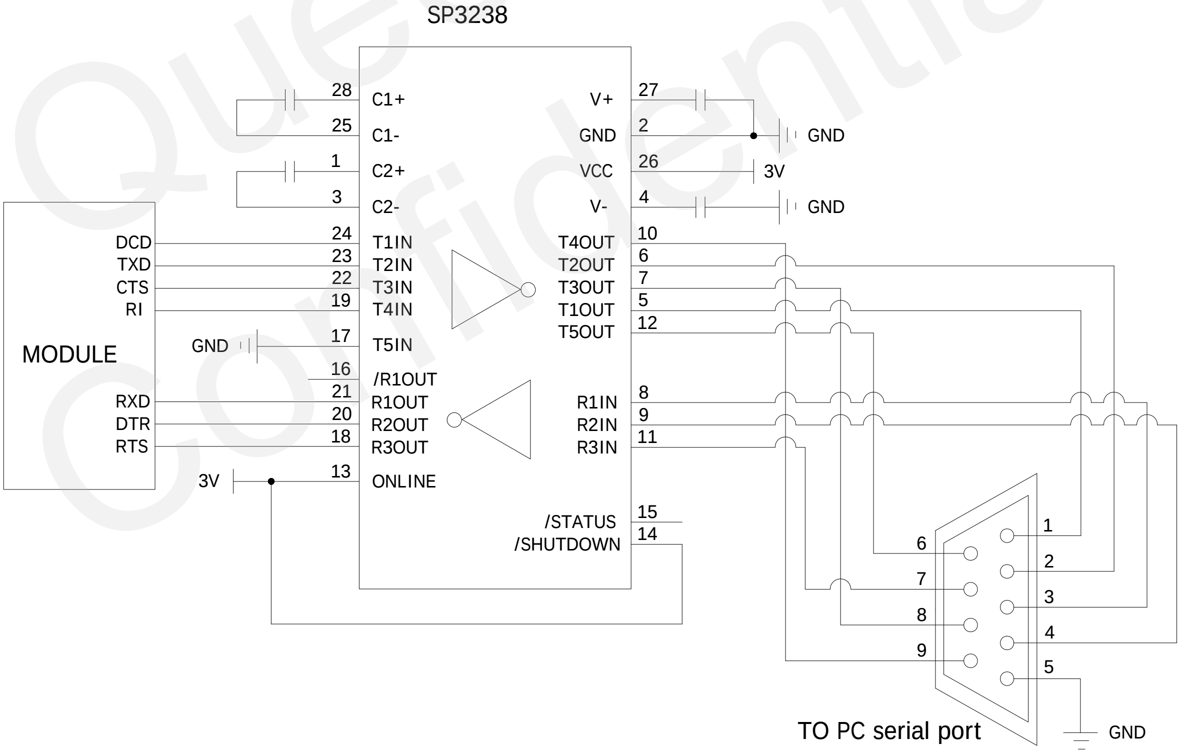


Figure 23: RS232 level converter circuit

Note 1：For details information about serial port application, please refer to document [10]

3.10 Audio interfaces

The module provides two analogy input channels and two analogy output channels.
AIN1 and AIN2, which may be used for both microphone and line inputs. An electret microphone is usually used. AIN1 and AIN2 are both differential input channels.
AOUT1 and AOUT2, which may be used for both receiver and speaker outputs. AOUT1 channel is typically used for a receiver built into a handset, while AOUT2 channel is typically used with headset or hands-free speaker. AOUT1 channel is a differential channel and AOUT2 is a single-ended channel. SPK2P and AGND can establish a pseudo differential mode. If customer needs to play Melody or Midi ringtone for incoming call, AOUT2 Channel should always be used. These two audio channels can be swapped by "AT+QAUDCH" command. For more details, please refer to *document [1]*.
For each channel, customer can use AT+QMIC to adjust the input gain level of microphone. Customer can also use "AT+CLVL" to adjust the output gain level of receiver and speaker. "AT+QECHO" is to set the parameters for echo cancellation control. "AT+QSIDET" is to set the side-tone gain level. For more details, please refer to *document [1]*.

Note:

- ***Use AT command "AT+QAUDCH" to select audio channel:***
  0--AIN1/AOUT1 (normal audio channel), the default value is 0.
  1--AIN2/AOUT2 (aux audio channel) .

Table 16: Pin definition of Audio interface

Interface	Name	Pin	Function
(AIN1/AOUT1)	MIC1P	23	Microphone1 input +
	MIC1N	24	Microphone1 input -
	SPK1P	22	Audio1 output+
	SPK1N	21	Audio1 output-
(AIN2/AOUT2)	MIC2P	25	Microphone2 input +
	MIC2N	26	Microphone2 input -
	SPK2P	20	Audio2 output+
	AGND	19	Suggest to be used in audio circuit. Don't connect to digital GND in host PCB as it could introduce TDD noise.

3.10.1 Microphone interfaces configuration

AIN1/IN2 channels come with internal bias supply for external electret microphone. A reference circuit is shown in Figure 24.

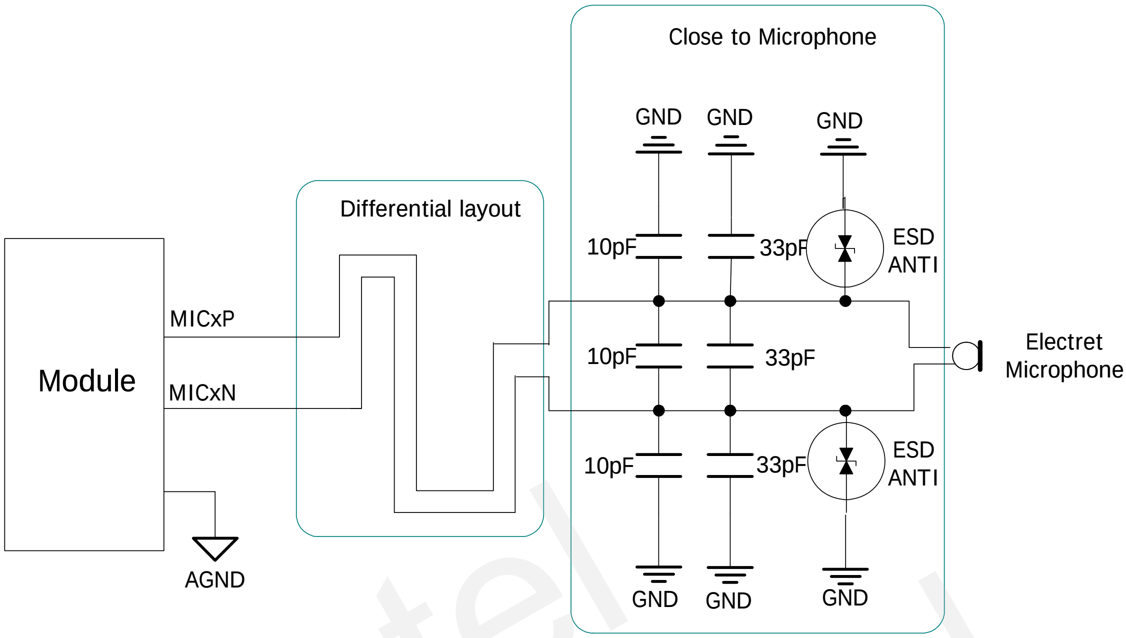


Figure 24: Microphone interface configuration of AIN1&AIN2

The 33pF capacitor is applied for filtering out 900MHz RF interference when the module is transmitting at GSM900MHz. Without placing this capacitor, TDD noise could be heard at the peer party of the voice communication. Moreover, the 10pF capacitor here is for filtering out 1800MHz RF interference. However, the resonant frequency point of a capacitor largely depends on the material and production technique. Therefore, customer would have to discuss with its capacitor vendor to choose the most suitable capacitor for filtering GSM900MHz and DCS1800MHz separately.

The severity degree of the RF interference in the voice channel during GSM transmitting period largely depends on the application design. In some cases, GSM900 TDD noise is more severe; while in other cases, DCS1800 TDD noise is more obvious. Therefore, customer can decide which capacitor to use based on test result. Sometimes, even no RF filtering capacitor is required.

The differential audio traces have to be placed according to the differential signal layout rule.

3.10.2 Speaker interface configuration

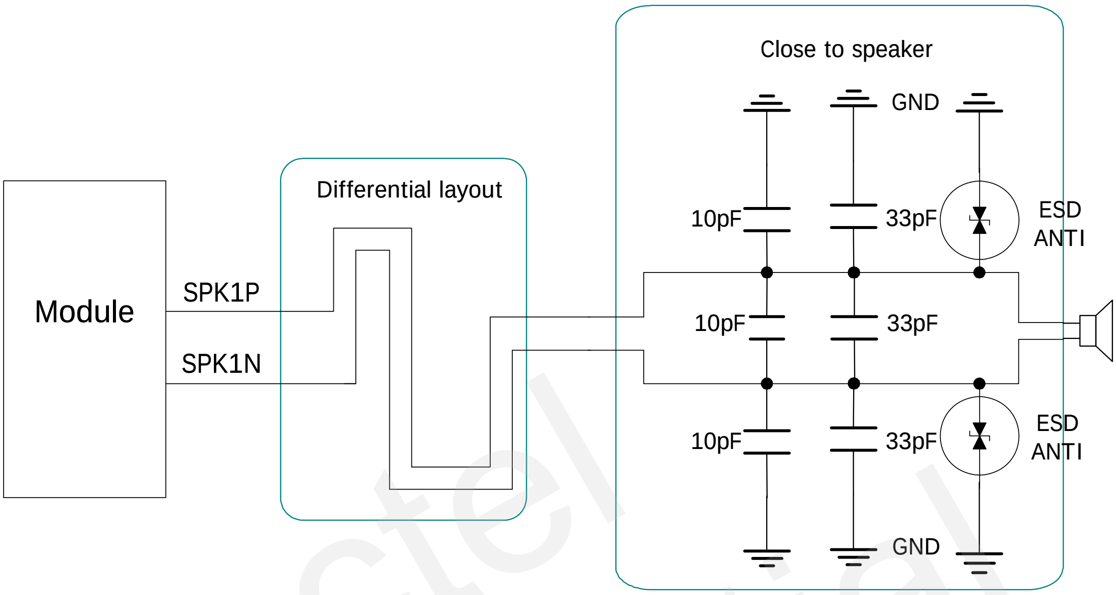


Figure 25: Speaker interface configuration of AOUT1

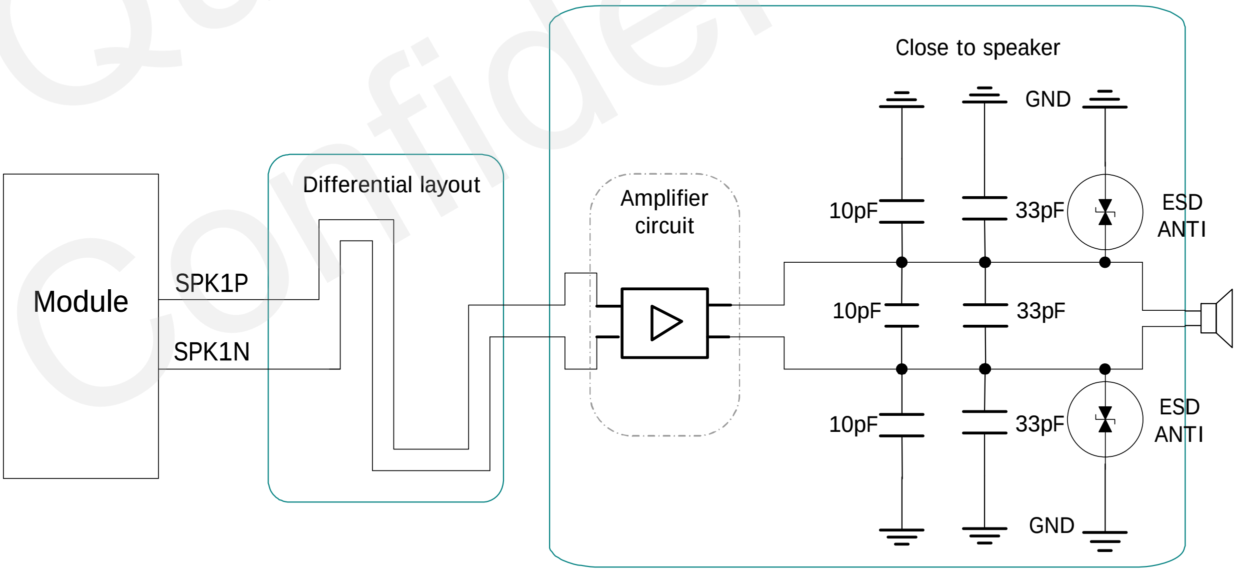


Figure 26: Speaker interface with amplifier configuration of AOUT1

Texas Instruments's TPA6205A1is recommended for a suitable differential audio amplifier. There are plenty of excellent audio amplifiers in the market.

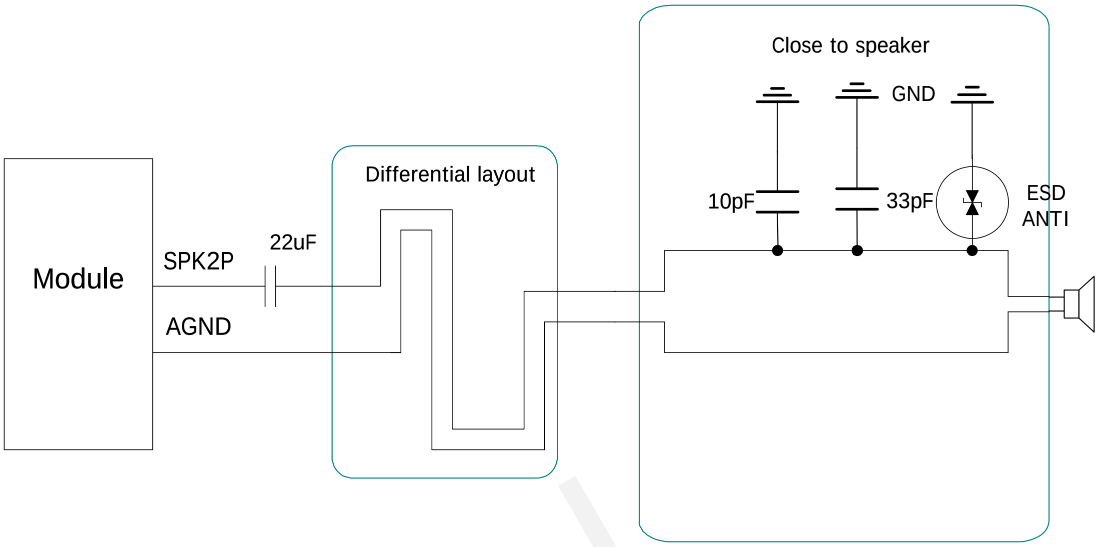


Figure 27: Speaker interface configuration of AOUT2

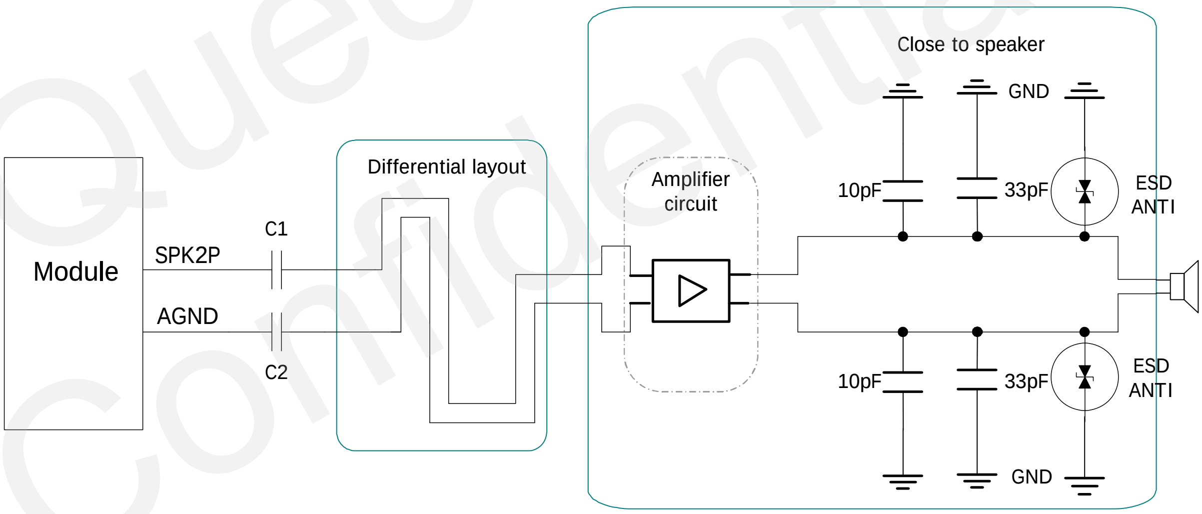


Figure 28: Speaker interface with amplifier configuration of AOUT2

Note: The value of C1 and C2 depends on the input impedance of audio amplifier.

3.10.3 Earphone interface configuration

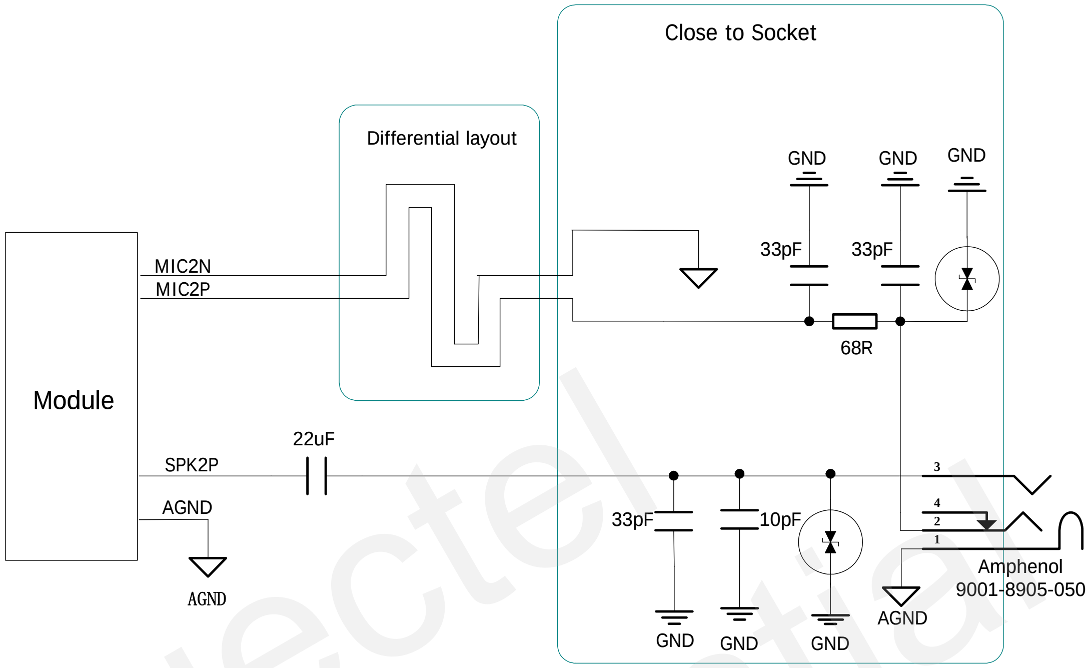


Figure 29: Earphone interface configuration

Table 17: Typical electret microphone characteristic

Parameter	Min	Typ	Max	Unit
Working Voltage	1.2	1.5	2.0	V
Working Current	200		500	uA
External Microphone Load Resistance		2.2		k Ohm

Table 18: Typical speaker characteristic

Parameter			Min	Typ	Max	Unit
Normal Output(SPK1)	Single Ended	Load resistance	28	32		Ohm
		Ref level	0		2.4	Vpp
	Differential	Load resistance	28	32		Ohm
		Ref level	0		4.8	Vpp

Auxiliary Output(SPK2)	Single Ended	Load resistance	16	32		Ohm
		Ref level	0		2.4	Vpp
Maxim driving current limit of SPK1 and SPK2					50	mA

3.11 Buzzer

The pin BUZZER in the SMT pads can be used to drive a buzzer to indicate incoming call. The output volume of buzzer can be set by "AT+CRSL". The reference circuit for buzzer is shown in Figure 30.

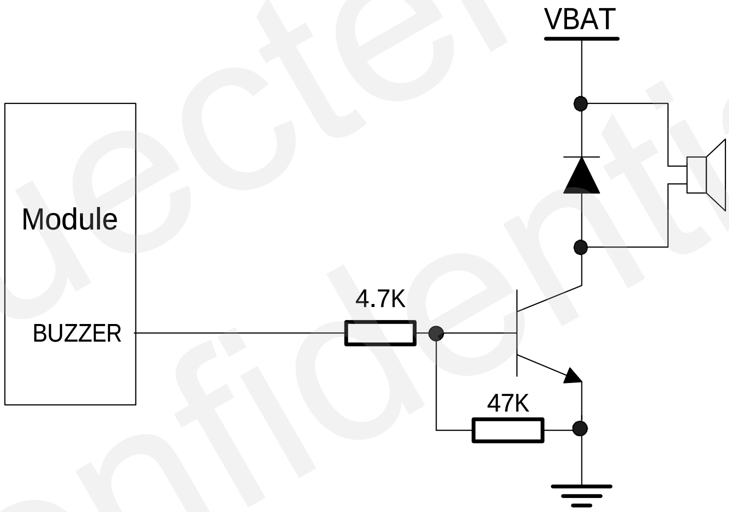


Figure 30: Reference circuit for Buzzer

Table 19: Pin definition of the Buzzer

Name	**Pin**	**Function**
BUZZER	39	Output of buzzer tone

Table 20: Buzzer output characteristic

Parameter	**Min**	**Typ**	**Max**	**Unit**
Working Voltage	2.0	2.8	VDD_EXT	V
Working Current			4	mA

3.12 SIM card interface

3.12.1 SIM card application

Customer can get information in SIM card by AT Command. For more information, please refer to *document [1]*.

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 21: Pin definition of the SIM interface

Name	Pin	Function
SIM_VDD	12	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	13	SIM Card data I/O
SIM_CLK	14	SIM Card Clock
SIM_RST	15	SIM Card Reset
SIM_PRESENCE	11	SIM Card Presence

Figure 31 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.

In Figure 31, 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 detail 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

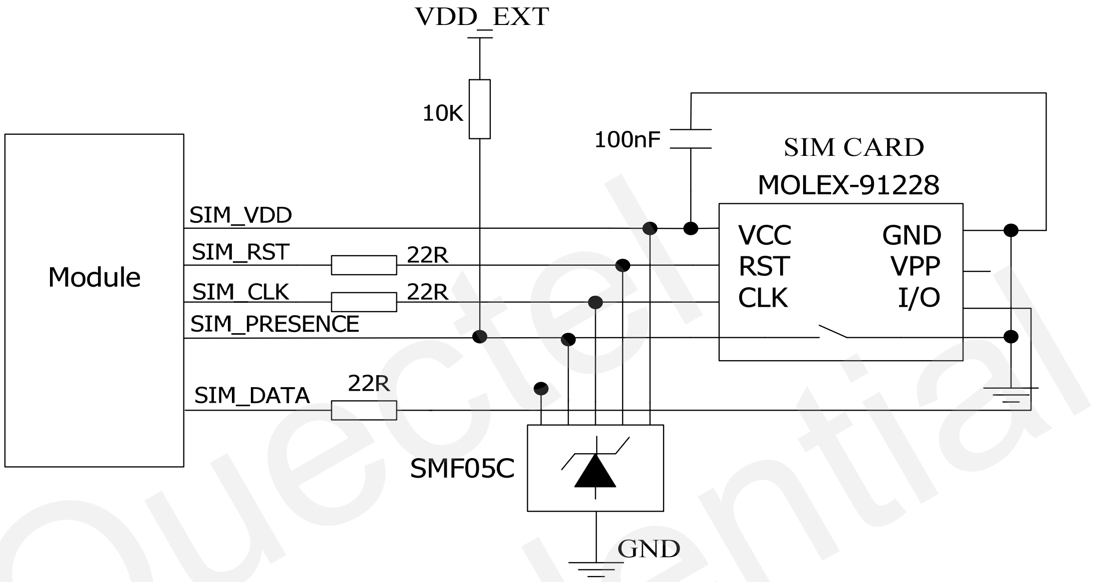


Figure 31: Reference circuit of the 8 pins SIM card

Note: Please do not use "AT+QSIMDET=1,1"to enable when Figure 31 circuit is adopted.

If customer doesn't need the SIM card detection function, keep SIM_PRESENCE open. The reference circuit using a 6-pin SIM card socket is illustrated as the following figure.

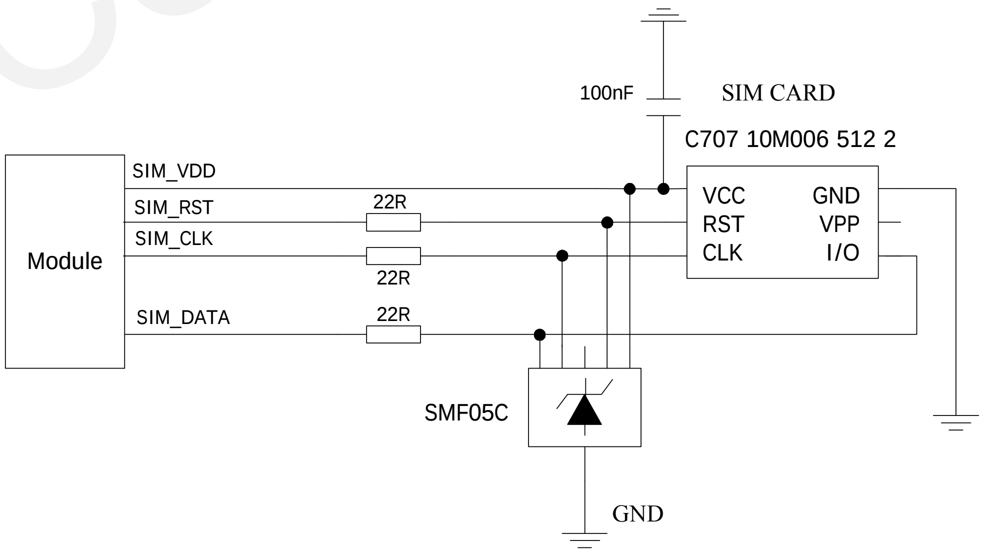


Figure 32: Reference circuit of the 6 pins SIM card

3.12.2 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.

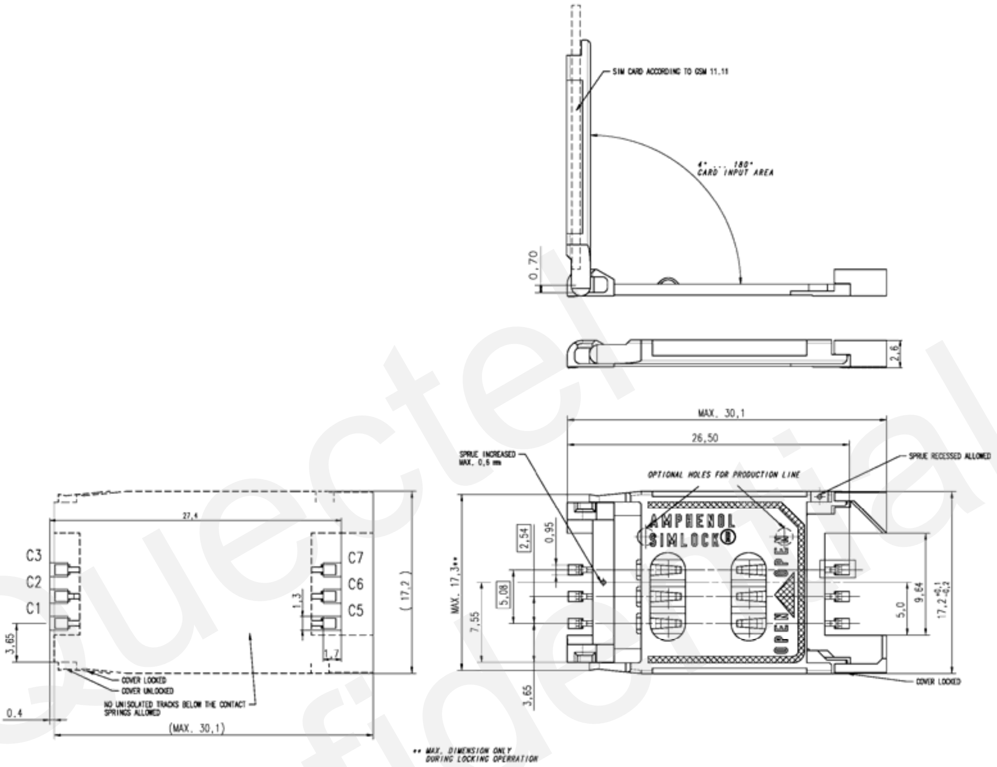


Figure 33: Amphenol C707 10M006 512 2 SIM card holder

Table 22: 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.

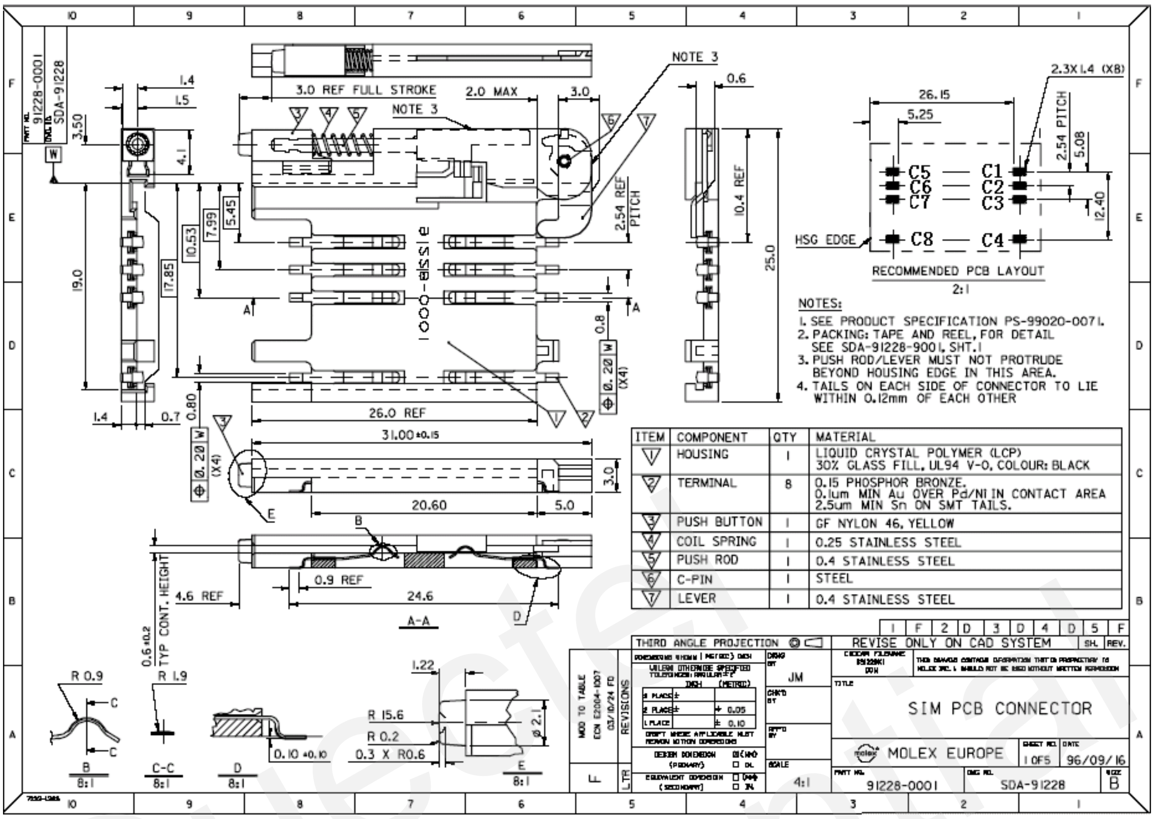


Figure 34: Molex 91228 SIM card holder

Table 23: 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.

3.13 LCD interface

The module contains a versatile LCD controller which is optimized for multimedia application. This function is not supported in standard module firmware, but only available with Quectel Open CPU function. By using Open CPU function, customer's application firmware can be embedded in the flash memory of the module, and it can invoke LCD related API functions to drive a suitable LCD.

The LCD controller supports many types of LCD modules including monochrome LCD, colour LCD. It contains a rich feature set to enhance the functionality. These features are:

- Up to 176×220 pixels resolution
- Supports 8-bpp (RGB332), 12-bpp (RGB444), 16-bpp (RGB565) color depths

The serial LCD display interface supports serial communication with LCD device. When used as LCD interface, the following table is the pin definition. LCD interface timing should be coordinated with the LCD device.

Table 24: Pin definition of the LCD interface

Name	Pin	Function
DISP_RST	5	LCD reset
DISP_D/C	4	Display data or command select
DISP_CS	3	Display enable
DISP_CLK	2	Display clock for LCD
DISP_DATA	1	Display data output

Note: This function is not supported in the default firmware.

3.14 Keypad interface

The keypad interface consists of 5 keypad column inputs and 5 keypad row outputs. The basic configuration is 5 keypad columns and 5 keypad rows, giving 25 keys.

Table 25: Pin definition of the keypad interface

Name	Pin	Function
KBC0	33	Keypad matrix column
KBC1	34	
KBC2	35	
KBC3	36	
KBC4	37	
KBR0	28	Keypad matrix row
KBR1	29	
KBR2	30	
KBR3	31	
KBR4	32	

The keypad interface allows a direct external matrix connection. A typical recommended circuit about the keypad is shown in the following figure.

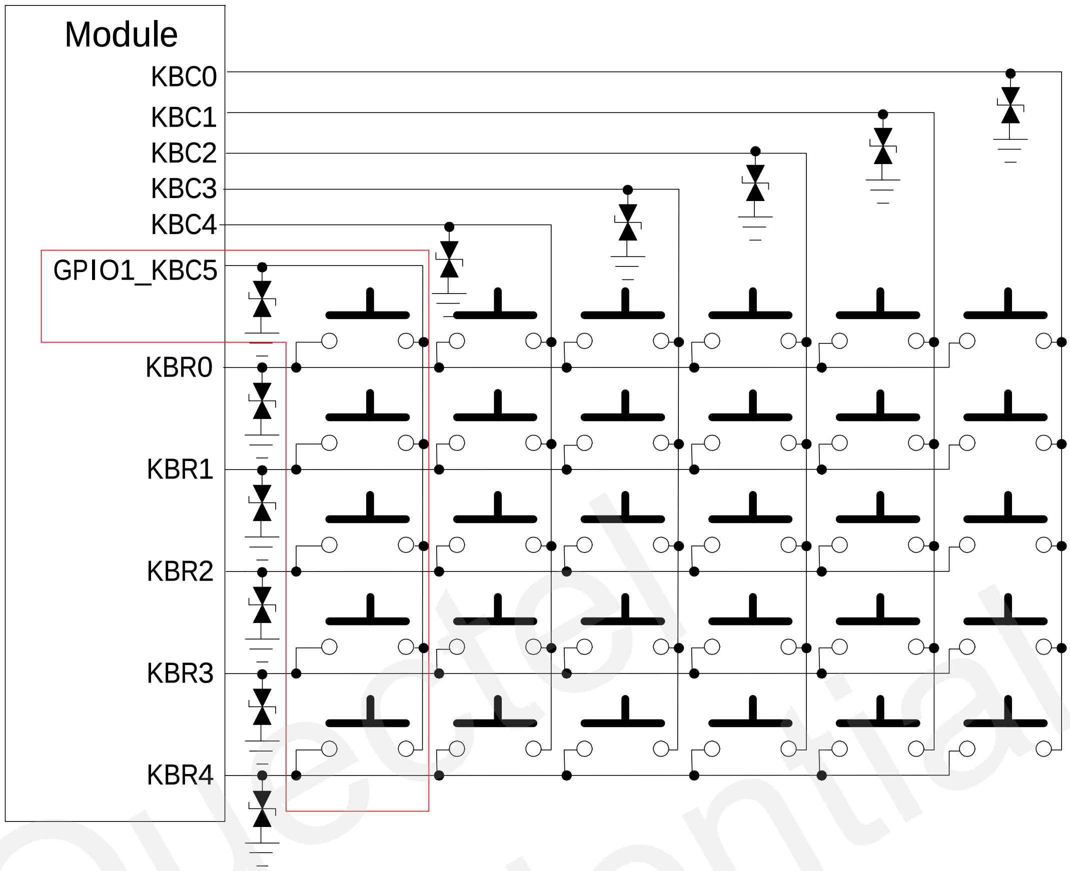


Figure 35: Reference circuit of the keypad interface

If a 5×5 matrix does not provide enough keys, GPIO1 could be multiplexed as KBC5 to configure a 5×6 keypad matrix. Then, the keypad interface consists of 5 keypad row outputs and 6 keypad column inputs. The basic configuration is 5 keypad rows and 6 keypad columns, giving 30 keys.

Note: This function is not supported in the default firmware.

3.15 ADC

The module provides two auxiliary ADC to measure the values of voltage. AT command "AT+QADC" to read the voltage value added on ADC0 pin. For detail of this AT command, please refer to *document [1]*.

To get the battery temperature, M12 provides the TEMP_BAT pin, which is internally pulled-up to 2.8V through 10Kohm. The battery pack should include an NTC resistor. If the NTC is not inside the battery, it must be in thermal contact with the battery. The NTC resistor must be connected between TEMP_BAT and GND. The requirement is: $R_{NTC} \approx 10k\Omega$ @ 25°C. AT command "AT+QEADC" to read the voltage value added on TEMP_BAT pin. For details of this AT command, please refer to *document [1]*.

Table 26: Pin definition of the ADC

Name	Pin	Function
ADC0	41	Analog to digital converter.
TEMP_BAT	40	Analog to digital converter to detect battery temperature

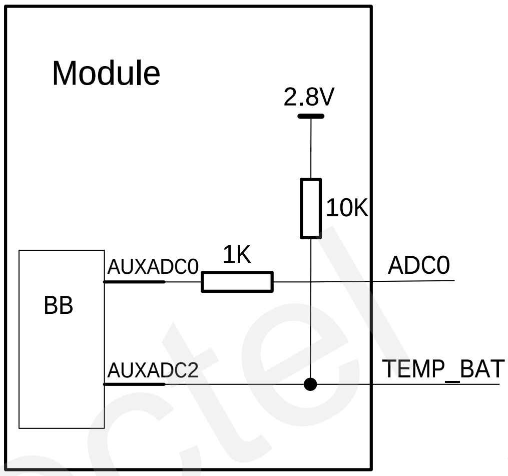


Figure 36: Internal circuit of the ADC

Table 27: Characteristic of the ADC

Item	Min	Typ	Max	Units
Voltage range	0		2.8	V
ADC Resolution	10		10	bits
ADC accuracy		2.7		mV

3.16 Behaviors of the RI

Table 28: 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 [10]***

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.

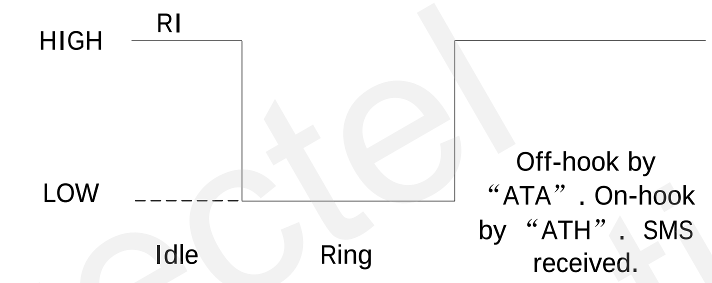


Figure 37: RI behavior of voice calling as a receiver

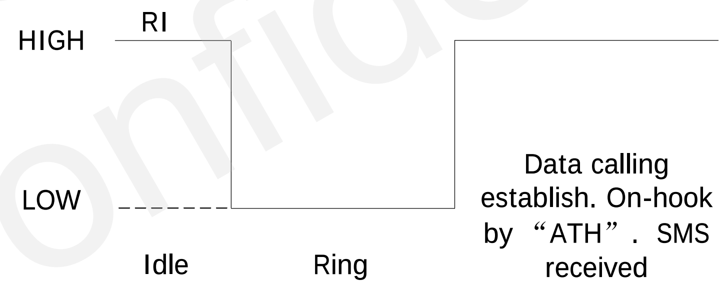


Figure 38: RI behaviour of data calling as a receiver

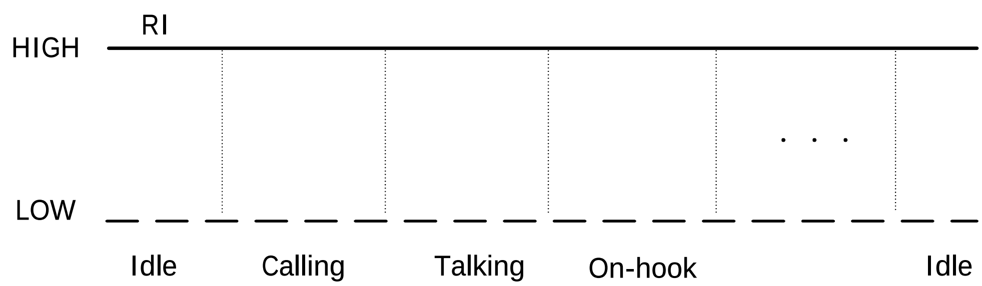


Figure 39: RI behavior as a caller

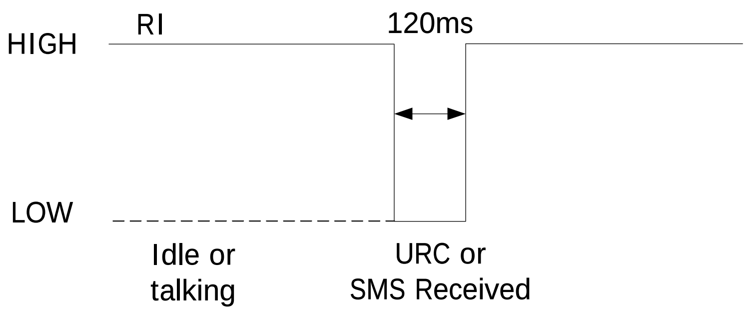


Figure 40: RI behavior of URC or SMS received

3.17 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 29.

Table 29: 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 41.

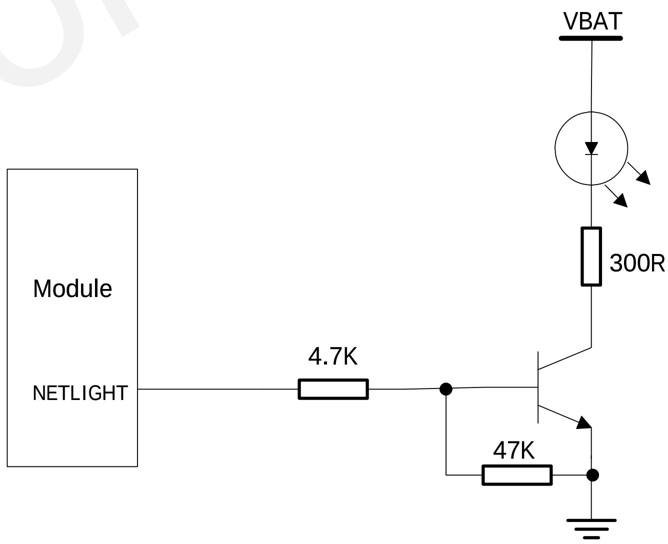


Figure 41: Reference circuit of the NETLIGHT

3.18 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 42.

Table 30: Pin definition of the STATUS

Name	Pin	Function
STATUS	54	Indication of module operating status

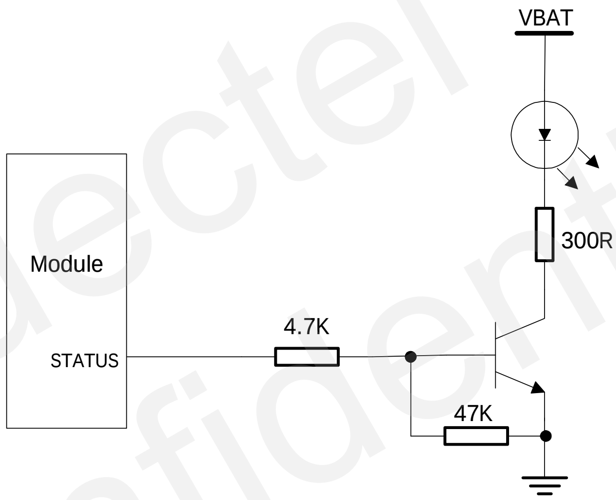


Figure 42: Reference circuit of the STATUS

3.19 General purpose input & output (GPIO)

The module provides a limited number of General Purpose Input/Output signal pins. The driving capability of these pins is 4mA. Every GPIO can be configured as input or output, and set to high or low when working as an output pin by "AT+QGPIO" command. Before using these GPIO pins, customer should configure them with "AT+QGPIO=1,x,x,x,x" firstly. For details, please refer to *document [1]*.

Table 31: Pin definition of the GPIO interface

Name	Pin	PU/PD	Function
GPIO0	64	Pulled up internally to 75K resistor	General Purpose Input/Output Port
GPIO1_KBC5	38	Pulled up internally to 75K resistor	General Purpose Input/Output Port Keypad interface KBR5

3.20 Open drain output (LIGHT_MOS)

The module provides an open drain output pin to control LCD or keyboard backlight. The output LIGHT_MOS can sink 150mA. This open-drain output switch is high impedance when disabled.

Table 32: Pin definition of the LIGHT_MOS

Name	Pin	Function
LIGHT_MOS	27	Open drain output port

Note: This function is not supported in the default firmware. There must be special firmware if customer needs this function. Please contact Quectel for more details.

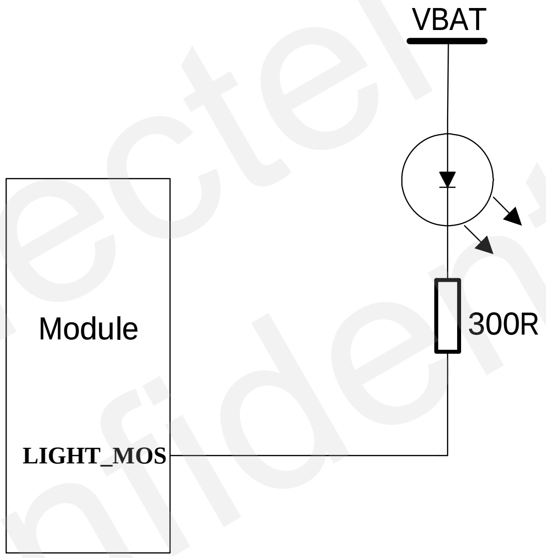


Figure 43: Reference circuit of the LIGHT_MOS

4 Antenna interface

The Pin 43 is the RF antenna pad. The RF interface has an impedance of 50Ω.

4.1 Antenna installation

M12 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. M12 comes with 2 grounding pads which are next to the antenna pad in order to give a better grounding.

Table 33: Pin definition of the RF_ANT

Name	Pin	Function
RF_ANT	43	RF antenna pad
GND	42	Ground
GND	44	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 34: 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 35: The module conducted RF receiving sensitivity

Frequency	Receive sensitivity
EGSM900	< -107dBm
DCS1800	< -107dBm

4.4 Operating frequencies

Table 36: The module operating frequencies

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

5 Electrical, reliability and radio characteristics

5.1 PIN assignment of the module

Table 37: M12 pin assignment

PIN NO.	PIN NAME	I/O	PIN NO.	PIN NAME	I/O
1	DISP_DATA	I/O	2	DISP_CLK	O
3	DISP_CS	O	4	DISP_D/C	O
5	DISP_RST	O	6	NETLIGHT	O
7	VDD_EXT	O	8	GND1	
9	DBG_RXD	I	10	DBG_TXD	O
11	SIM_PRESENCE	I	12	SIM_VDD	O
13	SIM_DATA	I/O	14	SIM_CLK	O
15	SIM_RST	O	16	VRTC	I/O
17	EMERG_OFF	I	18	PWRKEY	I
19	AGND	O	20	SPK2P	O
21	SPK1N	O	22	SPK1P	O
23	MIC1P	I	24	MIC1N	I
25	MIC2P	I	26	MIC2N	I
27	LIGHT_MOS	O	28	KBR0	O
29	KBR1	O	30	KBR2	O
31	KBR3	O	32	KBR4	O
33	KBC0	I	34	KBC1	I
35	KBC2	I	36	KBC3	I
37	KBC4	I	38	GPIO1_KBC5	I/O
39	BUZZER	O	40	TEMP_BAT	I
41	ADC0	I	42	GND2	
43	RF_ANT	I/O	44	GND3	
45	GND4		46	GND5	
47	GND6		48	GND7	
49	GND8		50	VBAT1	I
51	VBAT2	I	52	VBAT3	I
53	VCHG (1)	I	54	STATUS	O
55	RI	O	56	DCD	O
57	CTS	O	58	RTS	I
59	DTR	I	60	TXD	O

61	RXD	I		62	RESERVED	
63	RESERVED			64	GPIO0	I/O

Note: Please keep all reserved pins open.

（1）：This function is not supported in the default hardware configuration.

5.2 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 38: Absolute maximum ratings

Parameter	Min	Max	Unit
VBAT	0	4.7	V
Peak current of power supply	0	3	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

5.3 Operating temperature

The operating temperature is listed in the following table:

Table 39: Operating temperature

Parameter	Min	Typ	Max	Unit
Normal temperature	-30	25	70	℃
Restricted operation*	-30 to -35		70 to 75	℃
Storage temperature	-40		+85	℃

* 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.

5.4 Power supply ratings

Table 40: 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 1.1		uA mA
		Minimum functionality mode AT+CFUN=0 IDLE mode SLEEP mode AT+CFUN=4 IDLE mode SLEEP mode		 12 900 12 1		 mA uA mA mA
		IDLE mode EGSM900 DCS1800		 12 12		 mA mA
		TALK mode EGSM900[1)] DCS1800[2)]		 260 230		 mA mA
		DATA mode, GPRS (3 Rx,2Tx) EGSM900[1)] DCS1800[2)]		 435 390		 mA mA
		DATA mode, GPRS(2 Rx,3Tx) EGSM900[1)] DCS1800[2)]		 590 520		 mA mA
		DATA mode, GPRS (4 Rx,1Tx) EGSM900[1)] DCS1800[2)]		 280 245		mA mA
		DATA mode, GPRS (1Rx,4Tx) EGSM900[1)] DCS1800[2)]		 550 520		 mA mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM900.		1.8	2	A

[1)] Power control level PCL 5

[2)] Power control level PCL 0

5.5 Current consumption

The values for current consumption are shown in Table 41.

Table 41: The module current consumption

Condition	Current Consumption
Voice Call	
EGSM900	@power level #5 <300mA,Typical 260mA @power level #12,Typical 140mA @power level #19,Typical 100mA
DCS1800	@power level #0 <250mA,Typical 230mA @power level #7,Typical 150mA @power level #15,Typical 100mA
GPRS Data	
DATA mode, GPRS (1 Rx,1 Tx) CLASS 12	
EGSM 900	@power level #5 <350mA,Typical 260mA @power level #12,Typical 135mA @power level #19,Typical 90mA
DCS 1800	@power level #0 <300mA,Typical 230mA @power level #7,Typical 120mA @power level #15,Typical 90mA
DATA mode, GPRS (3 Rx, 2 Tx) CLASS 12	
EGSM 900	@power level #5 <550mA,Typical 435mA @power level #12,Typical 195mA @power level #19,Typical 150mA
DCS 1800	@power level #0 <450mA,Typical 390mA @power level #7,Typical 200mA @power level #15,Typical 155mA
DATA mode, GPRS (2 Rx, 3 Tx) CLASS 12	
EGSM 900	@power level #5 <600mA,Typical 590mA @power level #12,Typical 240mA @power level #19,Typical 165mA
DCS 1800	@power level #0 <490mA,Typical 520mA @power level #7,Typical 240mA @power level #15,Typical 170mA
DATA mode, GPRS (4 Rx,1 Tx) CLASS 12	
EGSM 900	@power level #5 <350mA,Typical 280mA @power level #12,Typical 160mA @power level #19,Typical 130mA
DCS 1800	@power level #0 <300mA,Typical 245mA @power level #7,Typical 155mA @power level #15,Typical 130mA

DATA mode, GPRS (1 Rx, 4 Tx) CLASS 12	
EGSM 900	@power level #5 <660mA,Typical 550mA @power level #12,Typical 275mA @power level #19,Typical 185mA
DCS 1800	@power level #0 <530mA,Typical 520mA @power level #7,Typical 280mA @power level #15,Typical 190mA

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.

5.6 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 42: The ESD endurance (Temperature:25℃,Humidity:45 %)

Tested point	Contact discharge	Air discharge
VBAT,GND	±5KV	±10KV
PWRKEY	±4KV	±8KV
SIM Card Interface	±4KV	+8KV/-6KV
Antenna port	±5KV	±10KV
SPK1P/1N, SPK2P/2N, MIC1P/1N, MIC2P/2N	±4KV	+8KV/-6KV

6 Mechanical dimension

This chapter describes the mechanical dimensions of the module.

6.1 Mechanical dimensions of module

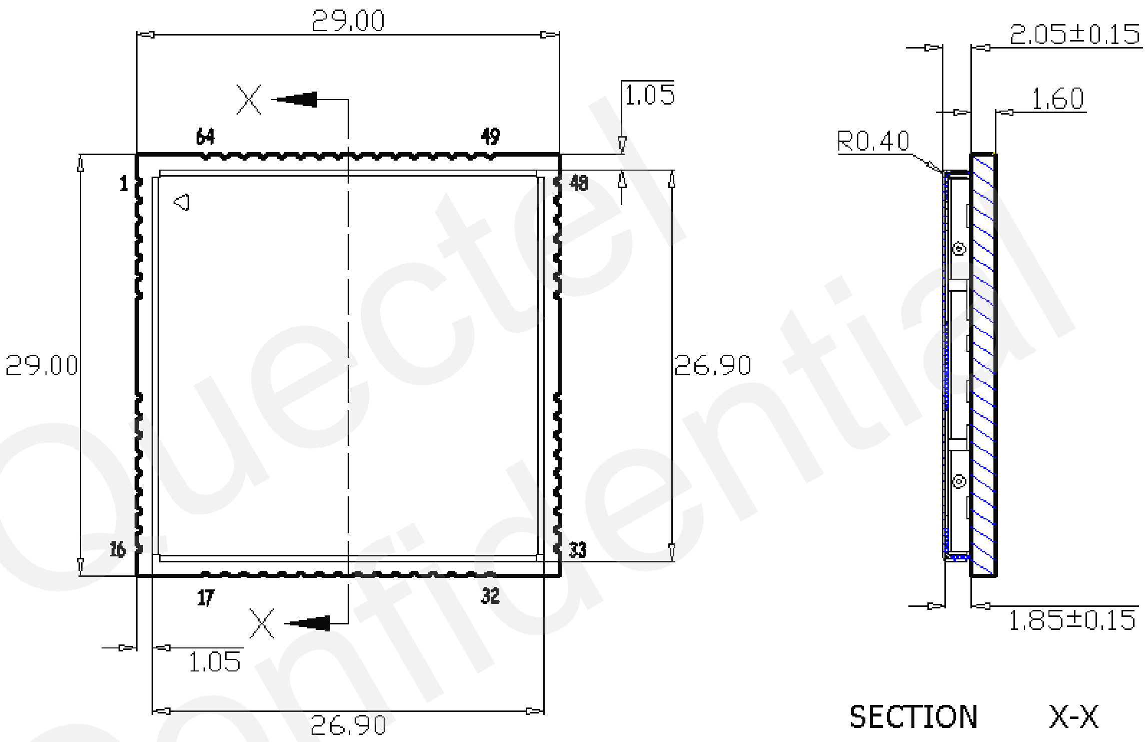


Figure 44: M12 top and side dimensions（Unit: mm）

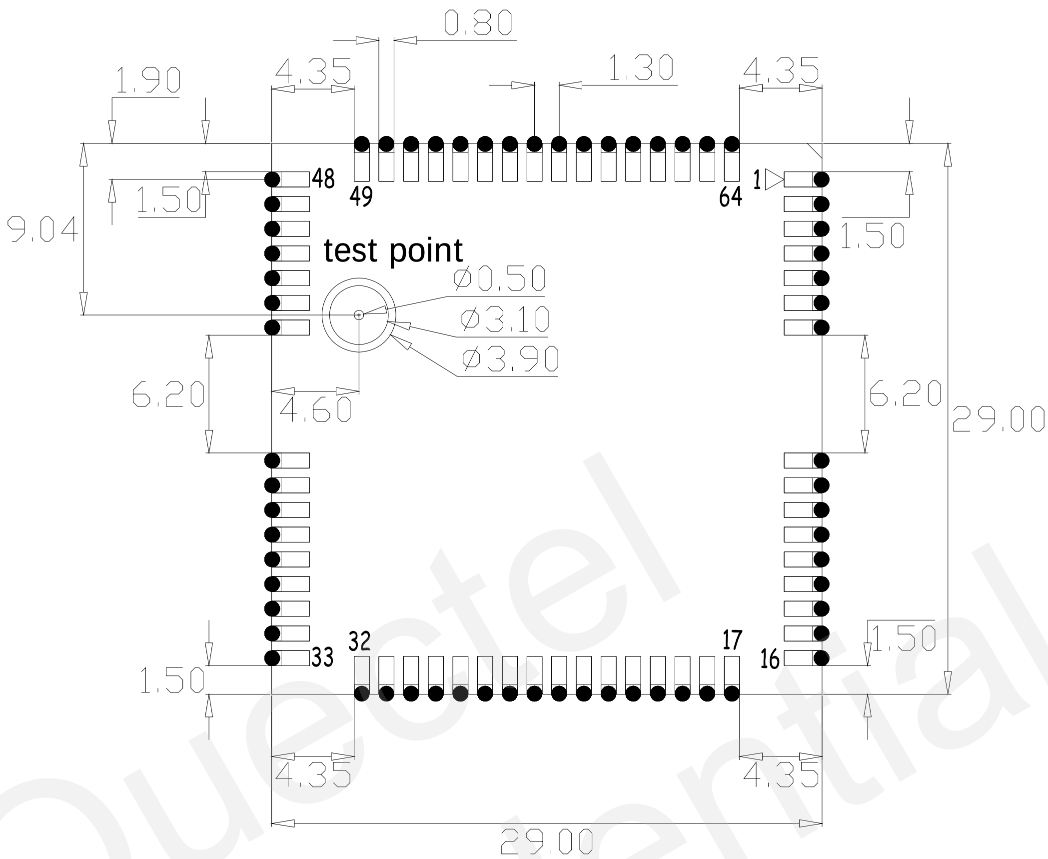


Figure 45: M12 bottom dimensions（Unit: mm）

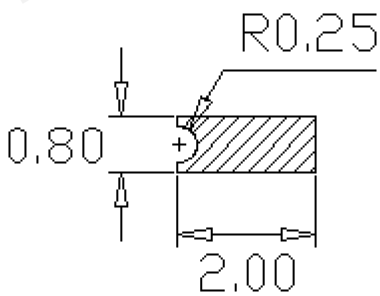
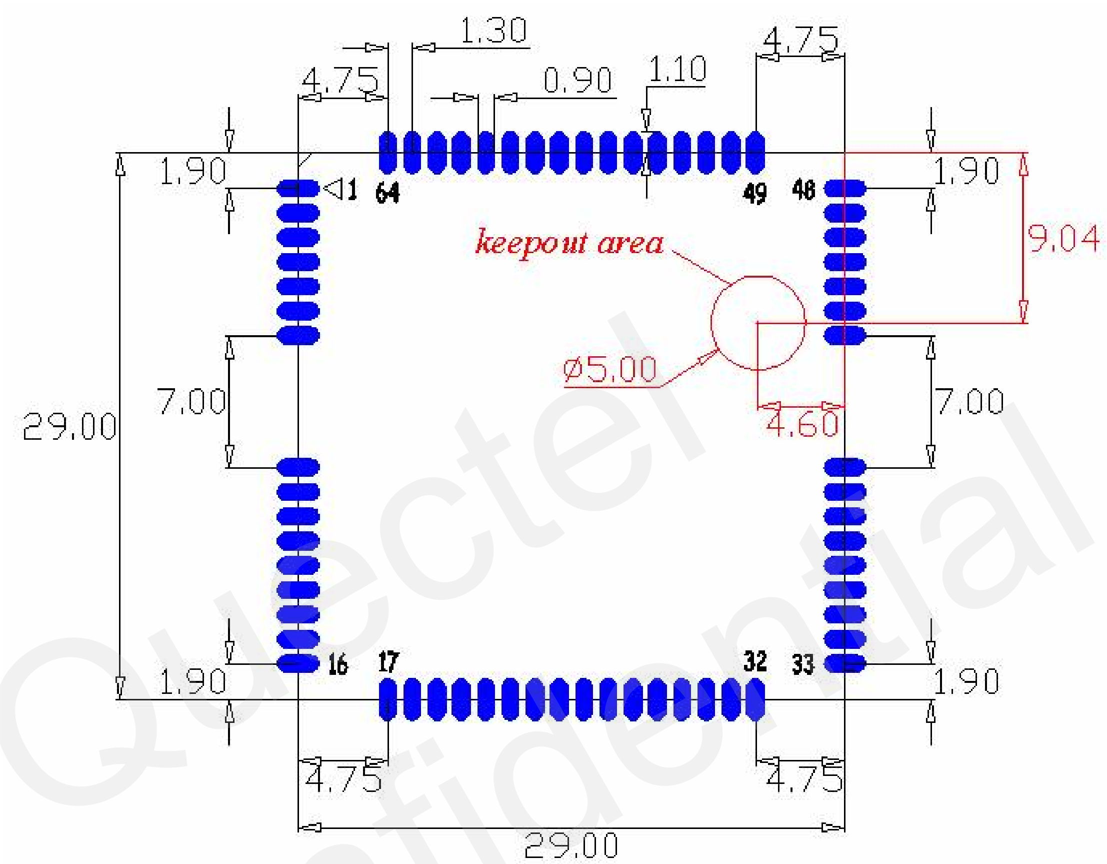
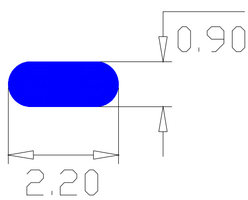


Figure 46: PAD bottom dimensions（Unit: mm）

6.2 Footprint of recommendation





single pad

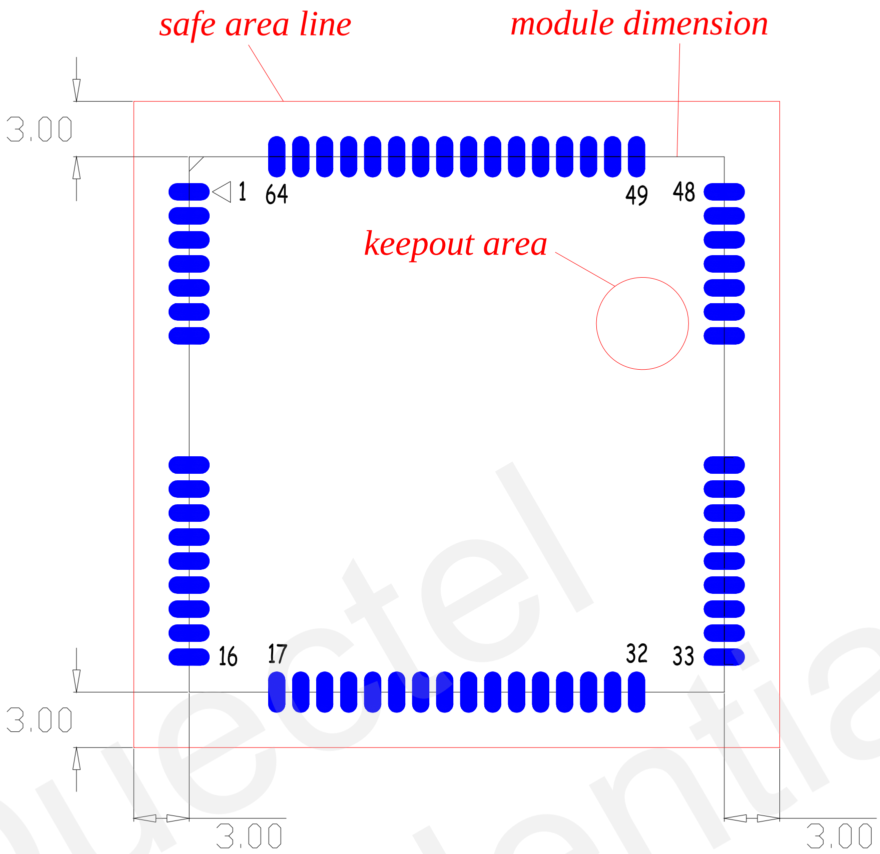


Figure 47: Footprint of recommendation（Unit: mm）

Note1：Keep out the area below the test point in the host PCB. Place solder mask.

Note2：In order to maintain the module, keep about 3mm between the module and other components in host PCB.

6.3 Top view of the module

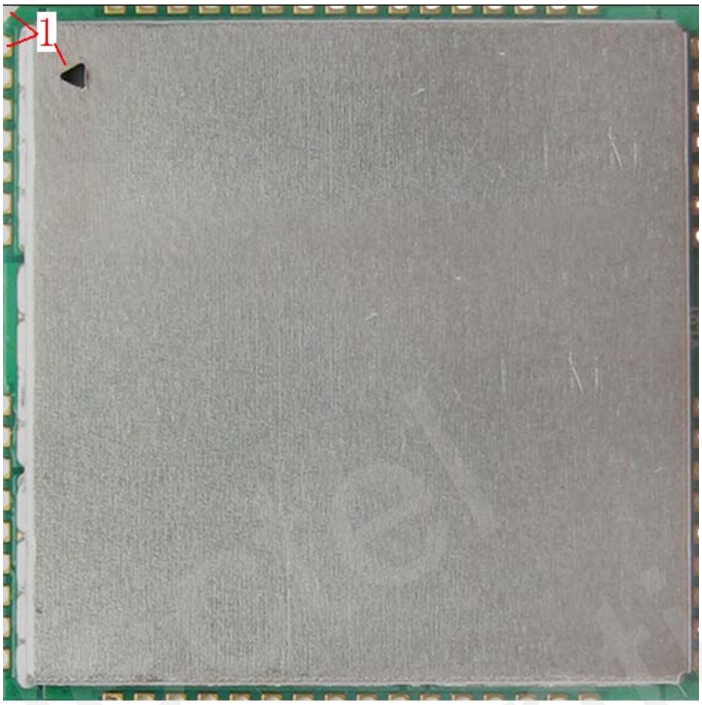


Figure 48: Top view of the module

6.4 Bottom view of the module

Figure 49: Bottom view of the module

Appendix A: GPRS coding schemes

Four coding schemes are used in GPRS protocol. The differences between them are shown in Table 43.

Table 43: Description of different coding schemes

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

Radio block structure of CS-1, CS-2 and CS-3 is shown as Figure 50:

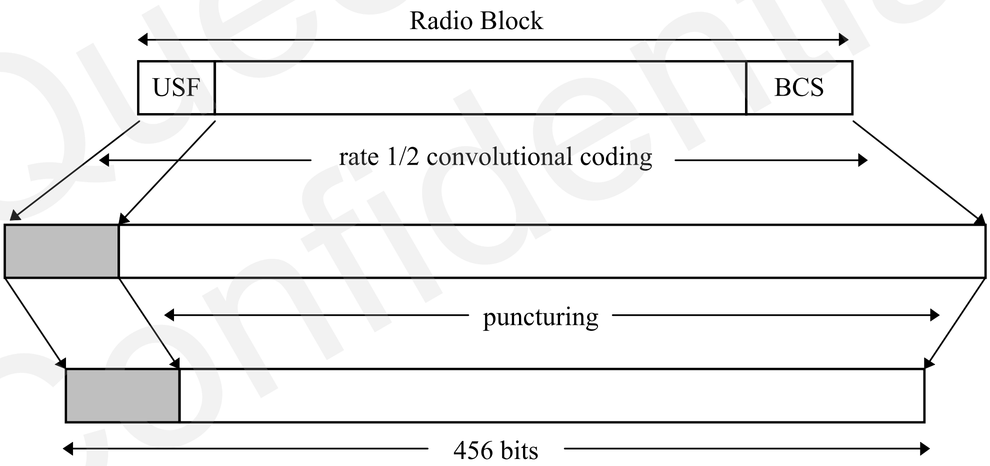


Figure 50: Radio block structure of CS-1, CS-2 and CS-3

Radio block structure of CS-4 is shown as Figure 51:

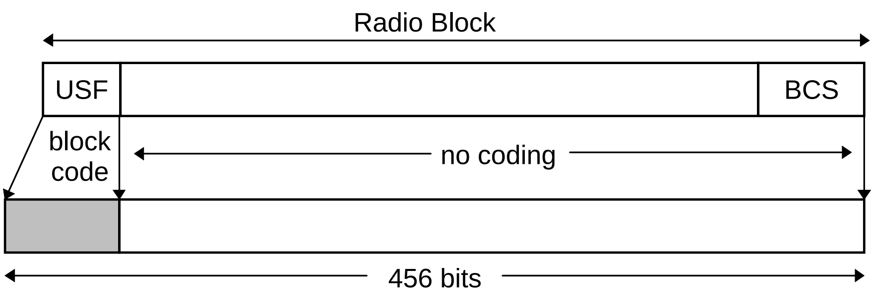


Figure 51: Radio block structure of CS-4

Appendix B: 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 44.

Table 44: 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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