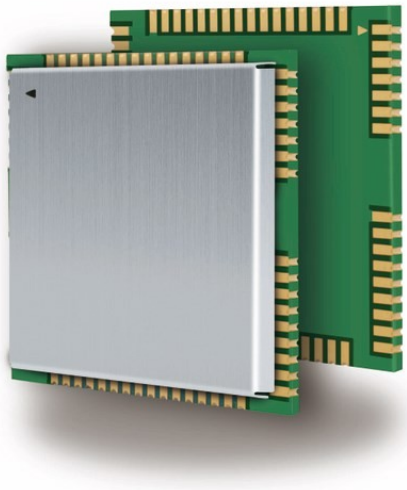
M12

Quectel Cellular Engine

Hardware Design

M12_HD_V3.3



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0. Revision history

Revision	Date	Author	Description of change
1.0	2010-07-20	Yong AN	Initial
1.1	2010-11-30	Yong AN	Added Chapter 4.5 for RF pad welding.
3.0	2012-02-14	Layne YE	1. Modified the power supply range. 2. Modified buzzer interface as RESERVED. 3. Modified the display interface as SD interface. 4. Modified the peak current in a transmitting burst. 5. Modified the current consumption in GSM talk mode and GPRS communication mode. 6. Modified the RF receiving sensitivity.
3.1	2012-03-15	Layne YE	1. Deleted the content of charging function. 2. Modified the current consumption in GSM talk mode and GPRS communication mode. 3. Disabled the module hardware flow control status by default.
3.2	2012-04-16	Layne YE	1. Deleted the alarm function and relevant AT Commands. 2. Deleted the function content of keyboard pins. 3. Deleted the function content of Light_MOS pin. 4. Deleted the FAX function. 5. Deleted the echo cancellation function. 6. Modified the keyboard pins as RESERVED. 7. Modified the name of GPIO1_KBC5 pin to GPIO1.
3.3	2012-09-20	Layne YE	1. Updated the module functional diagram. 2. Modified the DC characteristics of VRTC. 3. Updated the voltage drop during burst emission. 4. Updated the SIM card reference circuit. 5. Modified the level match reference circuits for 5V peripheral system. 6. Modified the maximum trace length of SD card signals and the maximum trace difference. 7. The AOUT1 audio channel suppored voice and audio output and so on.

1. Introduction

This document defines the M12 module and describes its hardware interface which are connected with the customer application and the air interface.

This document can help customer quickly understand module interface specifications, electrical and mechanical details. Associated with application notes and user guide, customer can use M12 module to design and set up mobile applications easily.

1.1. Related documents

Table 1: Related documents

SN	Document name	Remark
[1]	M12_ATC	M12 AT commands 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 commands 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]	M12_HD_AN01	M12 hardware design application notes
[12]	GSM_FW_Upgrade_AN01	GSM Firmware upgrade application notes
[13]	M10_EVB_UGD	M10 EVB user guide

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
Inorm	Normal Current
kbps	Kilo Bits Per Second
LED	Light Emitting Diode

Abbreviation	Description
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

Abbreviation	Description
SM	SIM phonebook

1.3. Safety cautions

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. Manufacturers 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

M12 is a Dual-band GSM/GPRS engine that works at frequencies of GSM900MHz and DCS1800MHz. M12 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*** and ***Appendix B***.

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

M12 is a 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.

Designed with power saving technique, the current consumption of M12 is as low as 1.3 mA in SLEEP mode when DRX is 5.

M12 is integrated with Internet service protocols, which are TCP/UDP, FTP and HTTP. 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: 3.3V ~4.6V Typical supply voltage: 4V
Power saving	Typical power consumption in SLEEP mode：1.3mA@ DRX=5 1.2mA@ 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+
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: -35°C ~ +75°C

	● Restricted operation: -40°C ~ -35°C and +75°C ~ +80°C [1)] ● Storage temperature: -45°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/UDP/FTP/HTTP/MMS/SMTP ● Support Packet Switched Broadcast Control Channel (PBCCH) ● CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps non-transparent ● Support Unstructured Supplementary Services Data (USSD)
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
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 Suppression ● Noise Reduction
Serial interface	Serial Port: ● Seven lines on serial port interface ● Used 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 ● Used for software debugging and log output UART3: ● Used for AT command
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±0.15×29±0.15×3.6±0.3mm Weight: 6g
Firmware upgrade	Firmware upgrade over Serial Port

1) When the module works in the temperature range, the deviation 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 shows a block diagram of M12 and illustrates the major functional parts.

- Power management
- Baseband
- Serial Flash
- The GSM radio frequency part
- The Peripheral interface
  —Power supply
  —Turn on/off interface
  —UART interface
  —Audio interface
  —SIM interface
  —ADC
  —SD card interface
  —RF interface

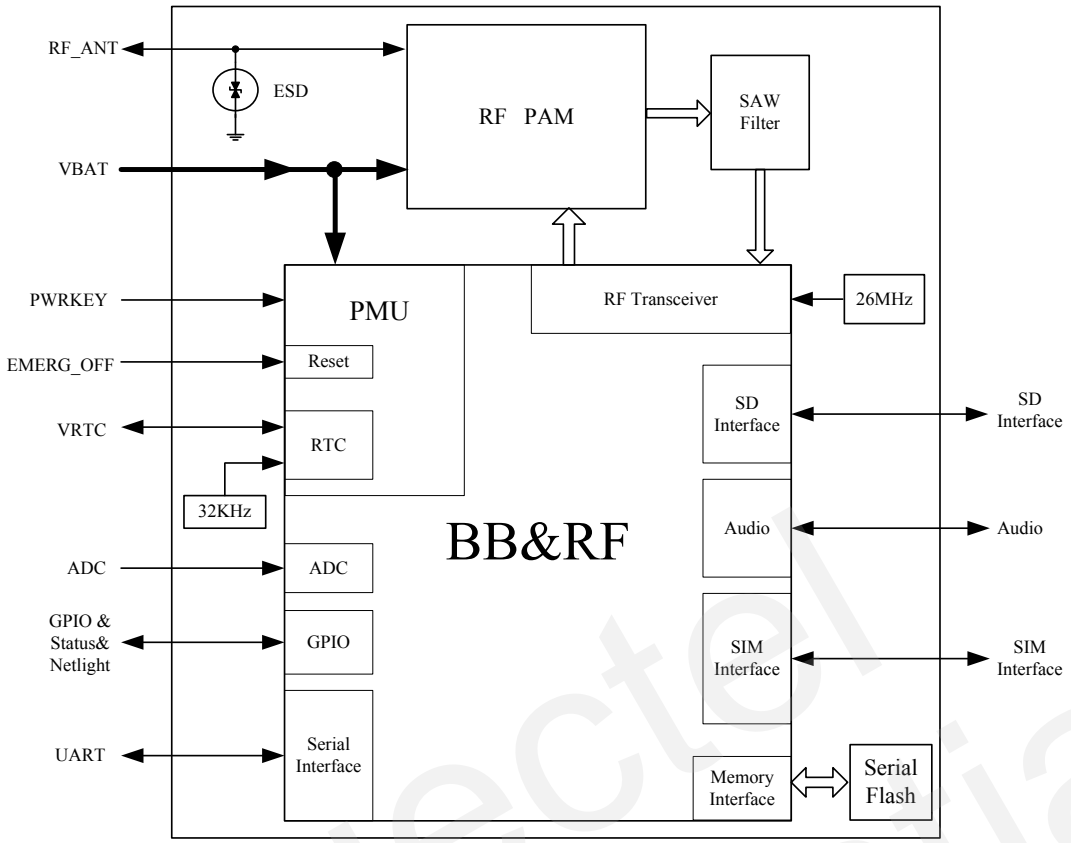


Figure 1: Module functional diagram

2.3. Evaluation board

In order to help customer on the application of M12, Quectel supplies an Evaluation Board (EVB) that hosts the module directly with appropriate power supply, SIM card holder, RS-232 serial interface, handset RJ11 port, earphone port, antenna and other peripherals to control or test the module. For more details, please refer to the ***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 the following chapters:

- Power supply ***(refer to Section 3.3)***
- Serial interfaces ***(refer to Section 3.8)***
- Audio interfaces ***(refer to Section 3.9)***
- SIM interface ***(refer to Section 3.10)***
- SD interface ***(refer to Section 3.16)***

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

3.1. Pins of module

3.1.1. Pin assignment

The following figure shows pin name and assignment of M12.

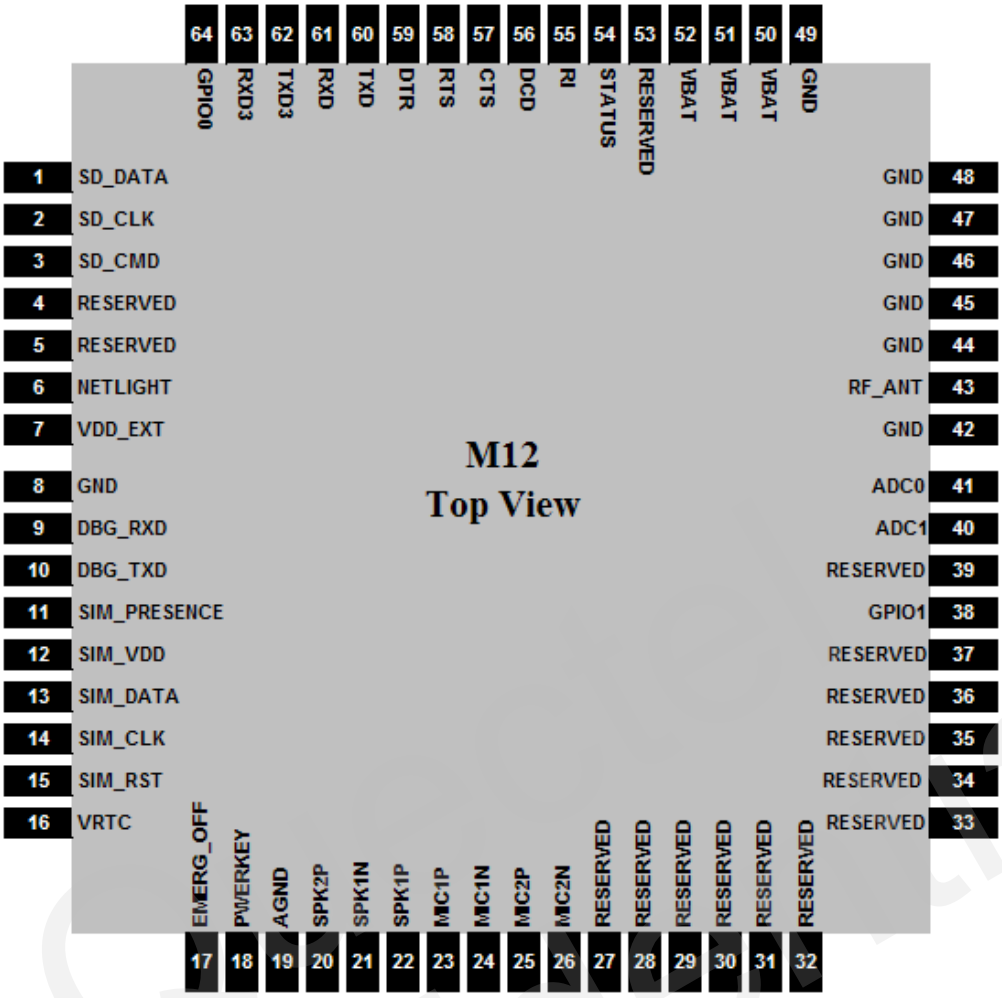


Figure 2: Top view of Module pin assignment

3.1.2. Pin description

Table 5: Pin description

Power supply					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
VBAT	50,51 52	I	Module main power supply. VBAT=3.3V~4.6V	Vmax= 4.6V Vmin=3.3V Vnorm=4.0V	It must be able to provide sufficient current in a transmitting burst which typically

					rises to 1.6A.
VRTC	16	I/O	Power supply for RTC when VBAT is not supplied. Charging for backup battery or golden capacitor when the VBAT is supplied.	VImax=3.3V VImin=1.5V VInorm=2.8V VOmax=2.85V VOmin=2.6V VOnorm=2.8V Iout(max)= 1mA Iin=2.6~5 uA	Recommended to connect to a backup battery or a golden capacitor.
VDD_EXT	7	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. Recommended to add a 2.2~4.7uF bypass capacitor, when using for power supply.
GND	8,42, 44~49		Digital ground		
Turn on /off					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
PWRKEY	18	I	Power on/off key. PWRKEY should be pulled down for a moment to turn on or off the system.	VILmax=0.1×VBAT VIHmin=0.6×VBAT VImax=VBAT	Pulled up to VBAT internally.
Emergency shutdown					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
EMERG_ OFF	17	I	Emergency off. Pulled down for at least 20ms, the module will be turned off in case of emergency. Use it only when normal shutdown through PWRKEY or AT command cannot 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	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
STATUS	54	O	Used to indicate module's operating status. High level indicates module power-on and low level indicates power-down.	VOLmax= 0.15×VDD_EXT VOHmin= 0.85×VDD_EXT	If unused, keep this pin open.
Audio interfaces					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
MIC1P MIC1N	23 24	I	Positive and negative voice-band input.	For Audio DC characteristics refer to ***Chapter 3.9***.	If unused, keep these pins open.
MIC2P MIC2N	25 26	I	Auxiliary positive and negative voice-band input.		
SPK1P SPK1N	22 21	O	Positive and negative voice-band output.		
SPK2P	20	O	Auxiliary positive voice-band output.		
AGND	19		Analog ground. Separate ground connection for external audio circuits.		
General purpose input/output					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
GPIO1	38	I/O	Normal input/output port/Keypad interface	VILmin=-0.3V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.3 VOLmax= 0.15×VDD_EXT VOHmin= 0.85×VDD_EXT	If unused, keep these pins open.
GPIO0	64	I/O	Normal input/output port		
NETLIGHT	6	O	Network status indication		

Main Serial port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
DTR	59	I	Data terminal ready	VILmin=-0.3V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.3 VOLmax= 0.15×VDD_EXT VOHmin= 0.85×VDD_EXT	If only use TXD, RXD and GND to communicate, recommended connecting RTS to GND via 0R resistor and keeping other pins open.
RXD	61	I	Receive data		
TXD	60	O	Transmit data		
RTS	58	I	Request to send		
CTS	57	O	Clear to send		
RI	55	O	Ring indicator		
DCD	56	O	Data carrier detection		
Debug port					
DBG_TXD	10	O	Serial interface for debugging only	Same as above	If unused, keep these pins open.
DBG_RXD	9	I			
UART3					
TXD3	62	O	Transmit data	Same as above	If unused, keep these pins open.
RXD3	63	I	Receive data		
SD card interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
SD_DATA	1	I/O	SD serial data	VILmin=-0.3V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.3 VOLmax= 0.15×VDD_EXT VOHmin= 0.85×VDD_EXT	If unused, keep these pins open. If used, SD_DATA is connected to SD card DATA0 pin.
SD_CLK	2	O	SD serial clock	VOLmax= 0.15×VDD_EXT VOHmax= 0.85×VDD_EXT	
SD_CMD	3	O	SD command		
SIM interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT

SIM_VDD	12	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 trace length is 200mm from the module pad to SIM card holder.
SIM_DATA	13	I/O	SIM data	SIM_VDD=3V VILmax=0.4V VIHmin= SIM_VDD-0.4 VOLmax=0.4V VOHmin= SIM_VDD-0.4 SIM_VDD=1.8V VILmax= 0.15×SIM_VDD VIHmin= SIM_VDD-0.4 VOLmax= 0.15×SIM_VDD VOHmin= SIM_VDD-0.4	
SIM_CLK	14	O	SIM clock	SIM_VDD=3V VILmax=0.4V VIHmin= 0.9×SIM_VDD VOLmax=0.4V VOHmin= 0.9×SIM_VDD SIM_VDD=1.8V VILmax= 0.12×SIM_VDD VIHmin= 0.9×SIM_VDD VOLmax= 0.12×SIM_VDD VOHmin= 0.9×SIM_VDD	
SIM_RST	15	O	SIM reset	SIM_VDD=3V VILmax=0.36V VIHmin= 0.9×SIM_VDD VOLmax=0.4V VOHmin= 0.9×SIM_VDD SIM_VDD=1.8V	

				VILmax= 0.12×SIM_VDD VIHmin= 0.9×SIM_VDD VOLmax= 0.12×SIM_VDD VOHmin= 0.9×SIM_VDD	
SIM_ PRESENCE	11	I	SIM card detection	VILmin=-0.3V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.3	If unused, keep this pin open.
AUX ADC					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
ADC0	41	I	General purpose analog to digital converter	Voltage range: 0V ~ 2.8V	If unused, keep this pin open.
ADC1	40	I			
RF interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
RF_ANT	43	I/O	RF antenna pad	Impedance of 50Ω	Refer to ***Chapter 4***.
Other interfaces					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
RESERVED	4,5, 27~37 39,53				Keep these pins open

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 data.
	GSM TALK	GSM connection is ongoing. 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 ongoing. 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[1)]	Normal shutdown by sending the "AT+QPOWD=1" command, using the PWRKEY or the EMERG_OFF 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)	"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, but the serial port is still accessible. The power consumption in this case is very low.	

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 Section 3.4.2.4.

3.3. Power supply

3.3.1. Power features of module

The power supply is one of the key issues in the designing GSM terminals. Due to the 577us radio burst emission in GSM every 4.615ms, power supply must be able to deliver high current peaks in a burst period. During these peaks, drops on the supply voltage must not exceed minimum working voltage of module.

For the M12 module, the max current consumption could reach to 1.6A during a transmit burst. It will cause a large voltage drop on the VBAT. In order to ensure stable operation of the module, it is recommended that the max voltage drop during the transmit burst does not exceed 400mV.

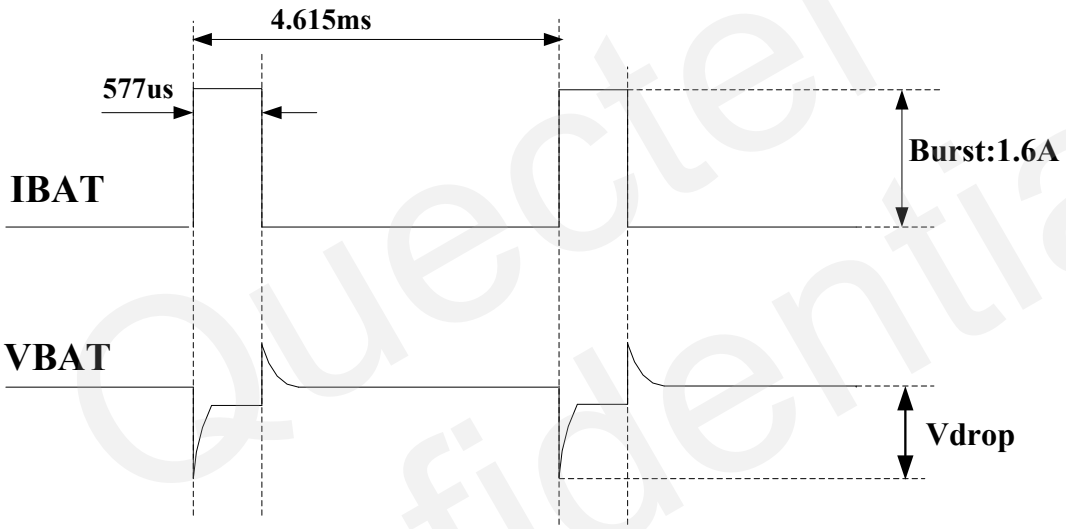


Figure 3: Voltage ripple during transmitting

3.3.2. Decrease supply voltage drop

The power supply rang of the module is 3.3V to 4.6V. Make sure that the input voltage will never drop below 3.3V even in a transmitting burst. If the power voltage drops below 3.3V, the module could turn off automatically. For better power performance, it is recommended to place a 100uF tantalum capacitor with low ESR (ESR=0.7Ω) and ceramic capacitors 100nF, 33pF and 10 pF near the VBAT pin. The reference circuit is illustrated in Figure 4.

The VBAT route should be wide enough to ensure that there is not too much voltage drop occurring during transmit burst. The width of trace should be no less than 2mm and the principle of the VBAT route is the longer route, the wider trace.

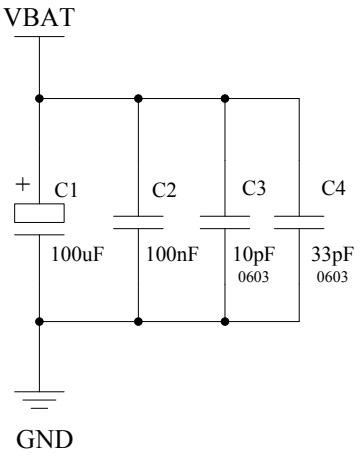


Figure 4: Reference circuit for the VBAT input

3.3.3. Reference design for power supply

The power design for the module is very important, since the performance of power supply for the module largely depends on the power source. The power supply is capable of providing the sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is suggested to use a LDO as module's power supply. If there is a big voltage difference between the input source and the desired output (VBAT), a switcher power converter is preferred to use as a power supply.

The following figure shows a reference design for +5V input power source. The designed output for the power supply is 4.16V and the maximum load current is 3A. In addition, in order to get a stable output voltage, a zener diode is placed close to the pins of VBAT. As to the zener diode, it is suggested to use a zener diode which reverse zener voltage is 5.1V and dissipation power is more than 1 Watt.

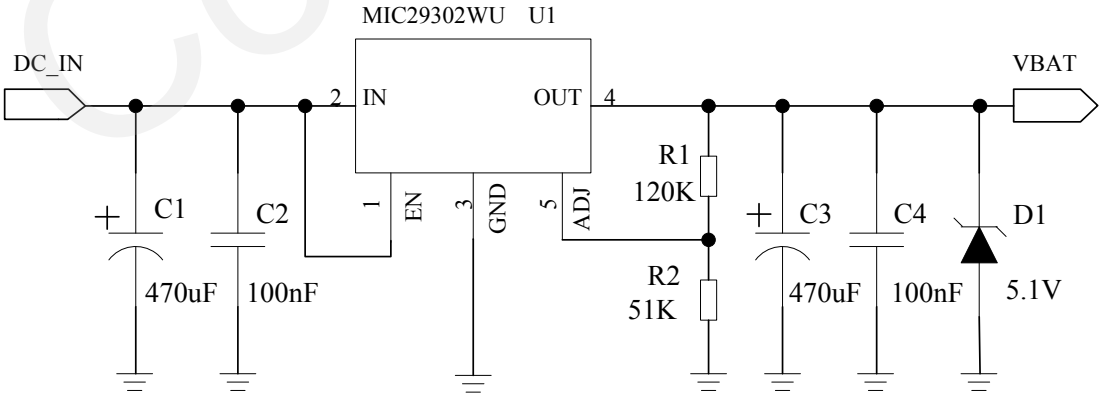


Figure 5: Reference circuit for power supply

3.3.4. Monitor power supply

To monitor the supply voltage, customer 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 module using PWRKEY pin

The module can be turned on through the PWRKEY pin. Customer 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 can monitor the level of the STATUS pin to judge whether the module is power-on or not.

Note: The module is set to autobauding mode (AT+IPR=0) in default configuration. In the autobauding mode, the URC "RDY" is not sent to host controller after powering on. 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 the module. Then an "AT+IPR=x;&W" should be sent to set a fixed baud rate for the module and save the configuration to flash memory of the module. After these configurations, the URC "RDY" would be received from the serial port of the module every time when the module is powered on. Refer to Chapter "AT+IPR" in document [1].

An open collector driver circuit is suggested to control the PWRKEY. A simple reference circuit is illustrated in Figure 6.

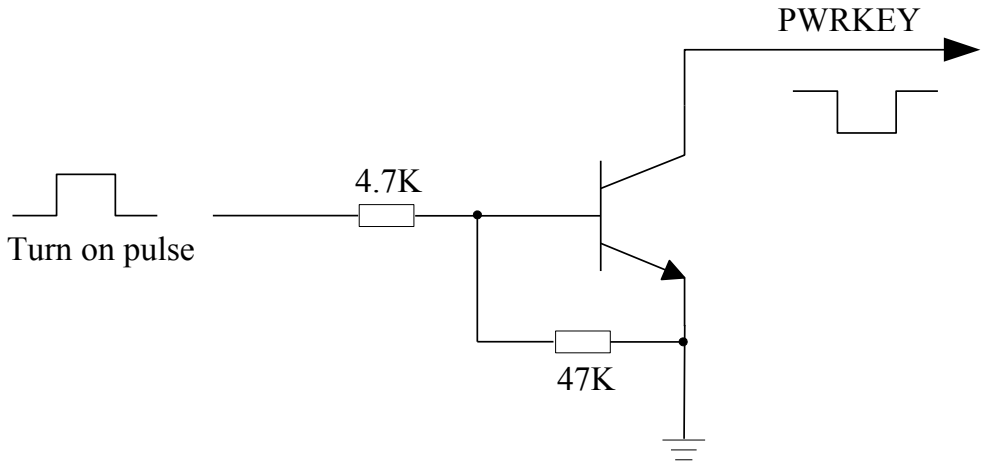


Figure 6: Turn on the module using driving circuit

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.

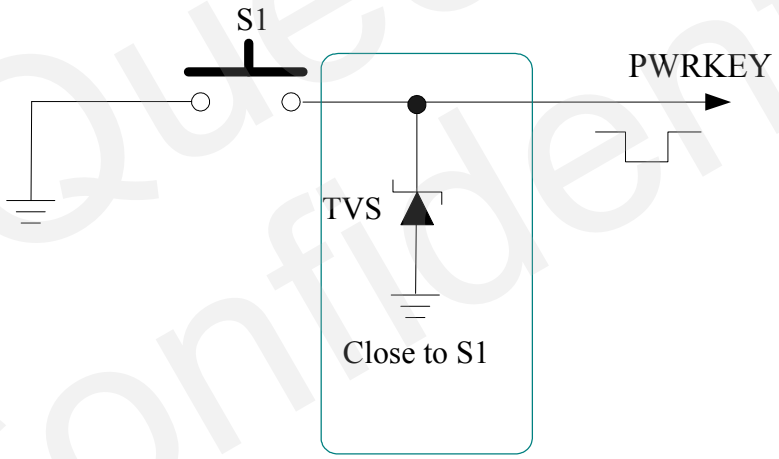


Figure 7: Turn on the module using keystroke

The power on scenarios is illustrated as the following figure.

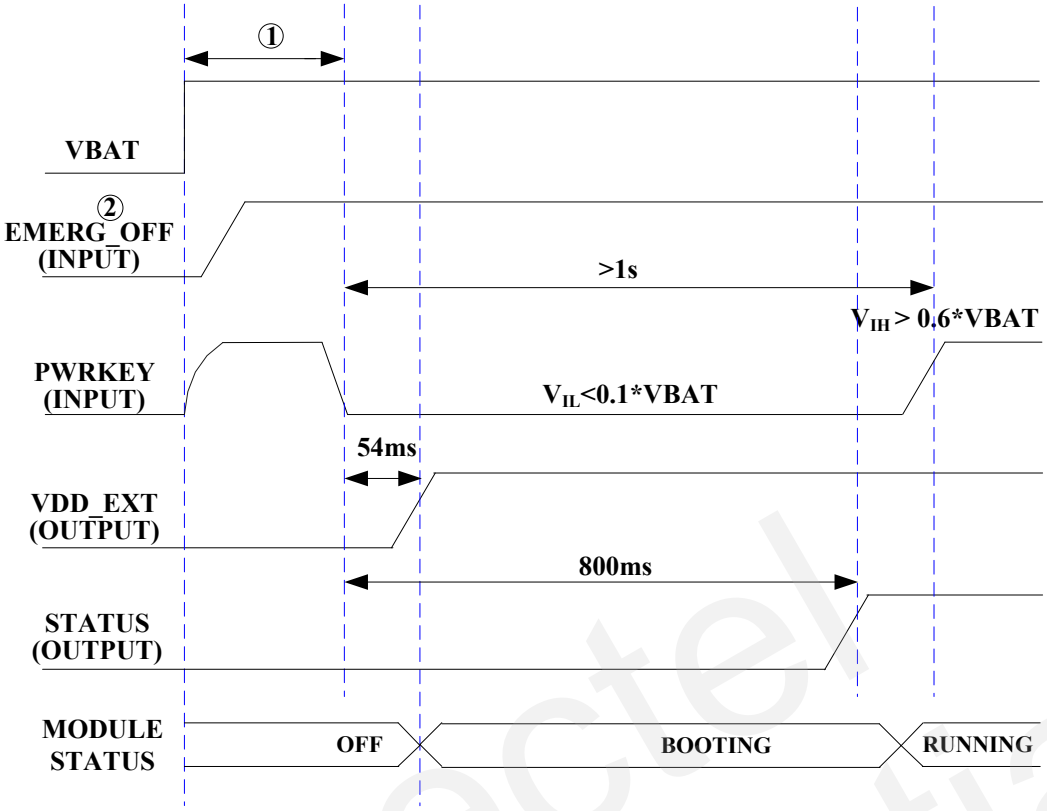


Figure 8: Timing of turning on system

① Make sure that VBAT voltage is stable before pulling down PWRKEY pin. The interval time between them is recommended 30ms.

② Keep the EMERG_OFF pin open if not used.

Note: Customer can monitor the voltage level of the STATUS pin to judge whether the module is turned on. After the STATUS pin goes to high level, PWRKEY could 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.

3.4.2. 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 PWRKEY pin

In application, the module can be turned off by driving the PWRKEY to a low level voltage for certain time. The power-down scenario is illustrated in Figure 9.

The power-down procedure causes the module to log off 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 as 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 other AT commands 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.

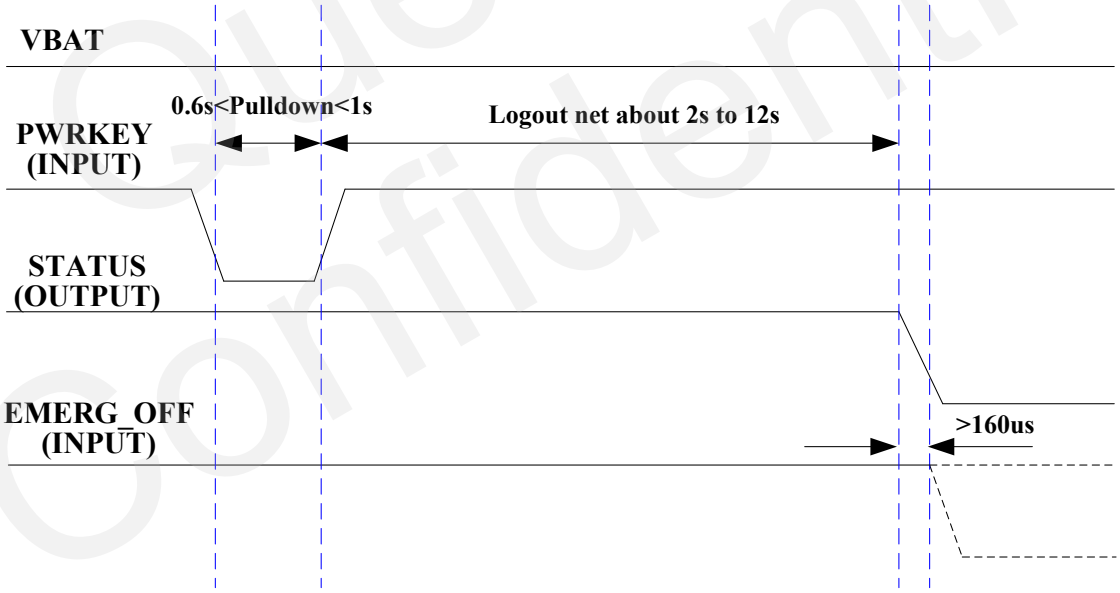


Figure 9: Timing of turning off the module

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 as shown below:

NORMAL POWER DOWN

After this moment, no other AT commands 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.

For details about the AT command of "AT+QPOWD", please refer to ***document [1]***.

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 is ≤ 3.5V, the following URC will be presented:

UNDER_VOLTAGE WARNING

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

OVER_VOLTAGE WARNING

The normal input voltage range is from 3.3V to 4.6V. If the voltage is > 4.6V or <3.3V, the module would automatically shutdown itself.

If the voltage is <3.3V, the following URC will be presented:

UNDER_VOLTAGE POWER DOWN

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

OVER_VOLTAGE POWER DOWN

Note: These result codes do not 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 other AT command can be executed, the module logs off 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 pin can be driven by an Open Drain/Collector driver or a

button. The circuit is illustrated as the following figures.

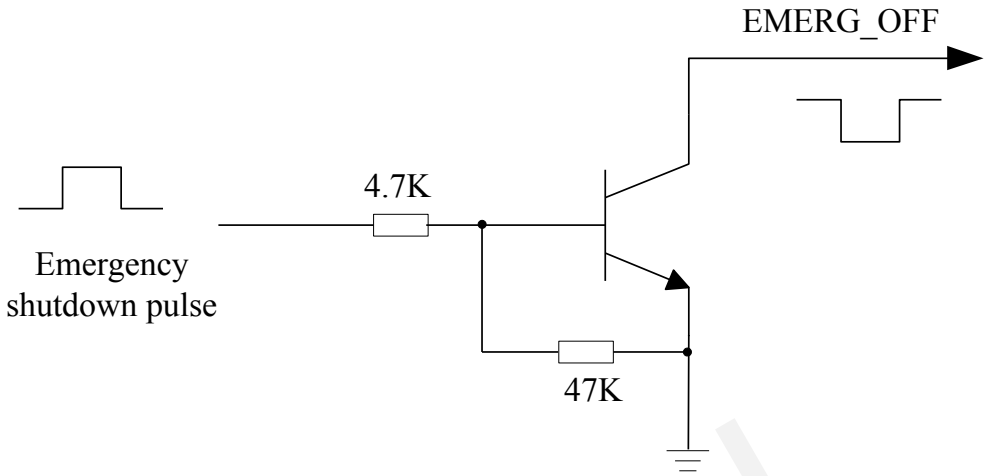


Figure 10: Reference circuit for EMERG_OFF by using driving circuit

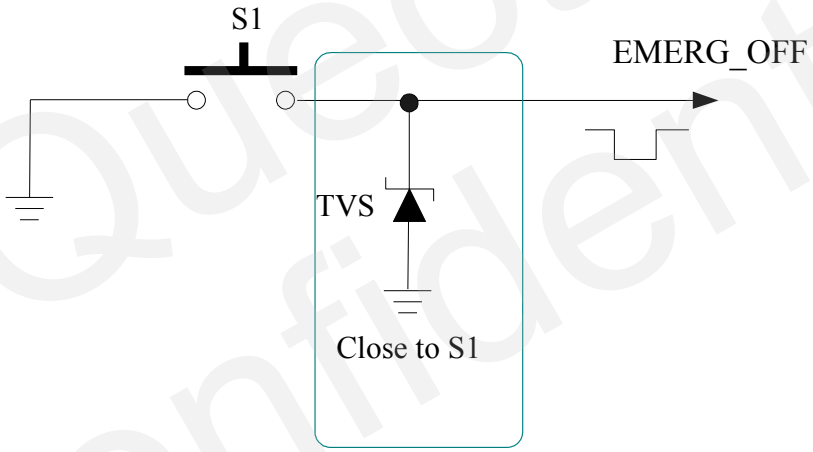


Figure 11: Reference circuit for EMERG_OFF by using button

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 is 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 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.

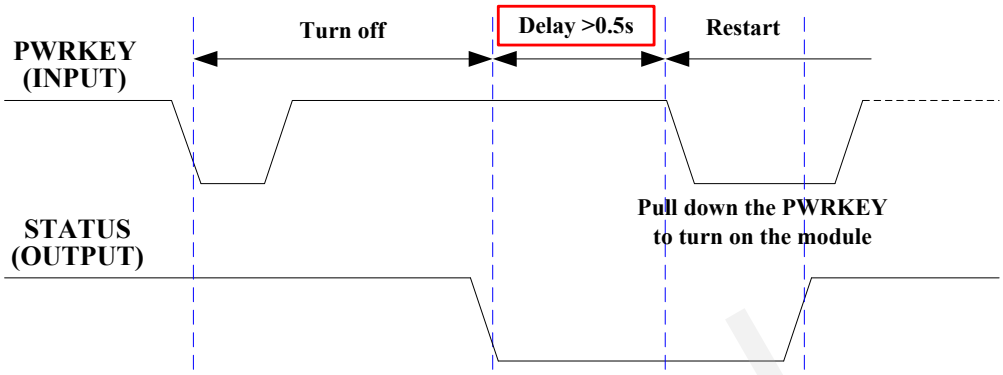


Figure 12: Timing of restarting system

The module can also be restarted by the PWRKEY after emergency shutdown. The restart scenario is illustrated as the following figure.

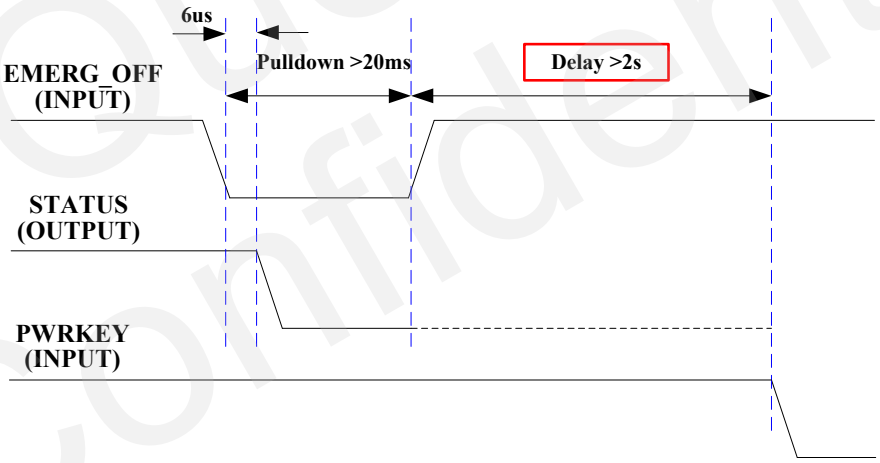


Figure 13: Timing of restarting system after emergency shutdown

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 minimize 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 not 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 will wake up the module from the SLEEP mode. The serial port will be active about 20ms after DTR is changed to a low level.

- Receive a voice or data call from network to wake up module.
- Receive a SMS from network to wake up module.

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

c3.6. Summary of state transitions

Table 7: Summary of state transition

Current mode	Next mode		
	Power down	Normal mode	Sleep mode
Power down		Use PWRKEY	
Normal mode	"AT+QPOWD", use PWRKEY pin, or use EMERG_OFF pin		Use AT command "AT+QSCLK=1" and pull DTR up
Sleep mode	Use PWRKEY pin, or use EMERG_OFF pin	Pull DTR down or incoming call or SMS or GPRS data transmission	

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 1.5K 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.

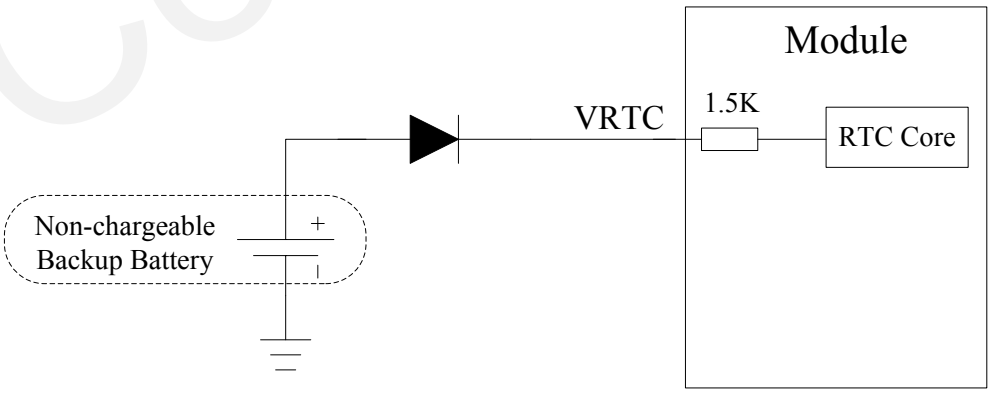


Figure 14: RTC supply from non-chargeable battery

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.

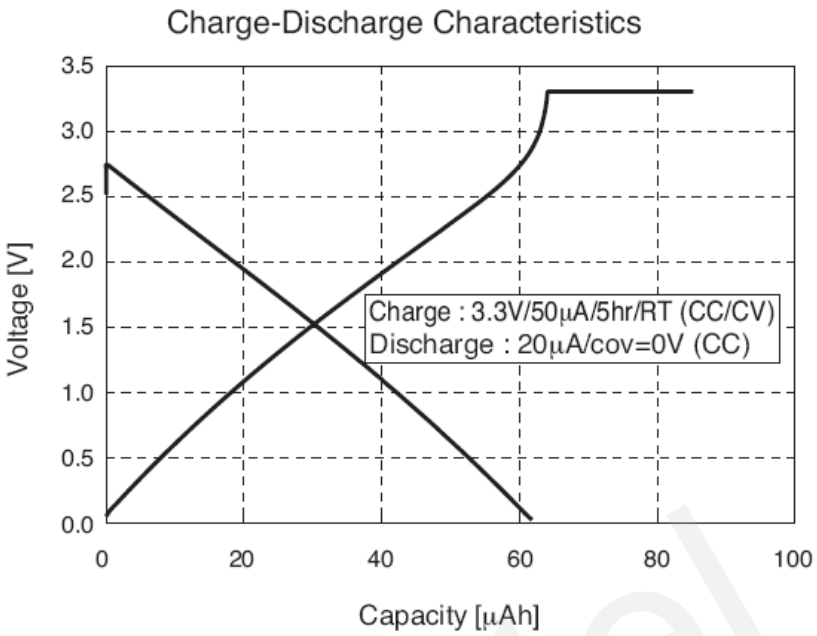


Figure 17: Seiko XH414H-IV01E Charge Characteristic

3.8. Serial interfaces

The module provides three unbalanced asynchronous serial ports including UART, Debug Port and UART3.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 UART Port:

- TXD: Send data to RXD of DTE
- RXD: Receive data from TXD of DTE
- RTS: Requests to send
- CTS: Clear to send
- DTR: DTE is ready and inform DCE (this pin can wake the module up)
- RI: Ring indicator (when the call, SMS, data of the module are coming, the module will output signal to inform DTE)
- DCD: Data carrier detection (The validity of this pin demonstrates the communication link is set up)

Note: The module disables hardware flow control by default. When hardware flow control is required, RTS and CTS should be connected to the host. AT command "AT+IFC=2,2" is used to enable hardware flow control. AT command "AT+IFC=0,0" is used to disable the hardware flow control. For more details, please refer to document [1].

The Debug Port:

- DBG_TXD: Send data to the COM port of computer
- DBG_RXD: Receive data from the COM port of computer

The UART3 Port:

- TXD3: Send data to the RXD of DTE
- RXD3: Receive data from the TXD of DTE

The logic levels are described in the following table.

Table 8: Logic levels of the serial interface

Parameter	Min	Max	Unit
V_{IL}	0	0.25×VDD_EXT	V
V_{IH}	0.75×VDD_EXT	VDD_EXT +0.3	V
V_{OL}	0	0.15×VDD_EXT	V
V_{OH}	0.85×VDD_EXT	VDD_EXT	V

Table 9: 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
UART Port	RI	55	Ring indicator
	RTS	58	Request to send
	CTS	57	Clear to send
	RXD	61	Receive data of the serial port
	TXD	60	Transmit data of the serial port
	DTR	59	Data terminal ready
	DCD	56	Data carrier detection
UART3 Port	TXD3	62	Transmit data of UART3
	RXD3	63	Receive data of UART3

3.8.1. UART Port

3.8.1.1. The features of UART Port

Seven lines on UART 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 etc. Multiplexing function is supported on the UART Port. So far only the basic mode of multiplexing is available.
- Support the communication baud rates as the following: 300,600,1200,2400,4800,9600,14400,19200,28800,38400,57600,115200.
- The default setting is autobauding mode. The following baud rates are supported for autobauding function: 4800, 9600, 19200, 38400, 57600, 115200.
- The module disable hardware flow control by default, AT command "AT+IFC=2,2" is used to enable hardware control.

After setting a fixed baud rate or autobauding, please send "AT" or "at" string at that rate. The UART port is ready when it responds "OK".

Autobauding allows the module to detect the baud rate by receiving the string "AT" or "at" from the host or PC automatically, which ensures module flexibility without considering which baud rate is used by the host controller. Autobauding is enabled by default. To take advantage of the autobauding mode, special attention should be paid according 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" string. 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 UART port has to be operated at 8 data bits, no parity and 1 stop bit (factory setting).
- The A/ and a/ commands cannot 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 it instead of using autobauding after start-up. For more details, please refer to Section "AT+IPR" in document [1].

3.8.1.2. The connection of UART

The connection between module and host via UART port is very flexible. Three connection styles are illustrated as below.

UART Port connection is shown as below when it is applied in modulation-demodulation.

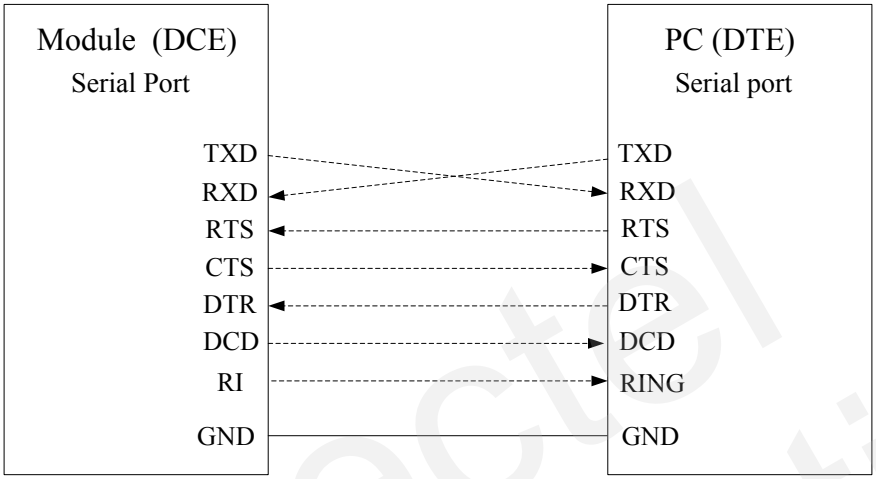


Figure 18: Connection of all functional UART port

Three lines connection is shown as below.

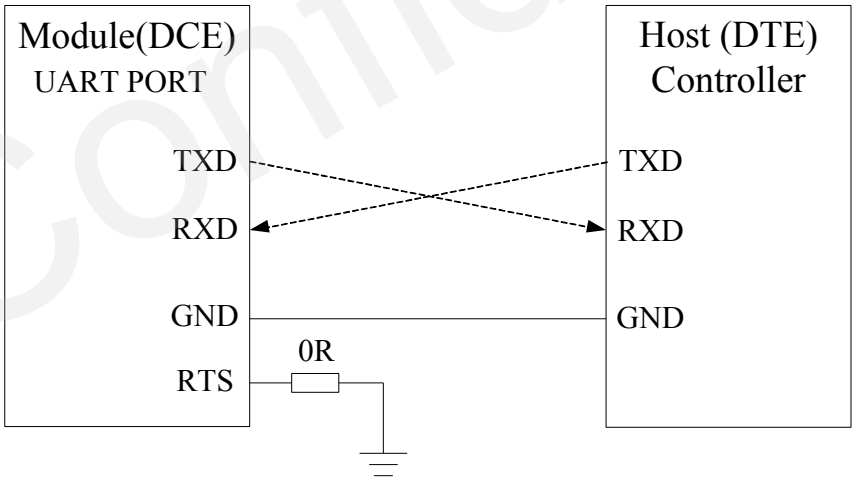


Figure 19: Connection of three lines UART port

UART Port with hardware flow control is shown as below. This connection will enhance the reliability of the mass data communication.

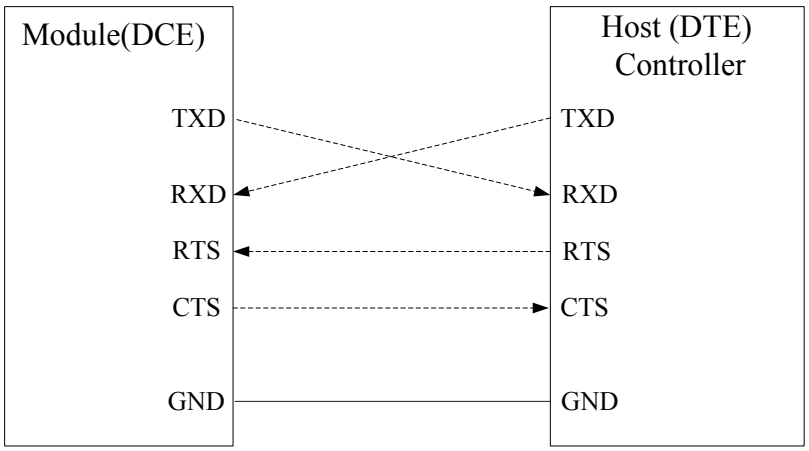


Figure 20: Connection of UART port with hardware flow control

3.8.1.3. Firmware upgrade

The TXD and RXD can be used to upgrade firmware. The PWRKEY pin must be pulled down before the firmware upgrade. Please refer to the following figure for firmware upgrade.

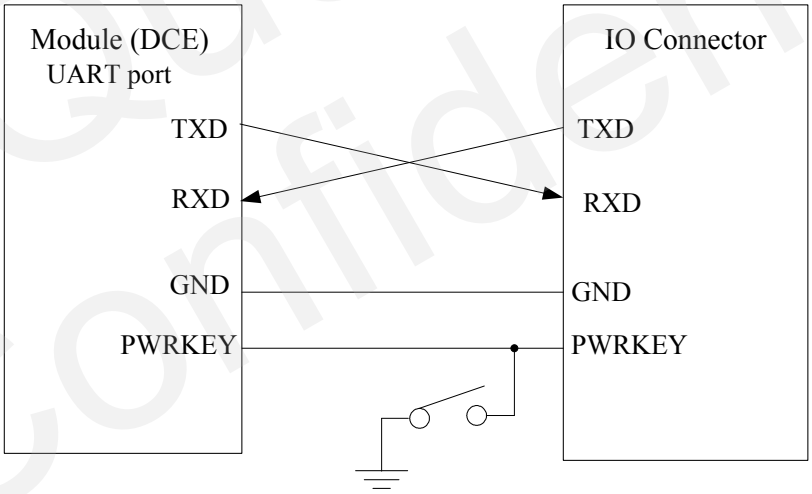


Figure 21: Connection of firmware upgrade

3.8.2. Debug Port

Debug Port:

- Two lines: DBG_TXD and DBG_RXD.
- It outputs log information automatically.
- Debug Port is only used for software debugging and its baud rate must be configured as

460800bps.

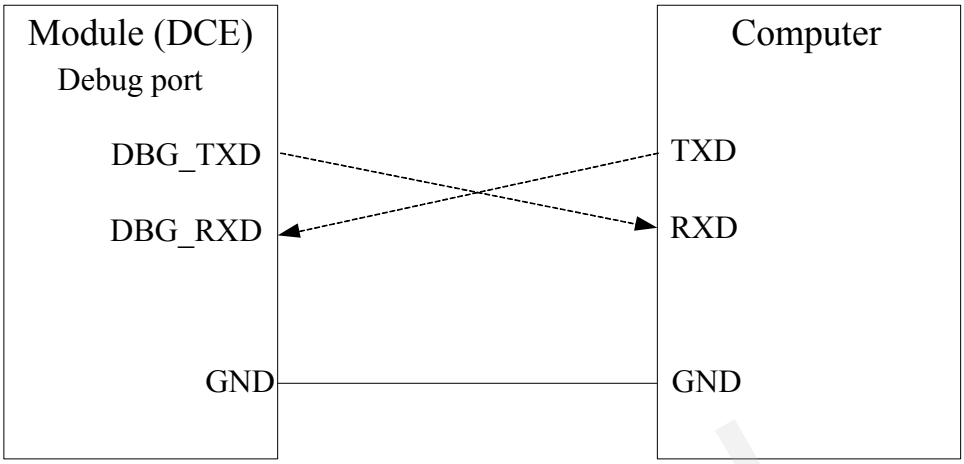


Figure 22: Connection of debug port

3.8.3. UART3 Port

UART3:

- Two data lines: TXD3and RXD3
- UART3 port is used for AT command only and does not support GPRS data, CSD, Multiplexing function etc.
- UART3 supports the communication baud rates as the following:
  4800, 9600, 14400, 19200,28800,38400,57600,115200
- The default baud rate setting is 115200bps, and autobauding is not supported. The baud rate can be modified by "AT+QSEDCB" command. For more details, please refer to ***document [1]***.

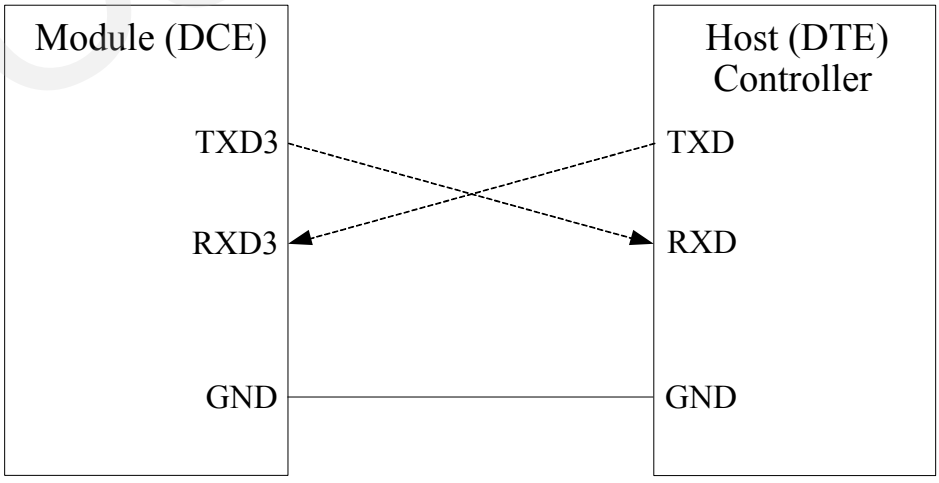


Figure 23: Connection of UART3 port

3.8.4. UART Application

The reference design of 3.3V level match is shown as below. When the peripheral MCU/ARM system is 3V, the divider resistor should be changed from 5.6K to 10K.

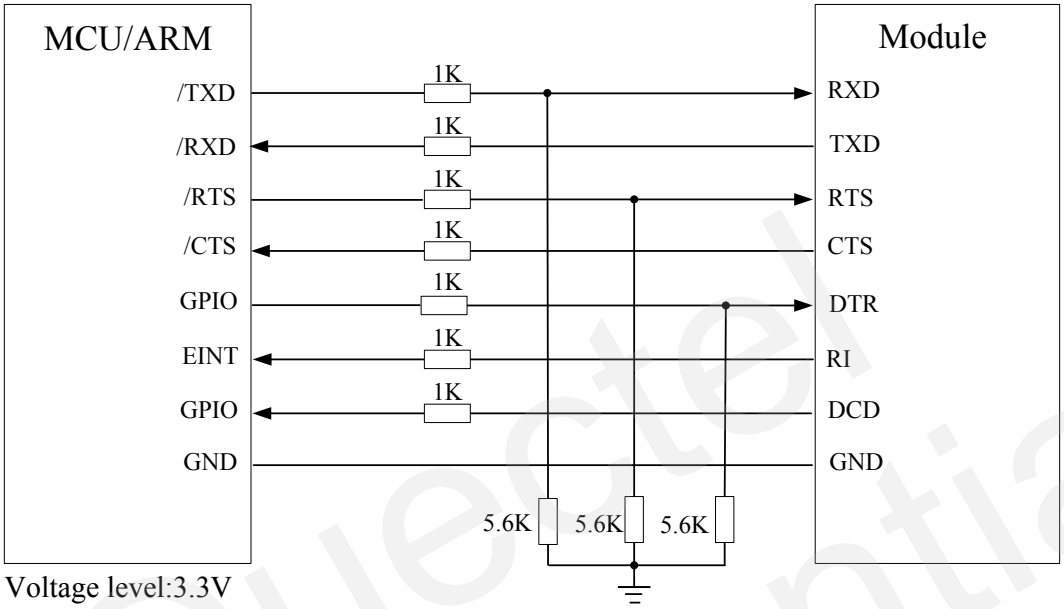


Figure 24: 3.3V level match circuit

The reference design of 5V level match is shown as below. The construction of dotted line can refer to the construction of solid line. Please pay attention to direction of connection. Input dotted line of the module should refer to input solid line of the module. Output dotted line of module should refer to output solid line of the module.

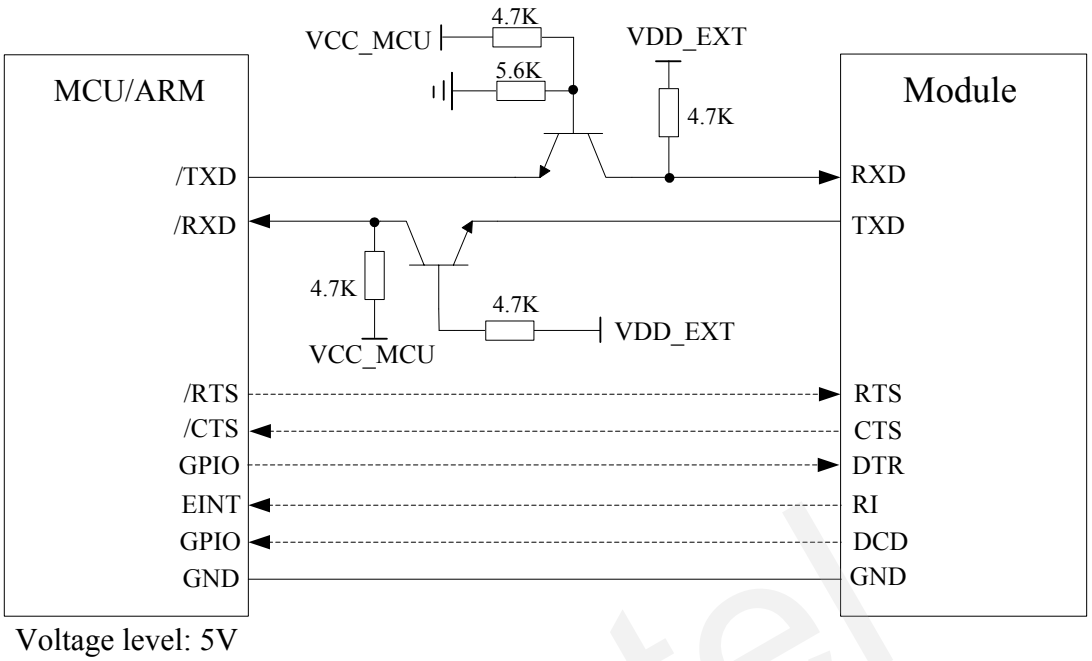


Figure 25: 5V level match circuit

The following picture is an example of connection between module and PC. A RS232 level shifter IC or circuit must be inserted between module and PC, since these three UART ports do not support the RS232 level, while support the CMOS level only.

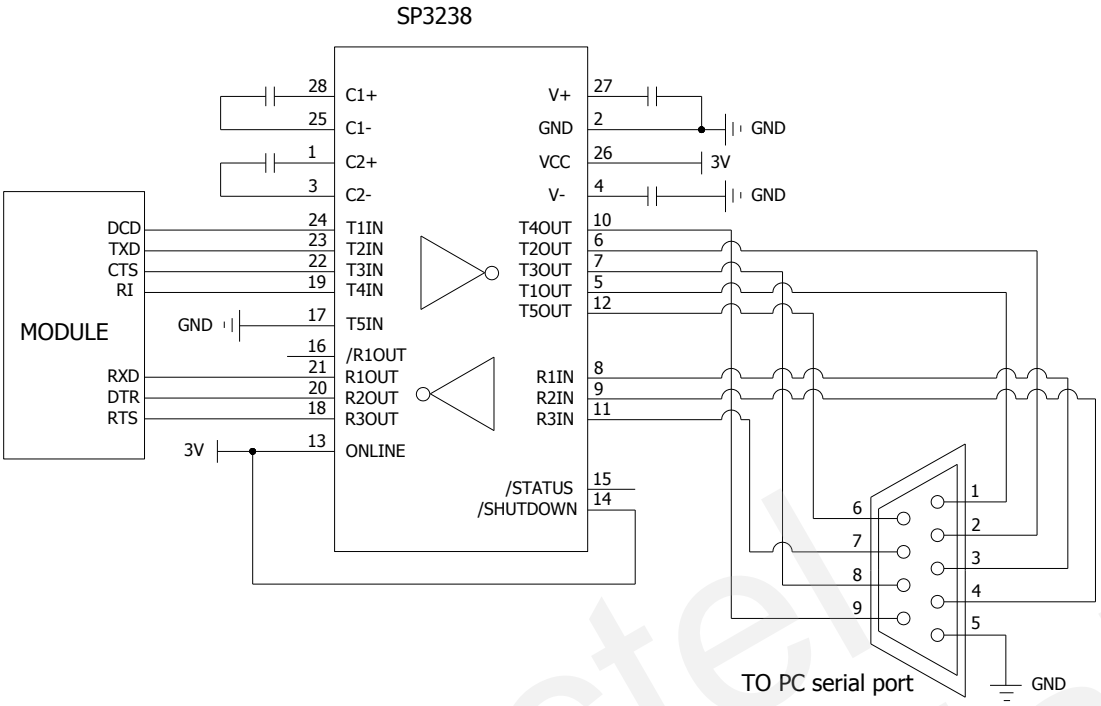


Figure 26: RS232 level match circuit

3.9. Audio interfaces

The module provides two analogy input channels and two analogy output channels.

Table 10: 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	It is suggested AGND is used in audio circuit. Do not connect it to digital ground in host PCB which could produce TDD noise.

- 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, while AOUT2 channel is typically used for headset or speaker. AOUT1 channel is a differential channel and AOUT2 is a single-ended channel. SPK2P and AGND can establish a pseudo differential mode. Both AOUT1 and AOUT2 support voice and audio output, and so on.
- These two audio channels can be swapped by "AT+QAUDCH" command. For more details, please refer to ***document [1]***.
  Use AT command "AT+QAUDCH" to select audio channel:
  0--AIN1/AOUT1 (normal audio channel), the default value is 0.
  1--AIN2/AOUT2 (auxiliary audio channel).

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+QSIDET" is to set the side-tone gain level. For more details, please refer to ***document [1]***.

3.9.1. Decrease TDD noise and other noise

The 33pF capacitor is applied for filtering out 900MHz RF interference when the module is transmitting at GSM900MHz. TDD noise could be heard without this capacitor. 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 out 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 have a choice based on test results. Sometimes, even no RF filtering capacitor is required.

The capacitor which is used for filtering out RF noise should be close to audio interface. Audio alignment should be as short as possible.

In order to decrease radio or other signal interference, the position of RF antenna should be kept away from audio interface and audio alignment. Power alignment and audio alignment should not be parallel, and power alignment should be far away from audio alignment.

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

3.9.2. Microphone interfaces configuration

AIN1/AIN2 channels come with internal bias supply for external electret microphone. A reference

circuit is shown in Figure 27.

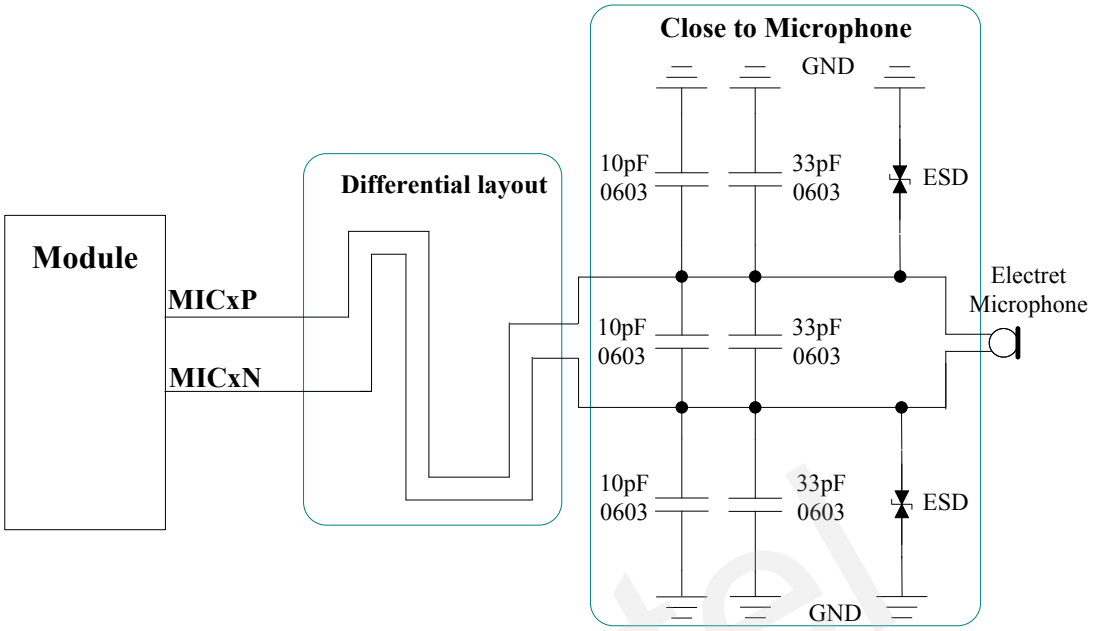


Figure 27: Microphone reference design for AIN1&AIN2

3.9.3. Receiver and speaker interface configuration

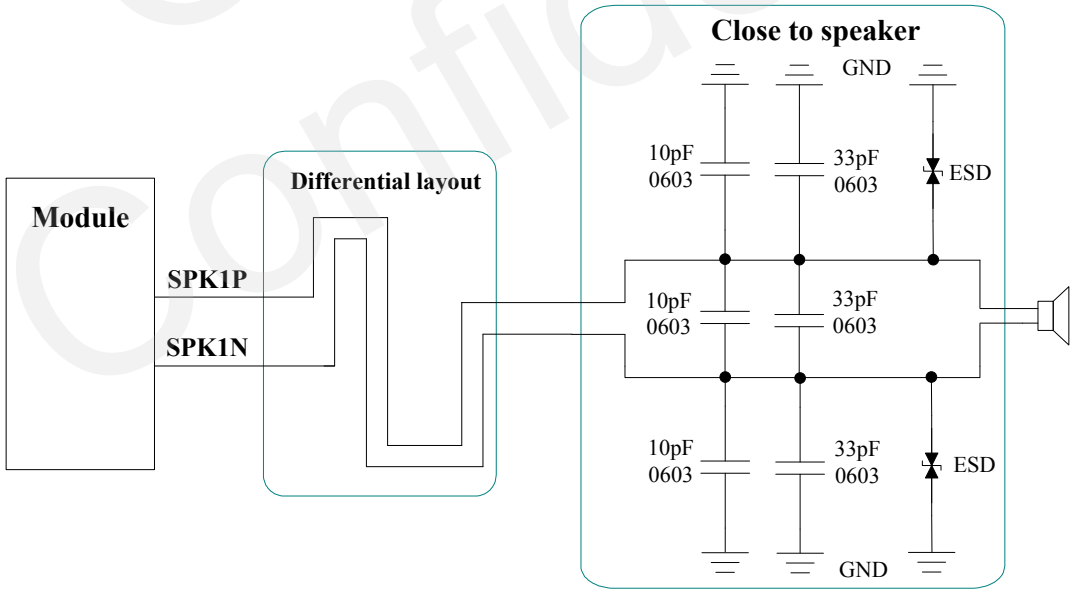


Figure 28: Reference design for AOUT1

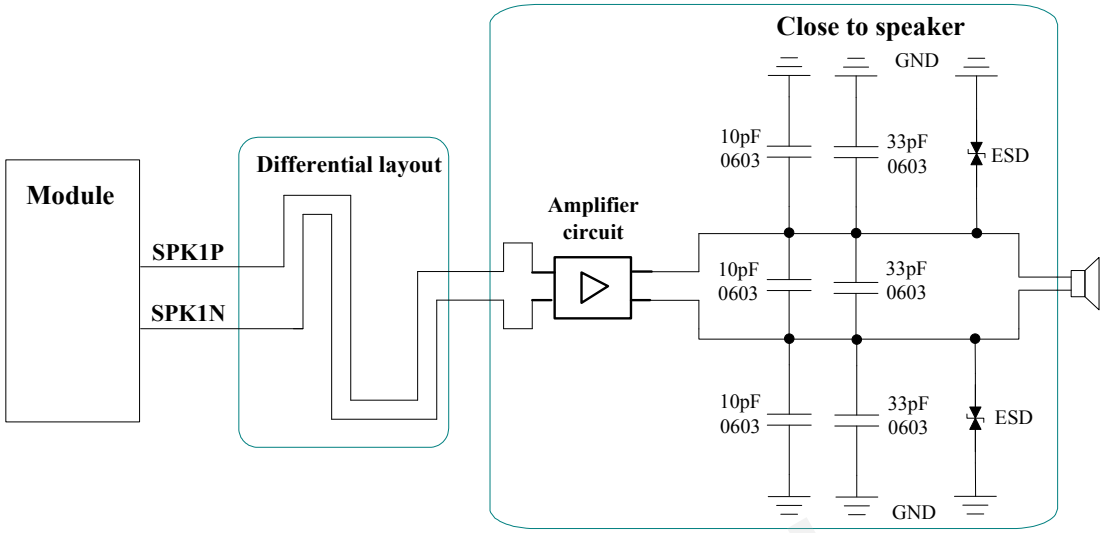


Figure 29: Reference design with an amplifier for AOUT1

Texas Instruments TPA6205A1 is recommended for a suitable differential audio amplifier. There are plenty of excellent audio amplifiers in the market.

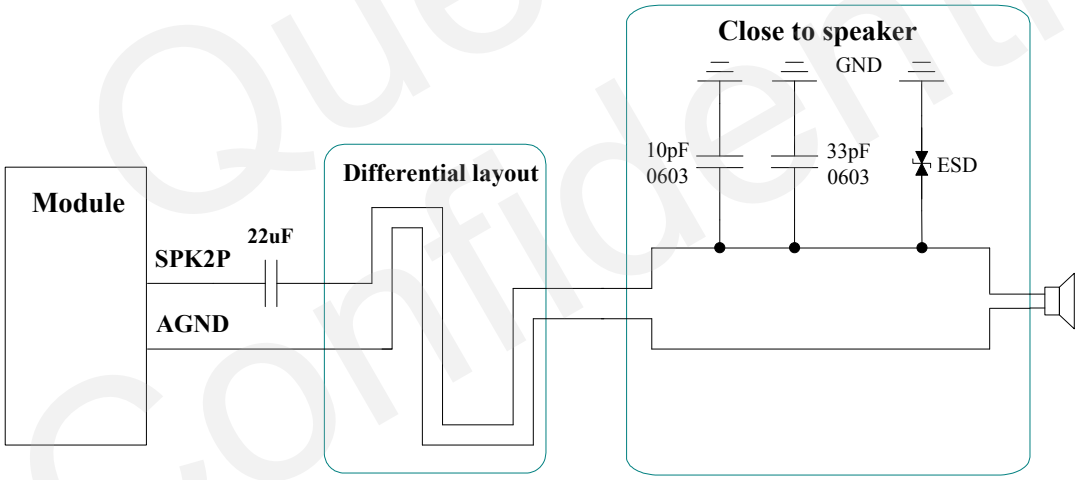


Figure 30: Reference design for AOUT2

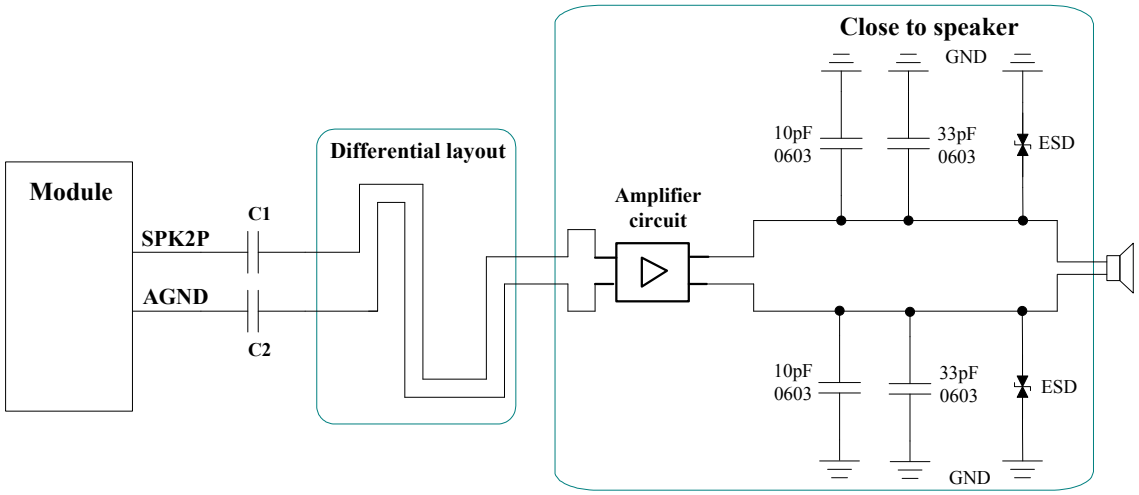


Figure 31: Reference design with an amplifier for AOUT2

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

3.9.4. Earphone interface configuration

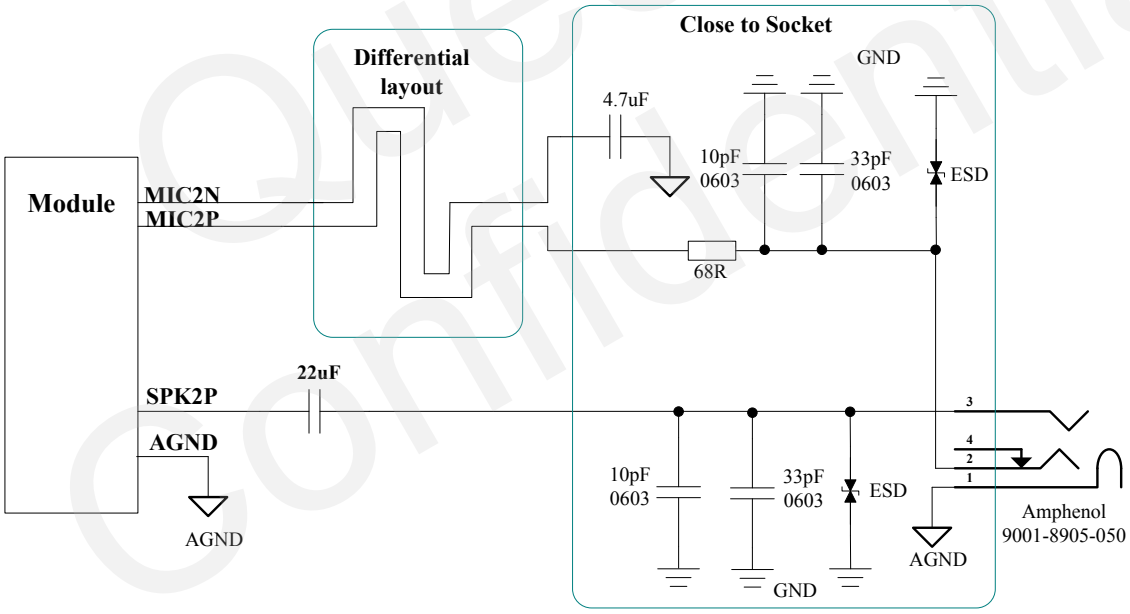


Figure 32: Reference design for an earphone

Table 11: 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 12: 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

3.10. SIM card interface

3.10.1. 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 13: 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 33 is the reference circuit for SIM interface, and here an 8-pin SIM card holder is used.

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 the SIM card is in the tray or not, the change of SIM_PRESENCE level from high to low level prompts 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

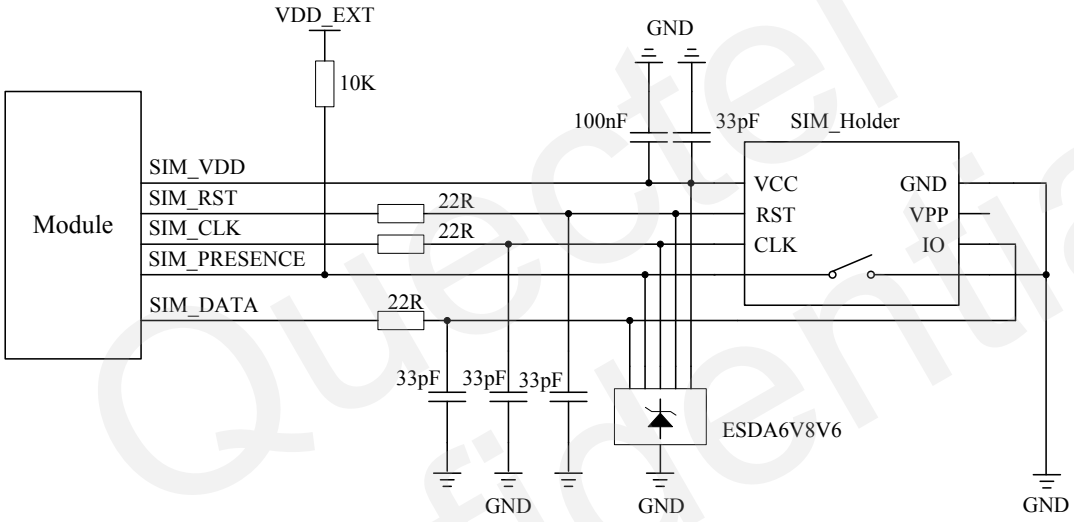


Figure 33: Reference circuit of the 8 pins SIM card

Note: Please do not use "AT+QSIMDET=1,1" which causes to initialize SIM card when the above circuit is adopted.

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

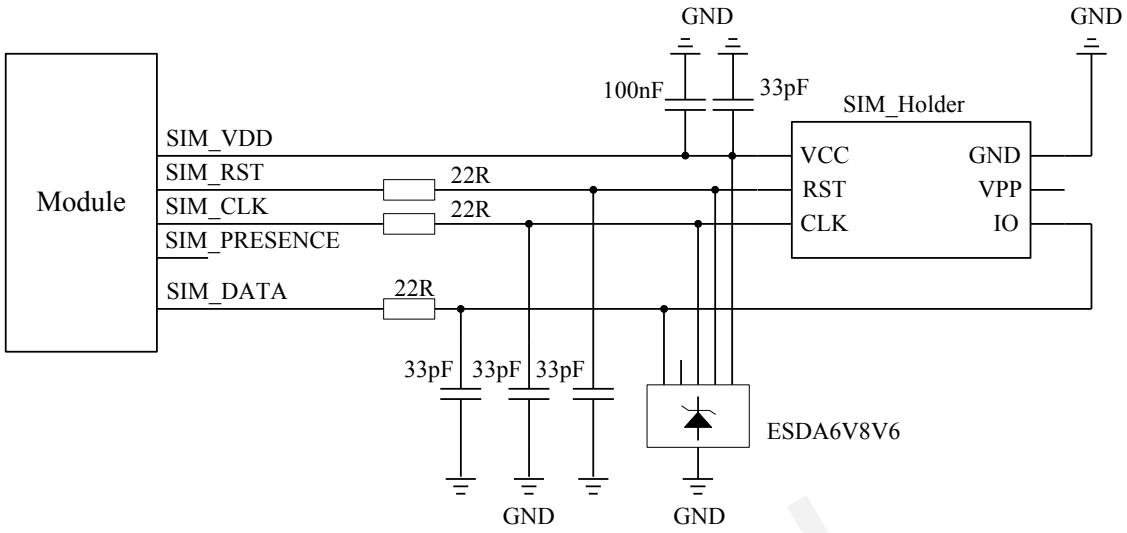


Figure 34: Reference circuit of the 6 pins SIM card

In SIM interface designing, in order to ensure good communication performance with SIM card, the following design principles should be complied with.

- Place the SIM card holder close to module as close as possible. Ensure the trace length of SIM signals do not exceed 200mm.
- Keep the SIM signals far away from VBAT power and RF trace.
- The width of SIM_VDD trace is not less than 0.5mm. Place a bypass capacitor close to SIM card power pin. The value of capacitor is less than 1uF.
- 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. So each of SIM_DATA and SIM_CLK line should be shield by ground. For good performance, the SIM_RST line also should be protected by the ground.
- In order to ensure good ESD protection, it is recommended to add TVS such as WILL (http://www.willsemi.com) ESDA6V8AV6. The capacitance of ESD component is less than 50pF. 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.
- Place the RF bypass capacitors (33pF) close to the SIM card on all signals line for improving EMI.

3.10.2. 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

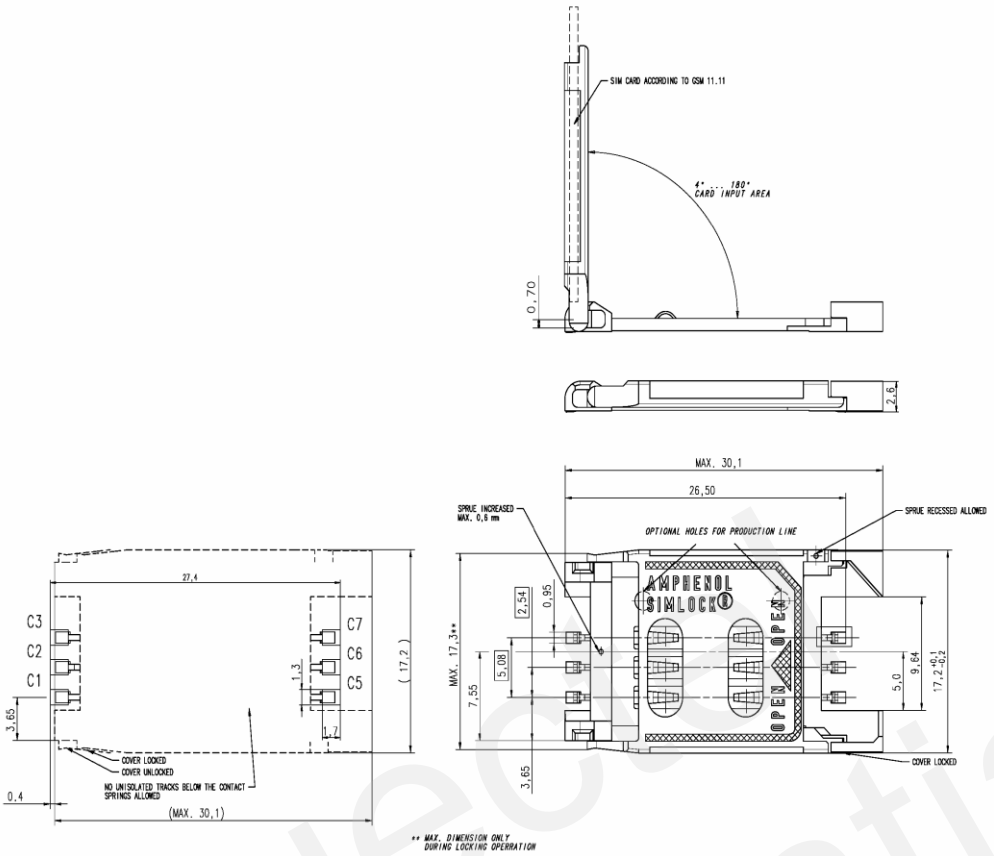


Figure 35: Amphenol C707 10M006 512 2 SIM card holder

Table 14: 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.

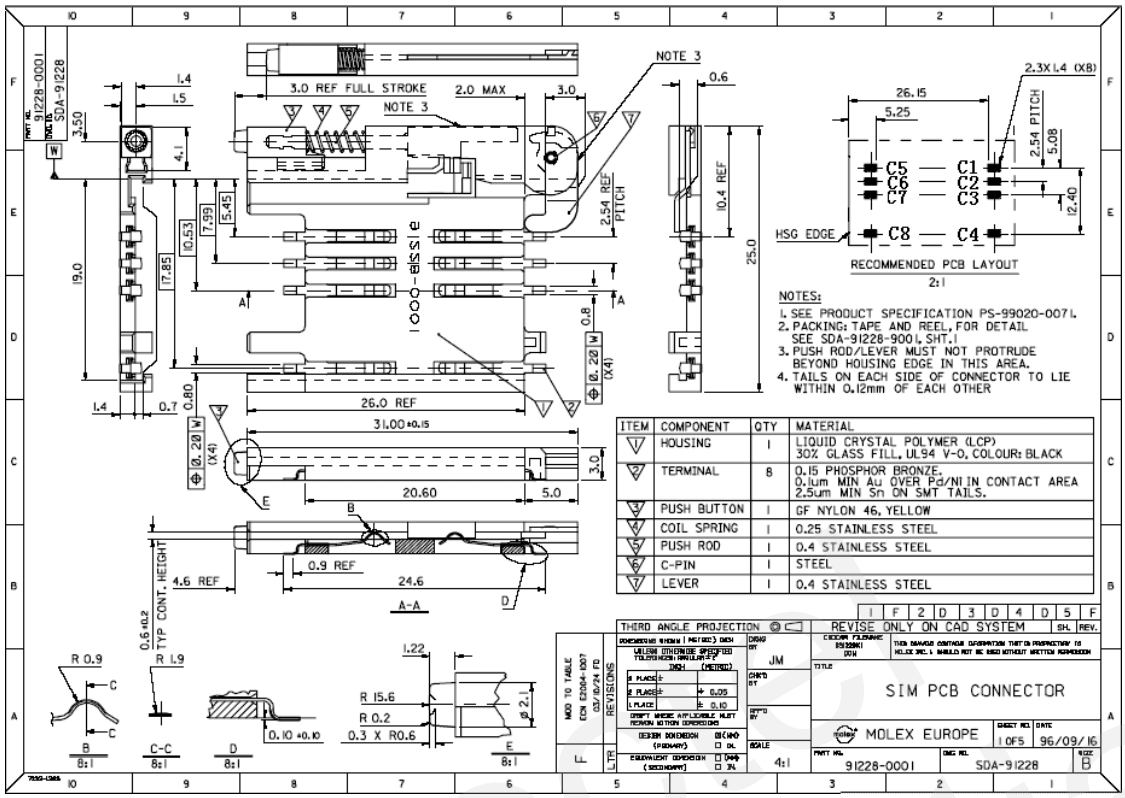


Figure 36: Molex 91288 SIM card holder

Table 15: 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 Connected
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.

3.11. ADC

The module provides two auxiliary ADC interfaces to measure the values of two analog inputs. AT command "AT+QADC" reads the voltage value present on the ADC0 pin. AT command "AT+QEADC" reads the voltage value present on the ADC1 pin. It is suggested that ADC0 channel is preferred in the use of ADC channel. For details of this AT command, please refer to ***document [1]***.

Table 16: Pin definition of the ADC

Name	Pin	Function
ADC0	41	Analog to digital converter.
ADC1	40	Analog to digital converter

Table 17: Characteristics of the ADC

Item	Min	Typ	Max	Units
Voltage Range	0		2.8	V
ADC Resolution		10		bits
ADC Accuracy		2.7		mV

3.12. Behaviors of the RI

Table 18: Behaviors of the RI

State	RI response
Standby	HIGH
Voice calling	Changed to LOW, then: 1. Changed to HIGH when call is established. 2. Use ATH to hang up the call, RI changes to HIGH. 3. Calling part hangs up, RI changes to HIGH first, and changes to LOW for 120ms indicating "NO CARRIER" as an URC, then changes to HIGH again. 4. Changed to HIGH when SMS is received.
Data calling	Changed to LOW, then: 1. Changed to HIGH when data connection is established. 2. Use ATH to hang up the data calling, RI changes to HIGH. 3. Calling part hangs up, RI changes to HIGH first, and changes to LOW for 120ms indicating "NO CARRIER" as an URC, then changes to HIGH again. 4. Changed 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 URC 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:

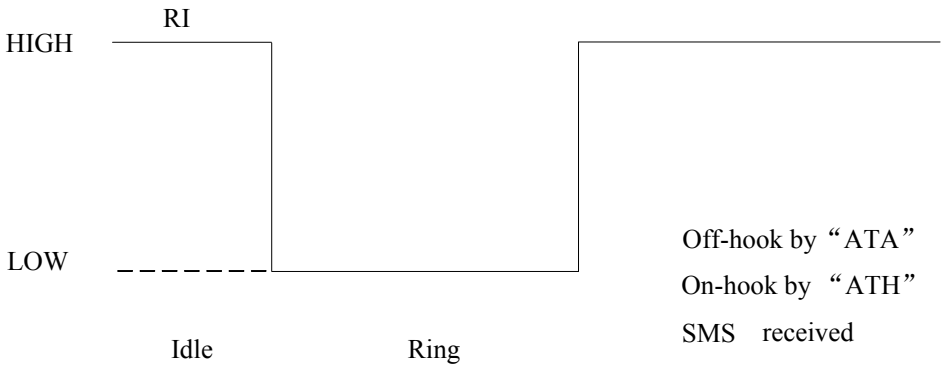


Figure 37: RI behaviour of voice calling as a receiver

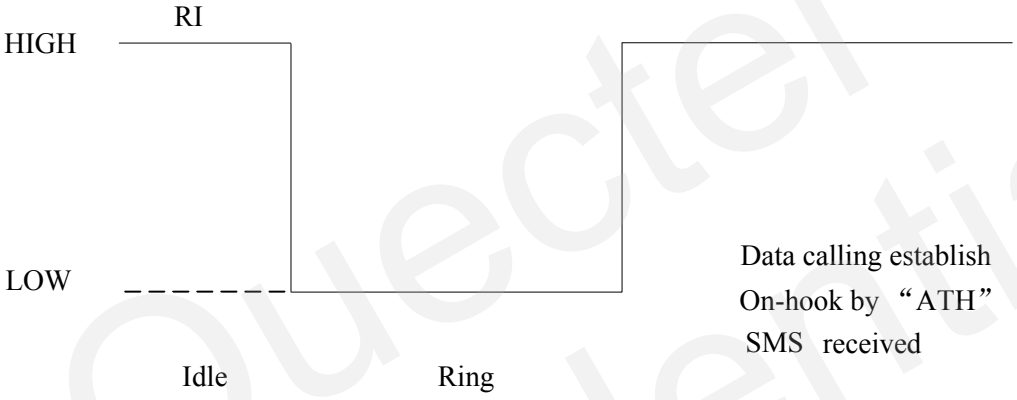


Figure 38: RI behaviour of data calling as a receiver

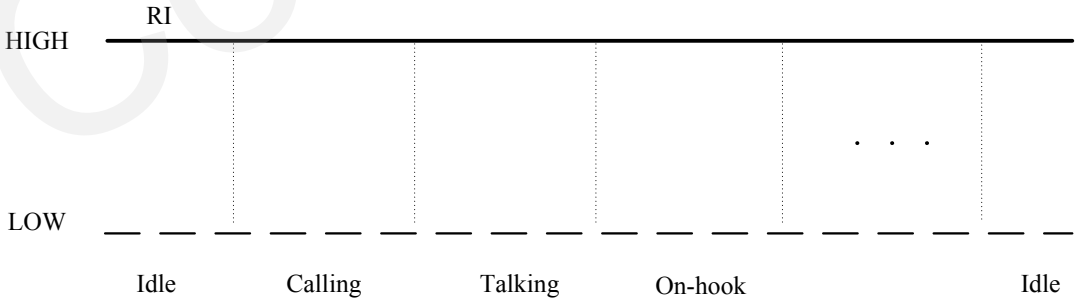


Figure 39: RI behaviour as a caller

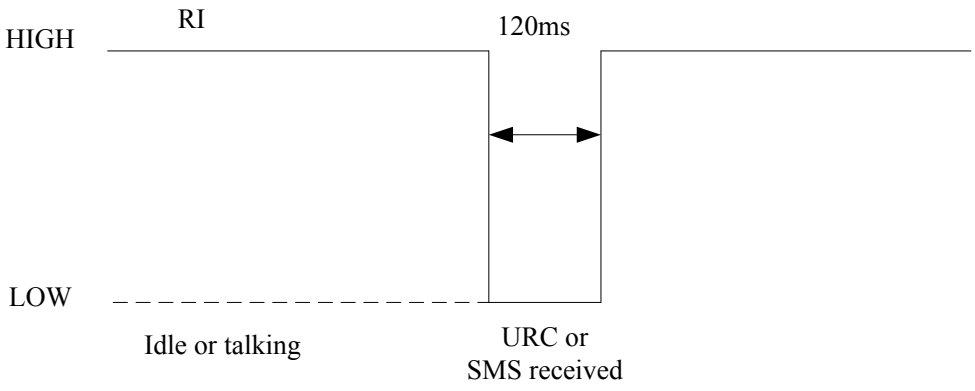


Figure 40: RI behaviour of URC or SMS received

3.13. Network status indication

The NETLIGHT signal can be used to drive a network status indicator LED. The working state of this pin is listed in Table 19.

Table 19: 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 transmission is ongoing.

A reference circuit is shown in the following figure.

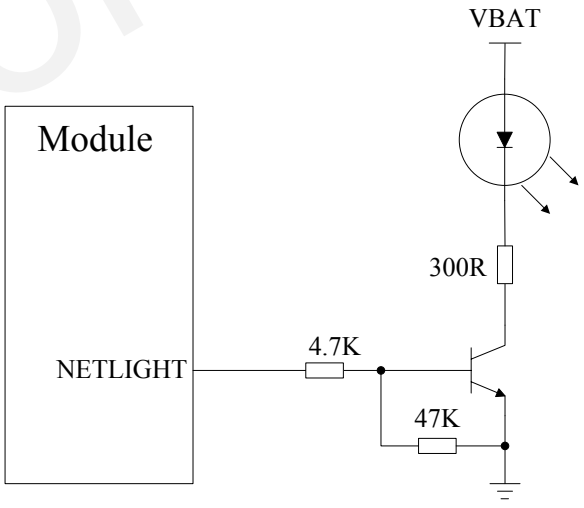


Figure 41: Reference circuit of the NETLIGHT

3.14. 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 ***Section 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 the module's operation status. A reference circuit is shown in Figure 42.

Table 20: Pin definition of the STATUS

Name	Pin	Function
STATUS	54	Indicate module's operating status

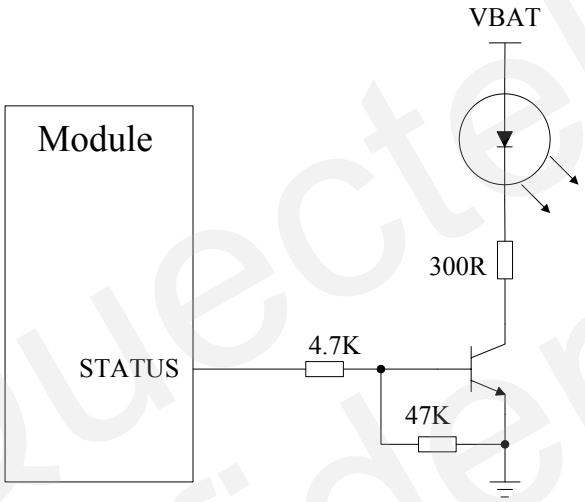


Figure 42: Reference circuit of the STATUS

3.15. 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 by AT command. For details, please refer to ***document [1]***.

Table 21: 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	38	Pulled up internally to 75K resistor	General Purpose Input/Output Port

3.16. SD card interface

The module provides SD card interface that supports many types of memory, such as Memory Stick, SD/MCC card and T-Flash or Micro SD card. The following are the main features of SD card interface:

- Only supports 1bit serial mode
- Do not support the SPI mode SD/MMC memory card
- Do not support multiple SD memory cards
- Do not support hot plug
- The data rate up to 26MHz in serial mode
- Up to 32GB maximum memory card capacity

Based on the interface features and reference circuit of SD card shown in figure 43, the users can easily design the SD card application circuit to enhance the memory capacity of the module. The users can store some high-capacity files to external memory card. Such as in the automotive application system, the module can record and store the audio file to the SD card, and also can play the audio files in SD card.

Table 22: Pin definition of the SD card interface

Name	Pin	Function
SD_DATA	1	Data output and input signal of SD card
SD_CLK	2	Clock signal of SD card output
SD_CMD	3	Command signal of SD card output

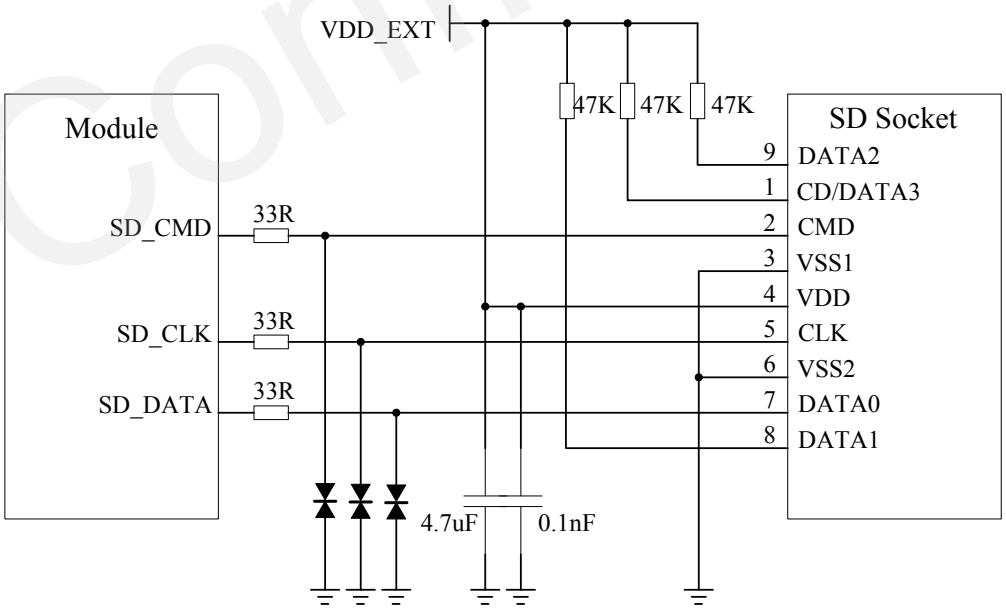


Figure 43: Reference circuit of SD card

Table 23: Pin name of the SD card and T-Flash(Micro SD) card

Pin No.	Pin name of SD card	Pin name of T-Flash(Micro SD) card
1	CD/DATA3	DATA2
2	CMD	CD/DATA3
3	VSS1	CMD
4	VDD	VDD
5	CLK	CLK
6	VSS2	VSS
7	DATA0	DATA0
8	DATA1	DATA1
9	DATA2	

In SD card interface designing, in order to ensure good communication performance with SD card, please follow the design principles below:

- Keep all the SD card lines far away from VBAT power and RF trace.
- Route all SD card signals as short as possible. Ensure the length of every trace does not exceed 10cm.
- The SD_CLK and SD_DATA and SD_CMD trace should be routed together. Keep trace difference of SD_DATA, SD_CMD and SD_CLK to be less than 10mm.
- In order to ensure good ESD protection, it is recommended to add TVS on signal pins with the capacitance less than 15pF.
- Reserve external pull-up resistor for other data lines except the DATA0 signal.
- The SD_CLK and SD_DATA line must be shielded by ground in order to improve EMI.

4. Antenna interface

The Pin 43 is the RF antenna pad. The RF interface has an impedance of 50Ω. A reference circuit is shown in the following figure. In order to adjust RF performance, it should reserve a Π-type matching circuit. By default, the resistance of R1 is 0Ω and capacitors C1 and C2 are not soldered.

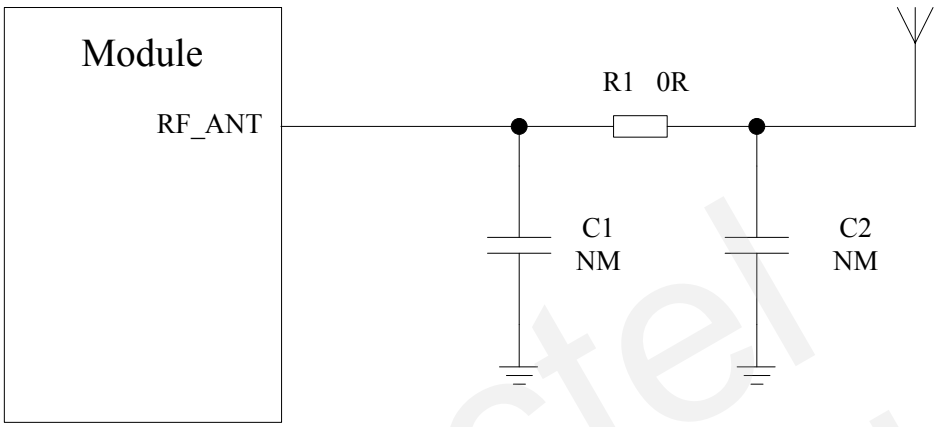


Figure 44: Reference circuit of RF interface

4.1. Antenna installation

M12 provides an RF antenna PAD for customer's antenna connection. The RF trace in host PCB connected to the module's RF antenna pad should be coplanar waveguide line or microstrip line, which characteristic impedance should be close to 50Ω. M12 comes with two grounding pads which are next to the antenna pad in order to give a better grounding.

Table 24: 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 25: 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 section 13.16 of 3GPP TS 51.010-1.

4.3. RF receiving sensitivity

Table 26: The module conducted RF receiving sensitivity

Frequency	Receiving sensitivity
EGSM900	< -108.5dBm
DCS1800	< -108.5dBm

4.4. Operating frequencies

Table 27: 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 45. Any incorrect welding type may cause poor performance both in transmitting power and receiving sensitivity.

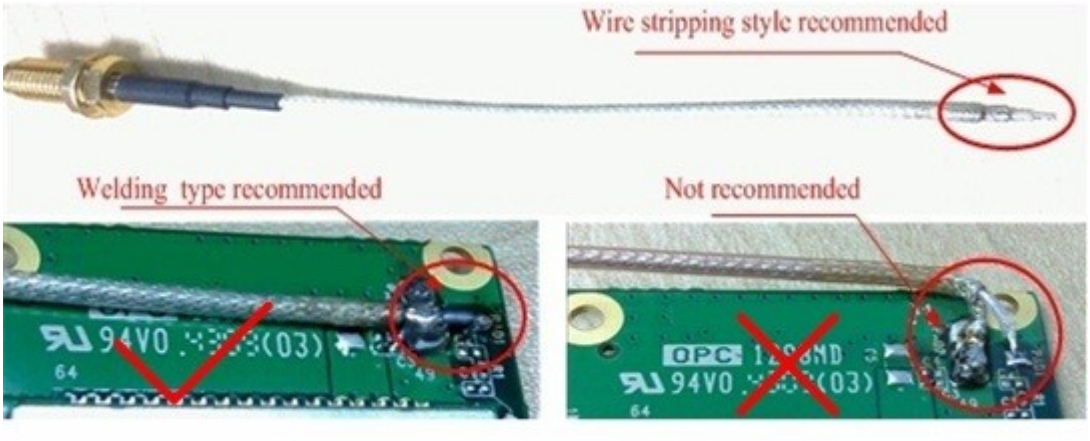


Figure 45: Recommendation of RF pad welding

5. Electrical, reliability and radio characteristics

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 28: Absolute maximum ratings

Parameter	Min	Max	Unit
VBAT	-0.3	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 29: Operating temperature

Parameter	Min	Typ	Max	Unit
Normal temperature	-35	25	+75	℃
Restricted operation[1)]	-40 to -35		+75 to +80	℃
Storage temperature	-45		+85	℃

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

5.3. Power supply ratings

Table 30: 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.	3.3	4.0	4.6	V
	Voltage drop during transmitting burst	Maximum power control level on GSM850 and GSM900.			400	mV
	Voltage ripple	Maximum power control level on GSM850 and GSM900 @ f<200kHz @ f>200kHz			 50 2	 mV mV
I_{VBAT}	Average supply current	POWER DOWN mode SLEEP mode @ DRX=5		29 1.3		uA mA
		Minimum functionality mode AT+CFUN=0 IDLE mode SLEEP mode AT+CFUN=4 IDLE mode SLEEP mode		 13 0.98 13 1.0		 mA mA mA mA
		IDLE mode EGSM900 DCS1800		 13 13		 mA mA
		TALK mode EGSM900[1)] DCS1800[2)]		 220 197		 mA mA
		DATA mode, GPRS (3 Rx,2Tx) EGSM900[1)] DCS1800[2)]		 373 340		 mA mA
		DATA mode, GPRS(2 Rx,3Tx) EGSM900[1)] DCS1800[2)]		 515 464		 mA mA
		DATA mode, GPRS (4 Rx,1Tx) EGSM900[1)] DCS1800[2)]		 230 216		 mA mA
		DATA mode, GPRS (1Rx,4Tx) EGSM900[1)]		 520		 mA

Parameter	Description	Conditions	Min	Typ	Max	Unit
		DCS1800[2)]		477		mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM900.		1.6	1.8	A

[1)] Power control level PCL 5
[2)] Power control level PCL 0

5.4. Current consumption

The values for current consumption are shown in Table 31.

Table 31: The module current consumption

Condition	Current Consumption
Voice Call	
GSM900	@power level #5 <270mA,Typical 220mA @power level #12,Typical 99mA @power level #19,Typical 73mA
DCS1800	@power level #0 <230mA,Typical 197mA @power level #7,Typical 94mA @power level #15,Typical 70mA
GPRS Data	
DATA mode, GPRS (1 Rx,1 Tx) CLASS 12	
EGSM 900	@power level #5 <350mA,Typical 193mA @power level #12,Typical 84mA @power level #19,Typical 63mA
DCS 1800	@power level #0 <300mA,Typical 185mA @power level #7,Typical 82mA @power level #15,Typical 60mA
DATA mode, GPRS (3 Rx, 2 Tx) CLASS 12	
EGSM 900	@power level #5 <550mA,Typical 373mA @power level #12,Typical 150mA @power level #19,Typical 103mA
DCS 1800	@power level #0 <450mA,Typical 340mA @power level #7,Typical 145mA @power level #15,Typical 98mA
DATA mode, GPRS (2 Rx, 3 Tx) CLASS 12	
EGSM 900	@power level #5 <600mA,Typical 515mA @power level #12,Typical 178mA

	@power level #19,Typical 111mA
DCS 1800	@power level #0 <490mA,Typical 464mA @power level #7,Typical 172mA @power level #15,Typical 102mA
DATA mode, GPRS (4 Rx,1 Tx) CLASS 12	
EGSM 900	@power level #5 <350mA,Typical 230mA @power level #12,Typical 118mA @power level #19,Typical 93mA
DCS 1800	@power level #0 <300mA,Typical 216mA @power level #7,Typical 118mA @power level #15,Typical 94mA
DATA mode, GPRS (1 Rx, 4 Tx) CLASS 12	
EGSM 900	@power level #5 <660mA,Typical 520mA @power level #12,Typical 180mA @power level #19,Typical 120mA
DCS 1800	@power level #0 <530mA,Typical 477mA @power level #7,Typical 198mA @power level #15,Typical 106mA

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.

5.5. Electro-static discharge

Although the GSM engine is generally protected against Electrostatic Discharge (ESD), precautions about ESD protection 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 the module are shown as the following table:

Table 32: The ESD endurance (Temperature:25℃,Humidity:45 %)

Tested point	Contact discharge	Air discharge
VBAT,GND	±5KV	±12KV
Antenna port	±5KV	±10KV
PWRKEY	±2KV	±4KV
SIM Card Interface	±2KV	±4KV
SPK1P/1N, SPK2P/2N, MIC1P/1N, MIC2P/2N	±2KV	±4KV

6. Mechanical dimensions

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical dimensions of the module

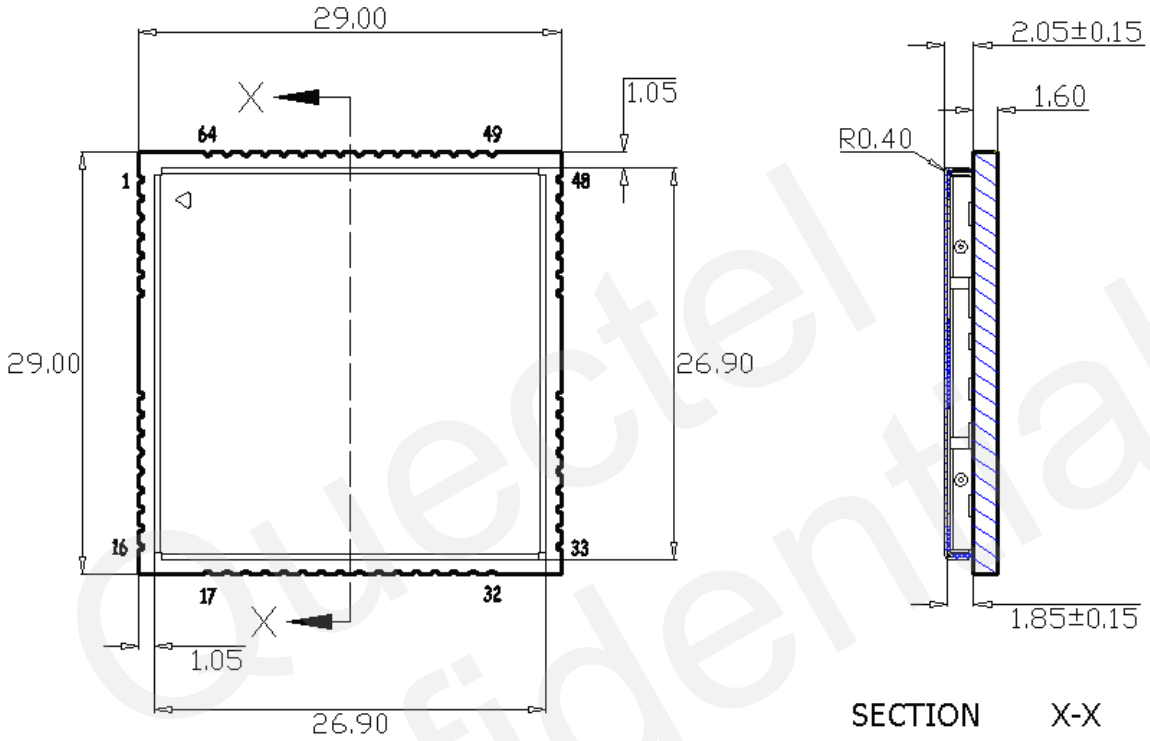


Figure 46: M12 top and side dimensions（Unit: mm）

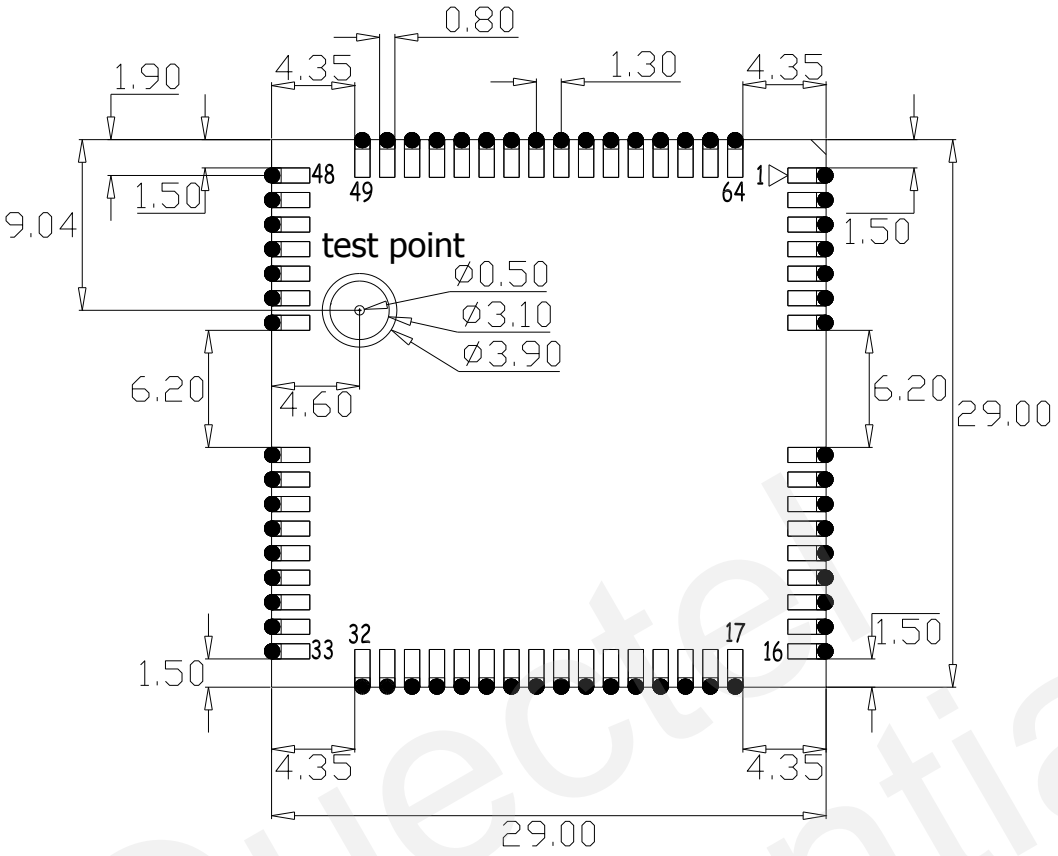


Figure 47: M12 bottom dimensions（Unit: mm）

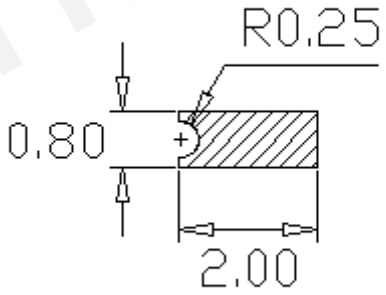
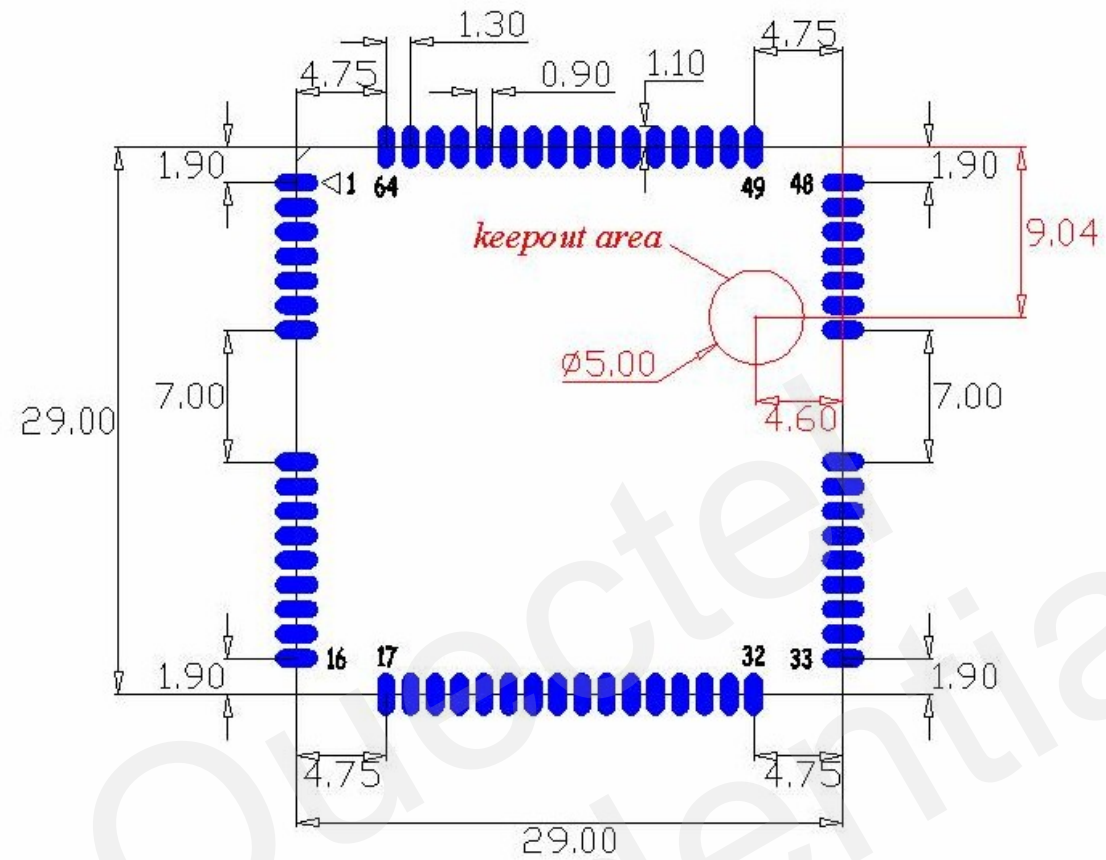
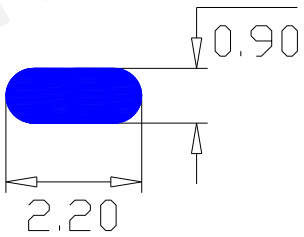


Figure 48: Pad bottom dimensions（Unit: mm）

6.2. Footprint of recommendation





single pad

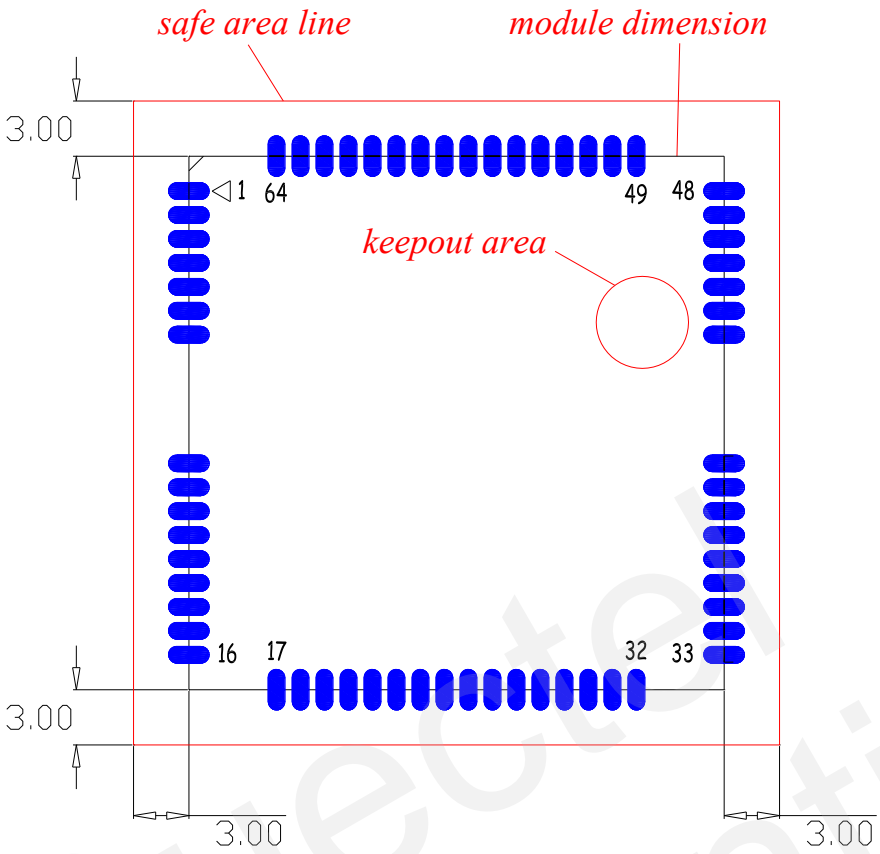


Figure 49: Footprint of recommendation（Unit: mm）

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.

Note3：Keep out area in above figure in which is forbid to pour ground copper. Since the RF test point in this area, avoid generating parasitic capacitance between RF test point and ground.

6.3. Top view of the module

Figure 50: Top view of the module

6.4. Bottom view of the module

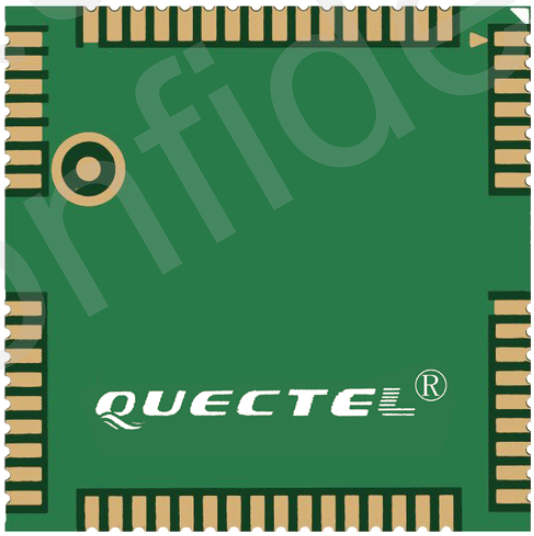


Figure 51: Bottom view of the module

Appendix A: GPRS coding schemes

Four coding schemes are used in GPRS protocol. The differences between them are shown in Table 33.

Table 33: 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 52:

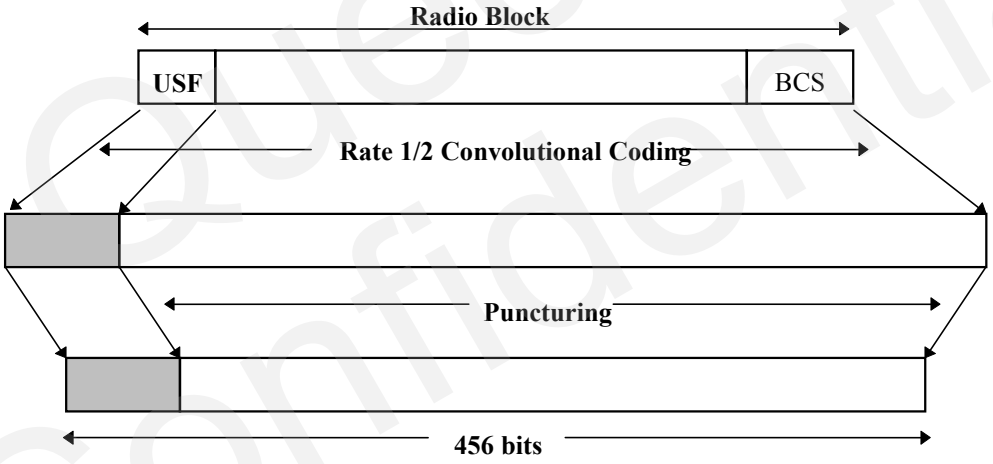


Figure 52: Radio block structure of CS-1, CS-2 and CS-3

Radio block structure of CS-4 is shown as Figure 53:

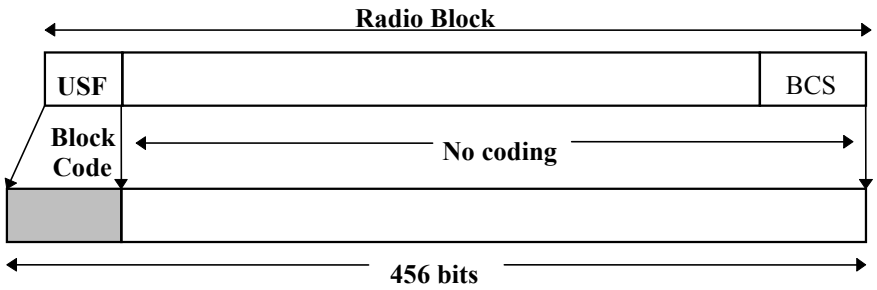


Figure 53: Radio block structure of CS-4

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 of the M12 module support is shown in Table 34.

Table 34: 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

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