M10 Hardware Design

GSM/GPRS Module Series

Rev. M10_Hardware_Design_V4.0

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About the Document

History

Revision	Date	Author	Description
1.00	2009-06-27	Tracy ZHANG	Initial
1.01	2009-09-18	Yong AN	1. Modified VRTC voltage inputting range 2. Modified Figure 1 3. Modified ordering information content in Chapter 6 4. Added VCHG pin description 5. Modified current consumption data in Table 36 6. Added appendix A and B
1.02	2009-11-12	Yong AN	1. Baud rate of the main UART port is set to autobauding mode from former fixed baud rate of 115200 in default configuration 2. Modified contents about autobauding in Section 3.8 3. Modified the SIM card detection function through "AT+QSIMDET"
1.03	2010-06-09	Yong AN	1. Added charging interface description 2. Added Serial Port 3 interface description 3. Added STATUS pin and its function description 4. Added GPIO control by AT+QGPIO command 5. Modified timing of powering on, powering down and restarting the module 6. Added ESD level of SIM card interface 7. Modified function description of audio AOUT2 channel 8. Disabled VDD_EXT pin as the indication of power-on and power-down 9. Both STATUS and AT+QGPIO functions are supported at R05A05 release version and later, while Serial Port 3 function will be supported at R06AXX and later
2.0	2010-07-30	David WEI	Added the recommendation of RF pad welding

3.0	2012-02-28	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 7. Deleted the content of charging function
3.1	2012-03-22	Layne YE	1. Modified the current consumption in GSM talk mode and GPRS communication mode 2. Disabled Module's hardware flow control 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	2012-10-15	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 supported voice and audio output and so on
4.0	2014-11-04	King HAO	1. Used the new technical document template 2. Updated DC characteristics of module's pins 3. Updated Figure 5: Reference Circuit for Power Supply 4. Modified the current consumption information in Section 5.3 & 5.4 5. Modified Over-voltage or Under-voltage Automatic Shutdown in Section 3.4.2.3 6. Modified RTC Backup in Section 3.6 7. Modified UART Application in Section 3.7.4 8. Modified SIM Card Interface in Section 3.9 9. Modified General Purpose Input & Output (GPIO) in Section 3.14 10. Added Antenna Requirement in Section 4.5 11. Added Storage and Manufacturing information in Chapter 7

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1 Introduction

This document defines the M10 module and describes its hardware interface which are connected with your application and the air interface.

This document can help you quickly understand module interface specifications, electrical and mechanical details. Associated with application notes and user guide, you can use M10 module to design and set up mobile applications easily.

1.1. Safety Information

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 M10 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 your failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobie while driving (even with a handsfree kit) cause distraction and can lead to an accident. You must comply with laws and regulations restrcting the use of wireless devices while driving.
	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. Consult the airline staff about the use of wireless devices on boarding the aircraft. If your device offers a Flight Mode which must be enabled prior to boarding an aircraft.
	Switch off your wireless device when in hospitals or clinics or other health care facilities. These requests are desinged to prevent possible interference with sentitive medical equipment.
	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.
	Your cellular terminal or mobile contains a transmitter and receiver. When it is ON , it receives and transmits radio frequency energy. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potencially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potencially exposive atmospheres including fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders.

2 Product Concept

2.1. General Description

M10 is a Quad-band GSM/GPRS engine that works at frequencies of GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. The M10 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 the ***Appendix B & C***.

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

M10 is an SMD type module with LCC package, which can be easily embedded into applications. It provides all hardware interfaces between the module and customer's host board.

Designed with power saving technique, the current consumption of M10 is as low as 1.3mA in SLEEP mode when DRX is 5.

M10 is integrated with Internet service protocols, such as TCP/UDP, FTP and HTTP. Extended AT commands have been developed for you to use these Internet service protocols easily.

The module fully complies with the RoHS directive of the European Union.

2.2. Key Features

The following table describes the detailed features of M10 module.

Table 1: Module Key Features

Feature	Implementation
Power Supply	Single supply voltage: 3.3V ~ 4.6V Typical supply voltage: 4.0V
Power Saving	Typical power consumption in SLEEP mode: 1.3mA @DRX=5 1.2mA @DRX=9
Frequency Bands	● Quad-band: GSM850, EGSM900, DCS1800, PCS1900 ● 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 GSM850 and EGSM900 ● Class 1 (1W) at DCS1800 and PCS1900
GPRS Connectivity	● GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● GPRS mobile station class B
DATA GPRS	● GPRS data downlink transfer: max. 85.6kbps ● GPRS data uplink transfer: max. 85.6kbps ● 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/PPP/HTTP/NTP/MMS/SMTP/PING ● Support Unstructured Supplementary Service Data (USSD)
Temperature Range	● Normal operation: -35°C ~ +80°C ● Restricted operation: -40°C ~ -35°C and +80°C ~ +85°C [1)] ● Storage temperature: -45°C ~ +90°C
SMS	● Text and PDU mode ● SMS storage: SIM card
SIM Interfaces	Support SIM card: 1.8V/3.0V
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
UART Interfaces	UART Port: ● Seven lines on UART port interface ● Used for AT command, GPRS data ● Multiplexing function ● Support autobauding from 4800bps to 115200bps Debug Port: ● Two lines on debug port interface DBG_TXD and DBG_RXD ● Use for software debugging and log output UART3 Port: ● Use for AT command
Phonebook Management	Support phonebook types: SM, ME, FD, ON, MT
SIM Application Toolkit	Support SAT class 3, GSM 11.14 Release 99
Real Time Clock	Supported
Physical Characteristics	Size: 29±0.15 × 29±0.15 × 3.6±0.2mm Weight: Approx.6.0g
Firmware Upgrade	Firmware upgrade via UART Port
Antenna Interface	Connected to antenna pad with 50Ω impedance control

NOTE

[1)] When the module works within this temperature range, the deviations from the GSM specification may occur. For example, the frequency error or the phase error will be increased.

Table 2: 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

2.3. Functional Diagram

The following figure shows a block diagram of M10 and illustrates the major functional parts.

- Radio frequency part
- Power management
- The peripheral interface
  —Power supply
  —Turn-on/off interface
  —UART interfaces
  —Audio interfaces
  —SIM interface
  —SD interface
  —ADC interfaces
  —RTC interface
  —RF interface

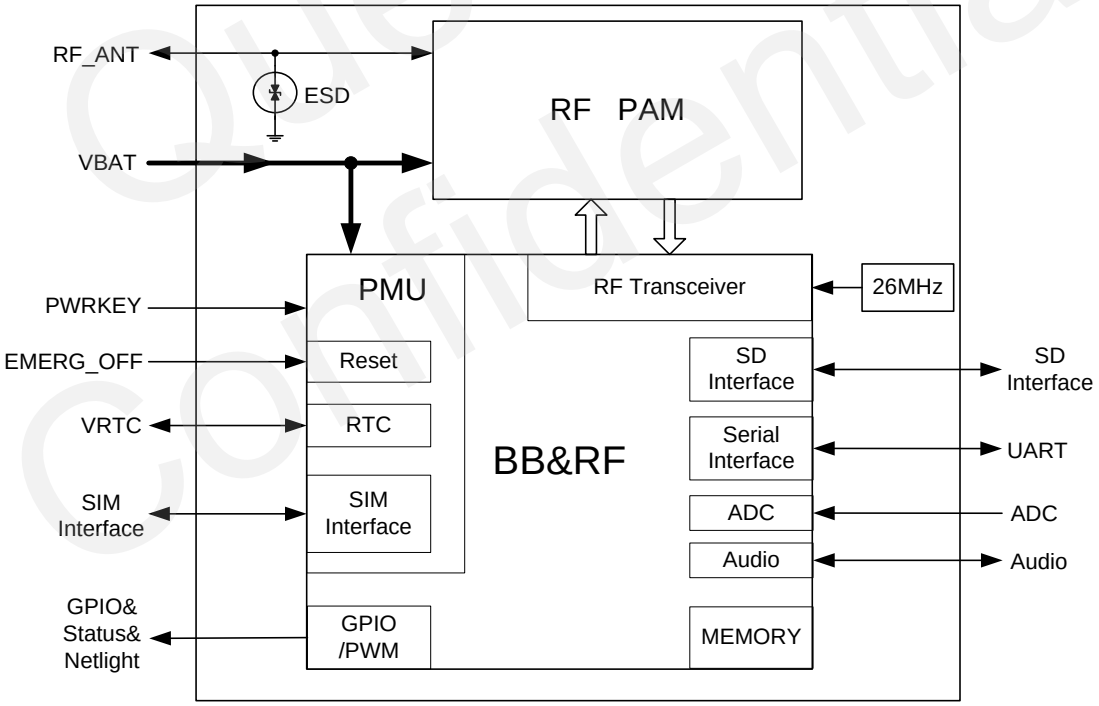

Figure 1: Module Functional Diagram

2.4. Evaluation Board

In order to help you to develop applications with M10, Quectel supplies an evaluation board (EVB), RS-232 to USB cable, power adapter, earphone, antenna and other peripherals to control or test the module. For details, please refer to the ***document [4]***.

3 Application Interface

The module adopts LCC package and has 64 pins. The following chapters provide detailed descriptions about these pins below:

- Power supply
- Power on/down
- Power saving
- RTC
- Serial interfaces
- Audio interfaces
- SIM interface
- ADC
- RI
- NETLIGHT
- Status
- GPIO
- SD card interface

3.1. Pin of Module

3.1.1. Pin Assignment

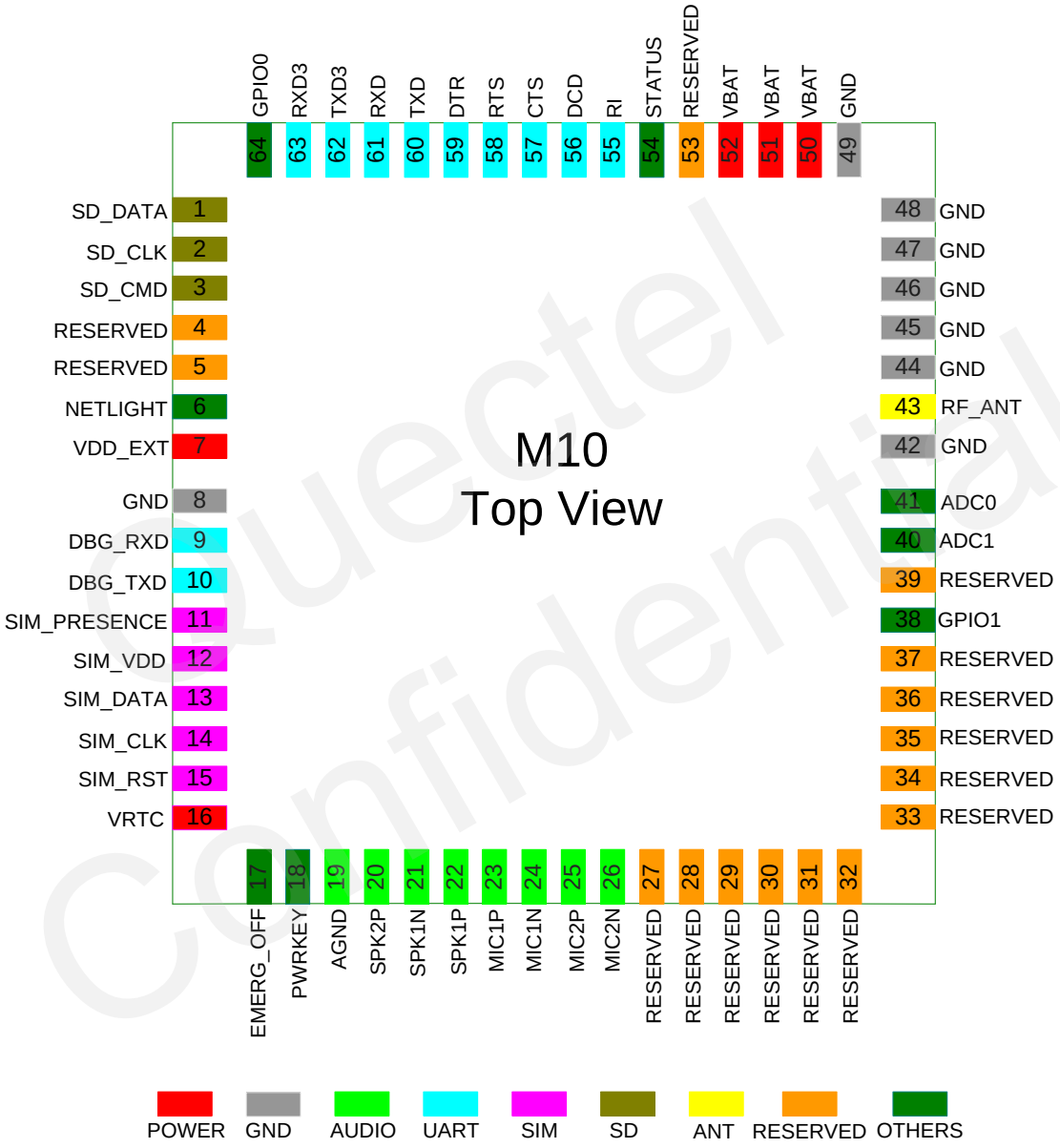

Figure 2: Pin Assignment

NOTE

Keep all reserved pins open.

3.1.2. Pin Description

Table 3: Pin Description

Power Supply					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
VBAT	50, 51, 52	I	Main power supply of module: VBAT=3.3V~4.6V	Vmax=4.6V Vmin=3.3V Vnorm=4.0V	Make sure that supply sufficient current in a transmitting burst typically rises to1.6A.
VRTC	16	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 applied.	VImax=3.3V VImin=1.5V VInorm=2.8V VOmax=3V VOmin=2V VOnorm=2.8V Iout(max)=2mA Iin≈10uA	If unused, keep this pin open.
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. Recommend to add a 2.2~4.7uF bypass capacitor, when using this pin for power supply.
GND	8, 42, 44~49		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 turn off the system.	VILmax=0.1×VBAT VIHmin=0.6×VBAT VImax=3.1V	
Emergency Shutdown					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT

EMERG_OFF	17	I	Emergency off. Pulled down for at least 40ms, which will turn off the module in case of emergency. Use it only when shutdown via PWRKEY or AT command cannot be achieved.	VILmax=0.45V VIHmin=1.35V Vopenmax=1.8V	Open drain/collector driver required in cellular device application. If unused, keep this pin open.
Module Indicator					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
STATUS	54	O	Indicate module's operating status. Output high level when module turns on, while output low level when module turns off.	VOHmin= 0.85×VDD_EXT VOLmax= 0.15×VDD_EXT	If unused, keep these pins open.
Audio Interfaces					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
MIC1P MIC1N	23, 24	I	Channel 1 positive and negative voice input	Refer to ***Section 3.8***	If unused, keep these pins open.
MIC2P MIC2N	25, 26	I	Channel 2 positive and negative voice input		
SPK1P SPK1N	22, 21	O	Channel 1 positive and negative voice output		1. If unused, keep these pins open. 2. Support both voice and ringtone output.
SPK2P	20	O	Channel 2 positive voice output		
AGND	19		Analog ground. Separate ground connection for external audio circuits.		If unused, keep this pin open.
General Purpose Input/Output					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
GPIO1	38	I/O	Normal input/output port	VILmin=0V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT	If unused, keep these pins open.
GPIO0	64	I/O	Normal input/output port		If unused, keep these pins open.

				VIHmax= VDD_EXT+0.2 VOLmax= 0.15×VDD_EXT VOHmin= 0.85×VDD_EXT	
Network Status Indicator					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
NETLIGHT	6	O	Network status indication	VOHmin= 0.85×VDD_EXT VOLmax= 0.15×VDD_EXT	If unused, keep this pin open.
UART Port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
DTR	59	I	Data terminal ready	VILmin=0V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.2 VOHmin= 0.85×VDD_EXT VOLmax= 0.15×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 indication		
DCD	56	O	Data carrier detection		
Debug Port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
DBG_TXD	10	O	Transmit data	Same as above	If unused, keep these pins open.
DBG_RXD	9	I	Receive data		
UART3 Port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
TXD3	62	O	Transmit data	Same as above	If unused, keep these pins open.
RXD3	63	I	Receive data		

SD 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+0.2 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	Power supply for SIM card	The voltage can be selected by software automatically. Either 1.8V or 3.0V.	All signals of SIM interfaces 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	VILmax= 0.25×SIM_VDD VIHmin= 0.75×SIM_VDD VOLmax= 0.15×SIM_VDD VOHmin= 0.85×SIM_VDD	
SIM_ CLK	14	O	SIM clock	VOLmax= 0.15×SIM_VDD VOHmin= 0.85×SIM_VDD	
SIM_RST	15	O	SIM reset	VOLmax= 0.15×SIM_VDD VOHmin= 0.85×SIM_VDD	
SIM_ PRESENCE	11	I	SIM card detection.	VILmin=0V VILmax=	

				0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.2	
ADC Interfaces					
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 these pins open.
ADC1	40	I		Voltage range: 0V ~ 2.8V	
RF Interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
RF_ANT	43	I/O	RF antenna pad	Impedance of 50Ω	
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 in the following chapters.

Table 4: Overview of Operating Modes

Mode	Function	
Normal Operation	GSM/GPRS SLEEP	After enabling sleep mode by **AT+QSCLK=1**, 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 UART 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 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		Normal shutdown by sending the **AT+QPOWD=1** command or using the PWRKEY or 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 UART 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 disabled, but the UART port is still accessible. The power consumption in this case is very low.

NOTE

Use the EMERG_OFF pin only when failing to turn off the module by the command **AT+QPOWD=1** and the PWRKEY pin. For more details, please refer to the ***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 designing GSM terminals. Because of the 577us radio burst in GSM every 4.615 ms, 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 M10 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.

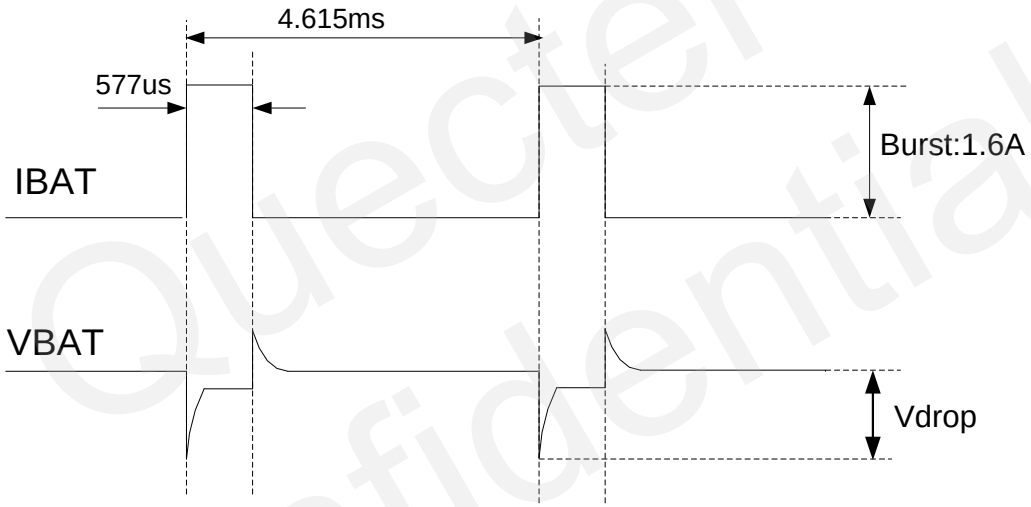

Figure 3: Voltage Ripple during Transmitting

3.3.2. Decrease Supply Voltage Drop

The power supply range 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 capacitor 100nF, 33pF and 10pF 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 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.

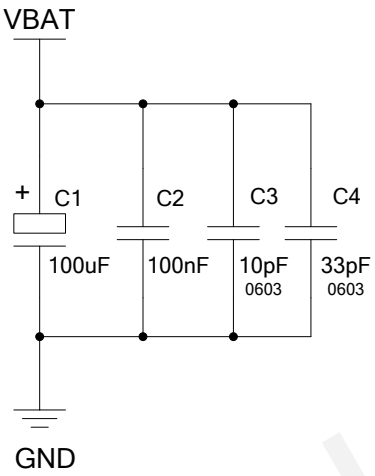

Figure 4: Reference Circuit for the VBAT Input

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 recommended 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 4.0V 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 whose reverse zener voltage is 5.1V and dissipation power is more than 1 Watt.

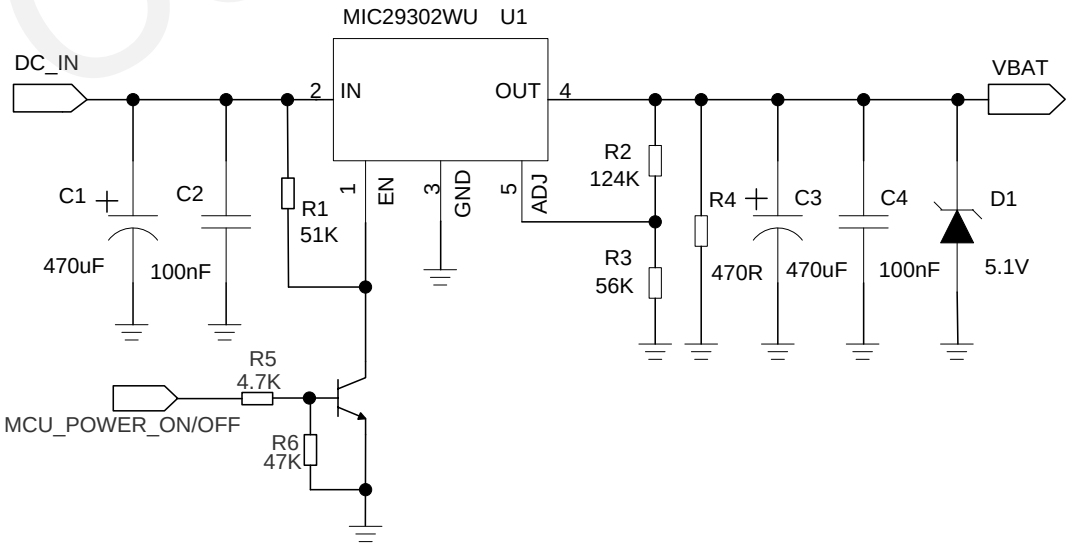

Figure 5: Reference Circuit for Power Supply

NOTE

It is suggested to control the module's main power supply (VBAT) via LDO enable pin to restart the module when the module has become abnormal. Power switch circuit like P-channel MOSFET switch circuit can also be used to control VBAT.

3.3.4. Monitor Power Supply

The command "AT+CBC" can be used to monitor the supply voltage of the module. The unit of the displayed voltage is mV.

For details, please refer to the ***document [1]***.

3.4. Power On and Down Scenarios

3.4.1. Power On

The module can be turned on by driving the pin PWRKEY to a low level voltage. An open collector driver circuit is suggested to control the PWRKEY. A simple reference circuit is illustrated as below.

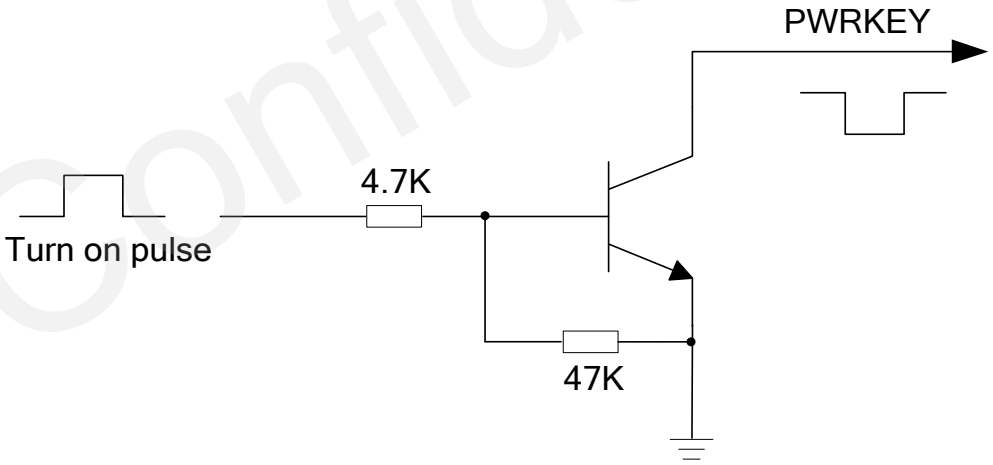

Figure 6: Turn On the Module with an Open-collector Driver

NOTES

1. M10 module is set to autobauding mode (AT+IPR=0) by default. In the autobauding mode, URC “RDY” is not reported to the host controller after module is powered on. When the module is powered on after a delay of 4 or 5 seconds, it can receive AT command. Host controller should first send an **AT** string in order that the module can detect baud rate of host controller, and it should continue to send the next **AT** string until receiving **OK** string from the module. Then enter **AT+IPR=x;&W** 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 UART Port of the module every time when the module is powered on. For more details, refer to the section **AT+IPR** in ***document [1]***.
2. AT command response indicates module is turned on successfully, or else the module fails to be turned on.

The other way to control the PWRKEY is through a button directly. A TVS component is indispensable to be placed nearby the button for ESD protection. For the best performance, the TVS component must be placed nearby the button. When pressing the key, electrostatic strike may generate from finger. A reference circuit is shown in the following figure.

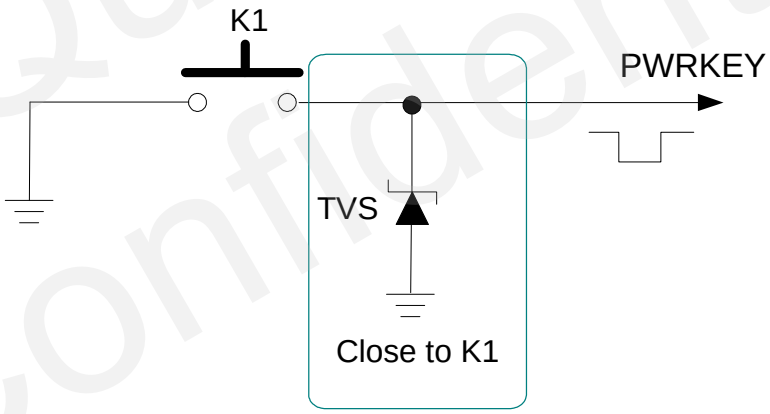

Figure 7: Turn On the Module with a Button

The turn-on timing is illustrated as the following figure.

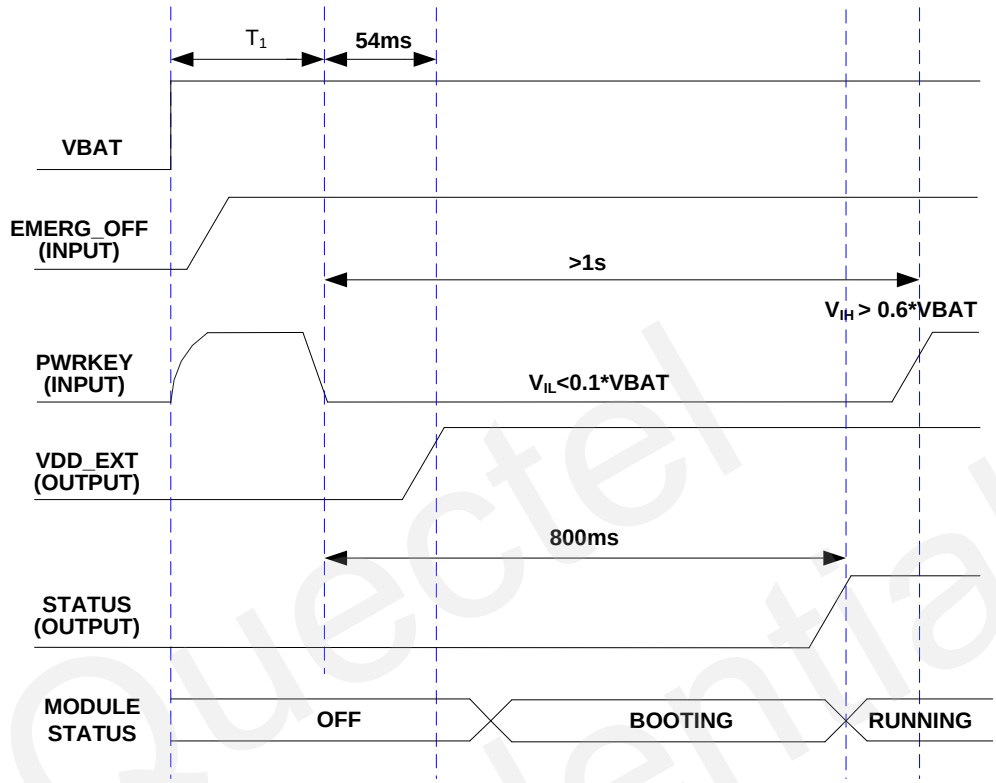

Figure 8: Turn-on Timing

NOTES

1. Make sure that VBAT is stable before pulling down PWRKEY pin. The time of T_1 is recommended as 100ms.
2. EMERG_OFF should be floated when it is unused.
3. For more details about the application of STATUS pin, please refer to the ***Chapter 3.13.***

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

It is a safe way to turn off the module by driving the PWRKEY to a low level voltage for a certain time. The power down scenario is illustrated below.

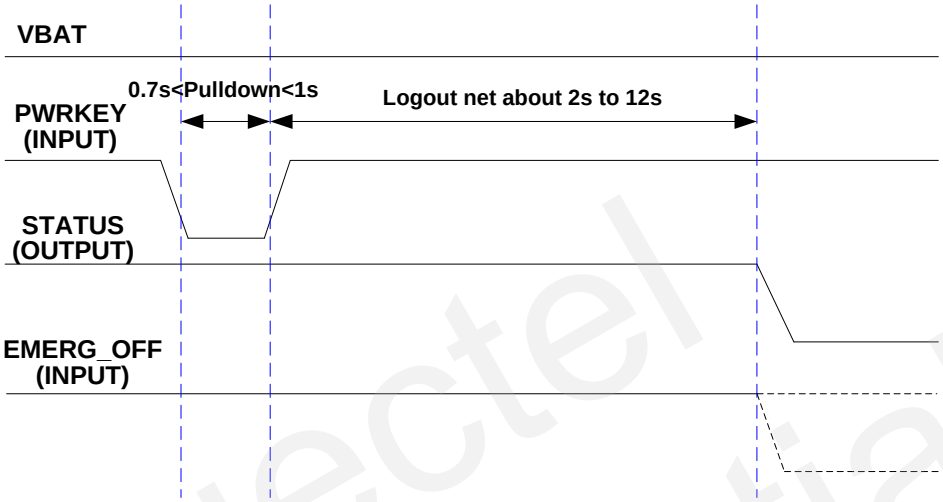

Figure 9: Turn-off Timing

The power down procedure causes the module to log off from the network and allows the firmware to save important data before completely disconnecting the power supply.

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

NORMAL POWER DOWN

After that moment, no further AT commands can be executed. 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.

NOTES

1. This unsolicited 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.
2. As logout network time is related to the local mobile network, it is recommended to delay about 12 seconds before disconnecting the power supply or restarting the module.
3. For more details about the application of STATUS pin, please refer to the ***Chapter 3.13.***

3.4.2.2. Power Down Module Using AT Command

It is also a safe way to turn off the module via AT command **AT+QPOWD=1.** This command will let the module to log off from the network and allow the firmware to save important data before completely disconnecting the power supply.

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

NORMAL POWER DOWN

After that moment, no further AT commands can be executed. And then the module enters the power down mode, only the RTC is still active.

Please refer to the ***document [1]*** for details about the AT command **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 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 shut down 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

After that moment, no further AT commands can be executed. The module logs off from network and enters power down mode, and only RTC is still active.

NOTES

1. These unsolicited 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.
2. Over-voltage warning and shutdown function is disabled by default.

3.4.2.4. Emergency Shutdown Using EMERG_OFF Pin

The module can be shut down by driving the pin EMERG_OFF to a low level voltage over 40ms 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.

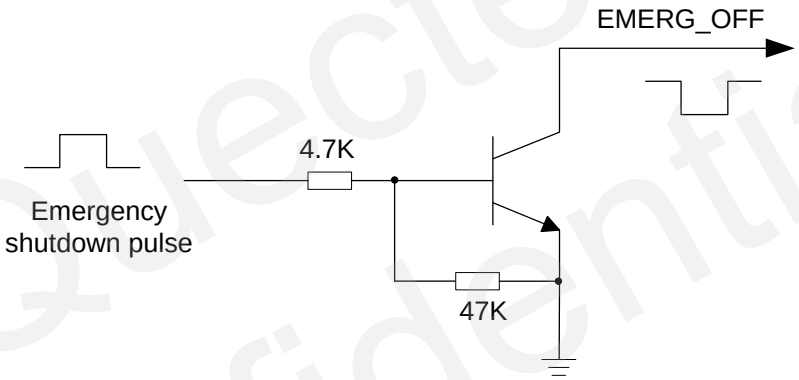

Figure 10: An Open-collector Driver for EMERG_OFF

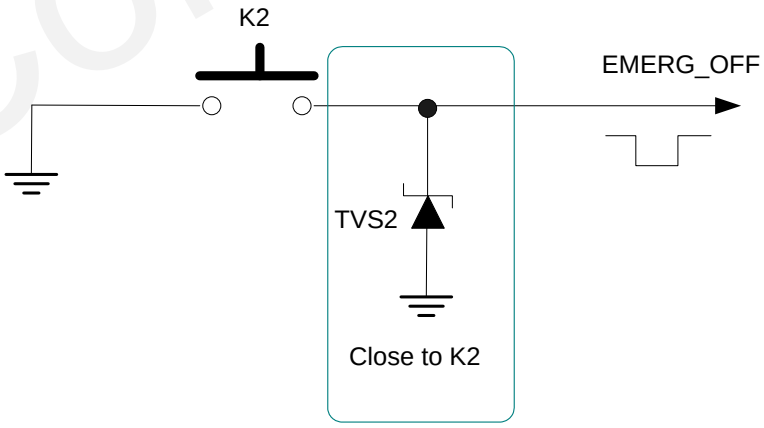

Figure 11: Reference Circuit for EMERG_OFF by Using Button

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 shut down 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 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

The module can be restarted by driving the PWRKEY to a low level voltage for a certain time, which is similar to the way of turning on module. In order to make the internal LDOs discharge completely after turning off the module, it is recommended to delay about 500ms before restarting the module. The restart timing is illustrated as the following figure.

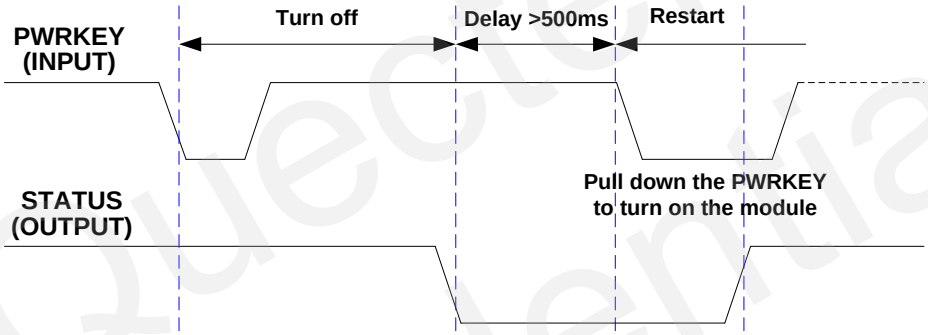

Figure 12: Timing of Restarting System

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

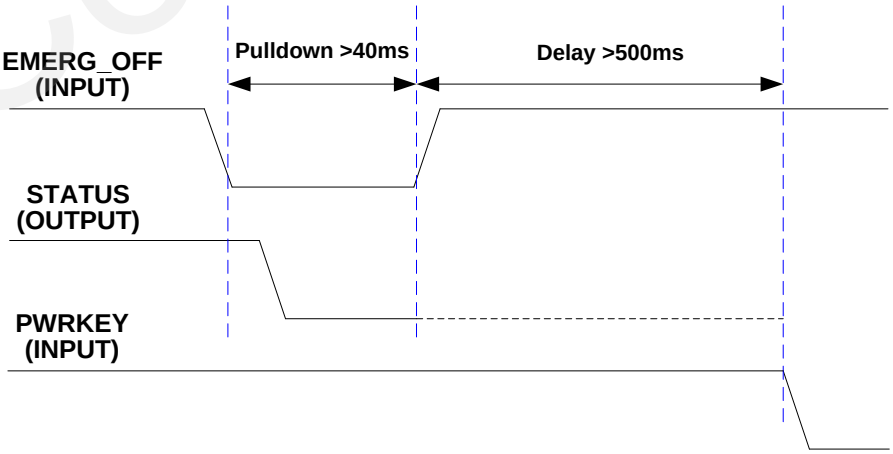

Figure 13: Timing of Restarting System after Emergency Shutdown

NOTE

For more details about the application of STATUS pin, please refer to the ***Chapter 3.13.***

3.5. Power Saving

Based on system requirements, 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 a minimum level. The consumption of the current can be minimized when the slow clocking mode is activated at the same time. The 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 disabled. In this case, the UART port is still accessible, but all AT commands related with RF function and SIM card function will be not available.

If the module has been set by the command with **AT+CFUN=4**, the RF function will be disabled, but the UART port is still active. In this case, all AT commands related with RF function will be not available.

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 the ***document [1]***.

3.5.2. SLEEP Mode

The SLEEP mode is disabled by default. You can enable it by **AT+QSCLK=1**. On the other hand, the default setting is **AT+QSCLK=0** and in this mode, the module cannot enter SLEEP mode.

When the module is set by the command with **AT+QSCLK=1**, you 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 UART 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 UART port

does not work.

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 set low, it would wake up the module from the SLEEP mode. The UART port will be active within 20ms after DTR is changed to low level.
- Receiving a voice or GPRS data from network will wake up the module.
- Receiving an SMS from network will wake up the module.

NOTE

DTR pin should be held at low level during communication between the module and DTE.

3.5.4. Summary of State Transition

Table 5: Summary of State Transition

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

3.6. RTC Backup

The RTC (Real Time Clock) function is supported. The RTC is designed to work with an internal power supply.

There are three kinds of designs for RTC backup power:

- Use VBAT as the RTC power source.

When the module is turned off and the main power supply (VBAT) is remained, the real time clock is still active as the RTC core is supplied by VBAT. In this case, the VRTC pin can be kept floating.

- Use VRTC as the RTC power source.

If the main power supply (VBAT) is removed after the module is turned off, a backup supply such as a coin-cell battery (rechargeable or non-chargeable) or a super-cap can be used to supply the VRTC pin to keep the real time clock active.

- Use VBAT and VRTC as the RTC power source.

As only powering the VRTC pin to keep the RTC will lead an error about 5 minutes a day, it is recommended to power VBAT and VRTC pin at the same time when RTC function is needed. The recommended supply for RTC core circuits are shown as below.

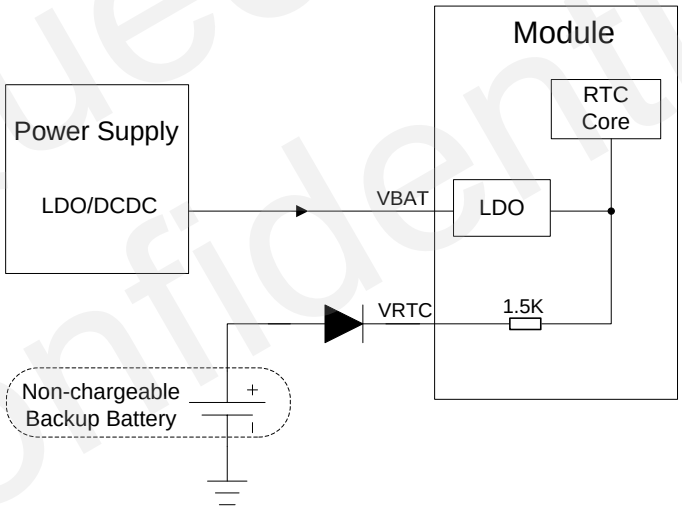

Figure 14: VRTC Is Supplied by a Non-chargeable Battery

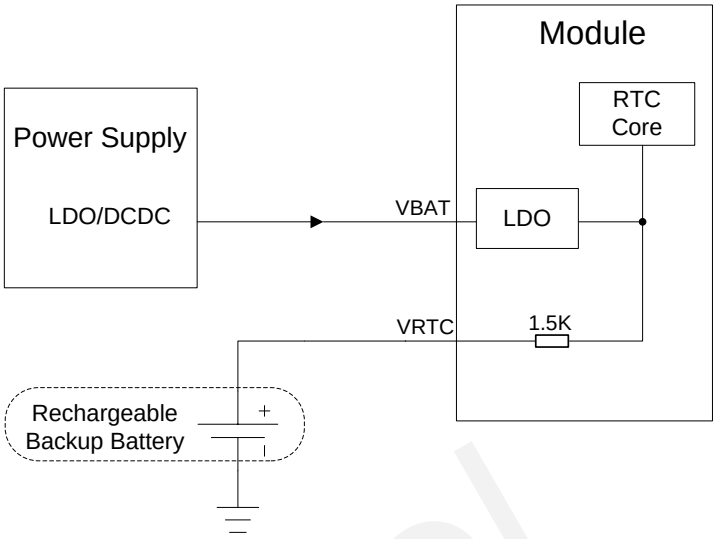

Figure 15: VRTC Is Supplied by a Rechargeable Battery

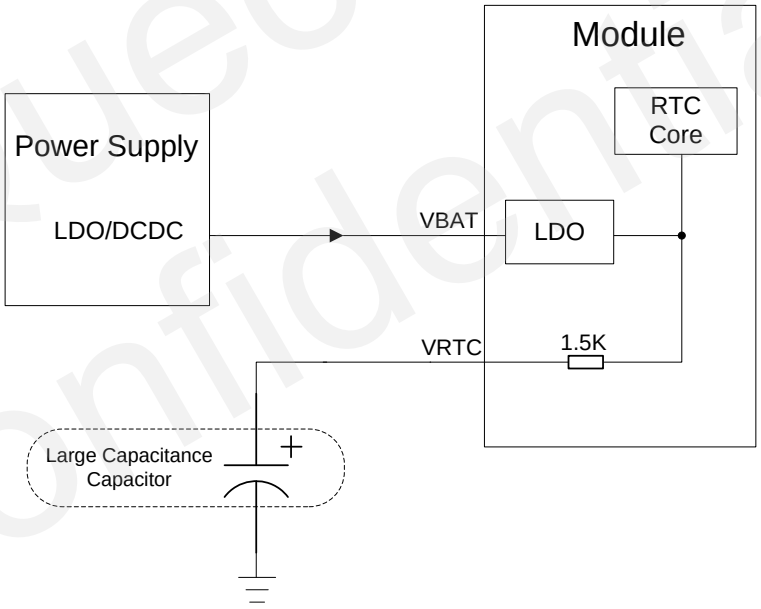

Figure 16: VRTC Is Supplied by a Capacitor

For the choice of a rechargeable or non-chargeable coin-cell battery, please visit http://www.sii.co.jp/en/.

NOTE

If you want to keep an accurate real time, please keep the main power supply VBAT alive .

3.7. Serial Interfaces

The module provides three serial ports: UART Port, Debug Port and UART3 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 UART Port:

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

NOTE

Hardware flow control is disabled 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 the ***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 6: Logic Levels of the UART Interfaces

Parameter	Min.	Max.	Unit
V_{IL}	0	0.25×VDD_EXT	V
V_{IH}	0.75×VDD_EXT	VDD_EXT +0.2	V
V_{OL}	0	0.15×VDD_EXT	V
V_{OH}	0.85×VDD_EXT	VDD_EXT	V

Table 7: Pin Definition of the UART Interfaces

Interface	Pin Name	Pin No.	Description
UART Port	TXD	60	Transmit data
	RXD	61	Receive data
	DTR	59	Data terminal ready
	RI	55	Ring indication
	DCD	56	Data carrier detection
	CTS	57	Clear to send
	RTS	58	Request to send
Debug Port	DBG_RXD	9	Receive data
	DBG_TXD	10	Transmit data
UART3 Port	RXD3	63	Receive data
	TXD3	62	Transmit data

3.7.1. UART Port

3.7.1.1. The Features of UART Port

- 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, 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 and 115200.
- The default setting is autobauding mode. Support the following baud rates for autobauding function:
  4800, 9600, 19200, 38400, 57600 and 115200.
- The module disables hardware flow control by default. AT command **AT+IFC=2,2** is used to enable hardware flow control.

After setting a fixed baud rate or autobauding, please send **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** from the host or PC automatically, which gives 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:

1. Synchronization between DTE and DCE:

When DCE (the module) powers on with the autobauding enabled, it is recommended to wait 4 or 5 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.

2. Restrictions on autobauding operation:

- The UART port has to be operated at 8 data bits, no parity and 1 stop bit (factory setting).
- 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** 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 the Section **AT+IPR** in ***document [1]***.

3.7.1.2. The Connection of UART Port

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

Reference design for Full-Function UART connection is shown as below when it is applied in modulation-demodulation.

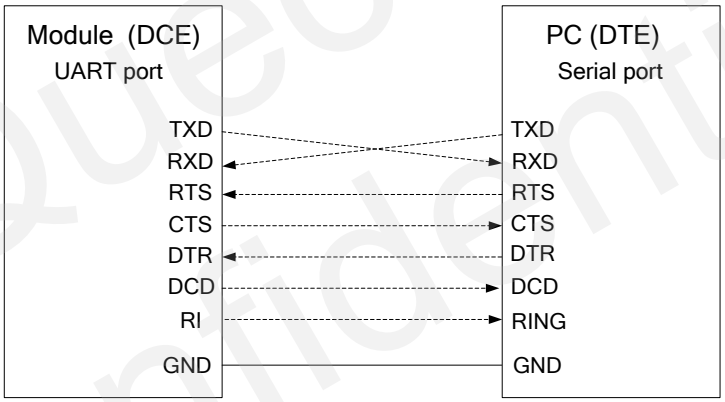

Figure 17: Reference Design for Full-Function UART

Three-line connection is shown as below.

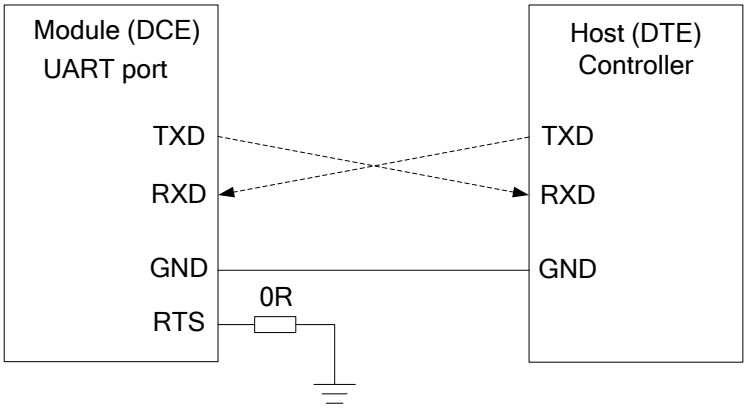

Figure 18: Reference Design for UART Port

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

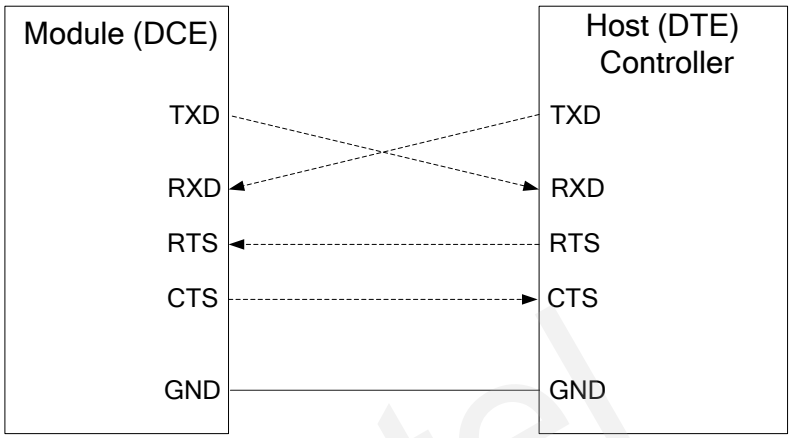

Figure 19: Reference Design for UART Port with Hardware Flow Control

3.7.1.3. Firmware Upgrade

The TXD, RXD can be used to upgrade firmware. The PWRKEY pin must be pulled down before firmware upgrade. The reference circuit is shown as below:

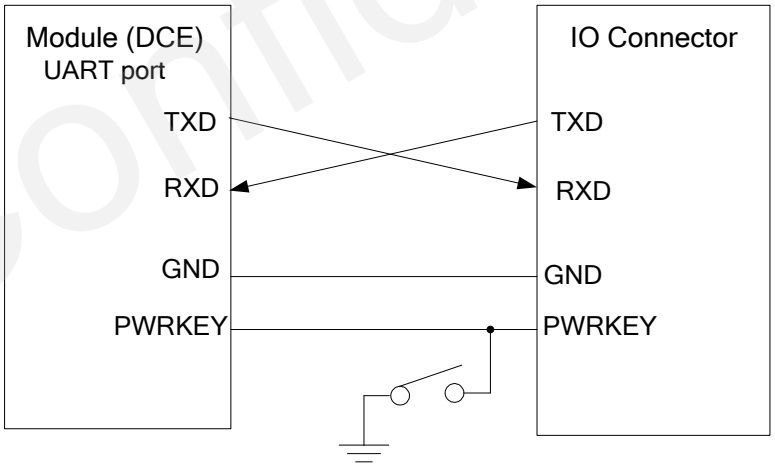

Figure 20: Reference Design for Firmware Upgrade

NOTE

The firmware of module might need to be upgraded due to certain reasons. It is recommended to reserve these pins in the host board for firmware upgrade.

3.7.2. Debug Port

- Two lines: DBG_TXD and DBG_RXD.
- It outputs log information automatically.
- Debug Port is only used for firmware debugging and its baud rate must be configured as 460800bps.

The reference design for Debug Port is shown as below.

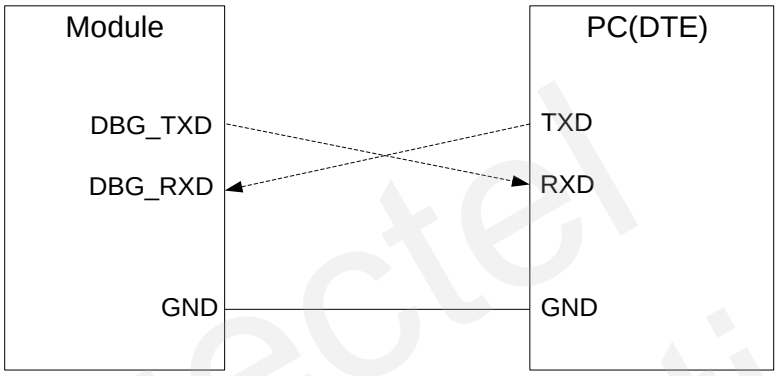

Figure 21: Reference Design for Debug Port

3.7.3. UART3 Port

- Two data lines: TXD3 and RXD3.
- UART3 port is used for AT command only and does not support GPRS data, multiplexing function etc.
- UART3 port supports the communication baud rates as the following:
  1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200bps.
- UART3 port could be used when you send **AT+QEAUART=1** string on the UART port.
- The default baud rate setting is 115200bps, and does not support autobauding. The baud rate can be modified by **AT+QSEDCB** command. For more details, please refer to the ***document [1]*.**

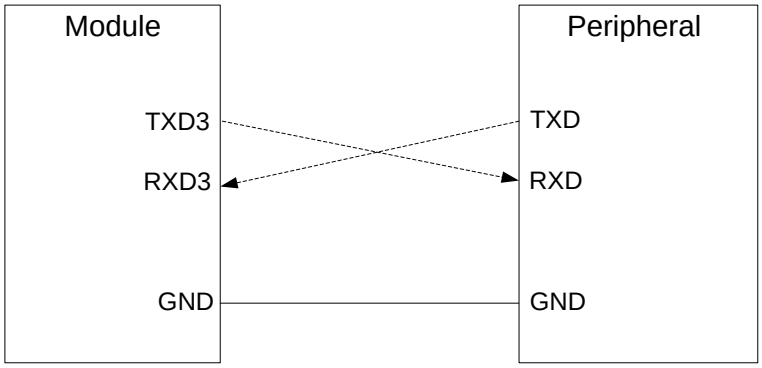

Figure 22: Reference Design for UART3 Port

3.7.4. UART Application

The reference design of 3.3V level match is shown as below. If the host is a 3V system, please change the 5.6K resistor to 10K.

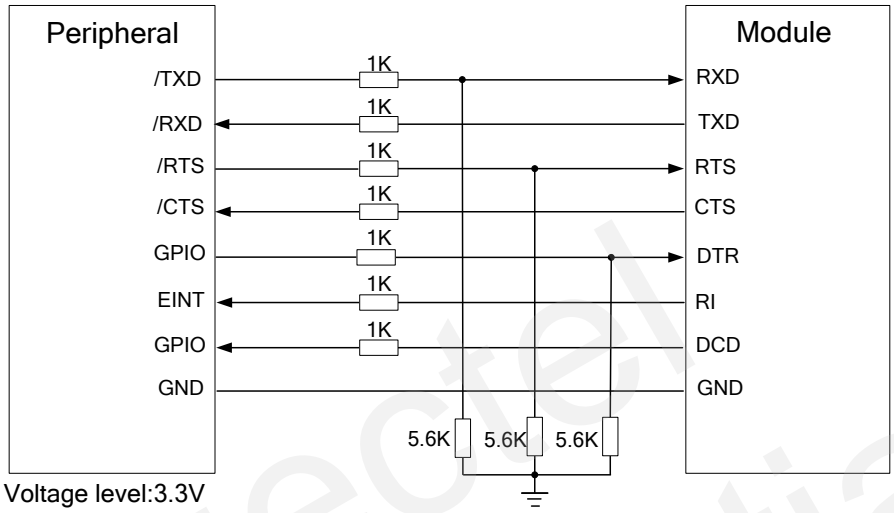

Figure 23: Level Match Design for 3.3V System

NOTE

It is highly recommended to add the resistor divider circuit on the UART signal lines when the host's level is 3V or 3.3V. For the higher voltage level system, a level shifter IC could be used between the host and the module. For more details about UART circuit design, please refer to ***document [5]***.

The following figure shows a sketch map between module and standard RS-232 interface. Since the electrical level of module is 2.8V, so a RS-232 level shifter must be used. Note that you should assure the IO voltage of level shifter which connects to module is 2.8V.

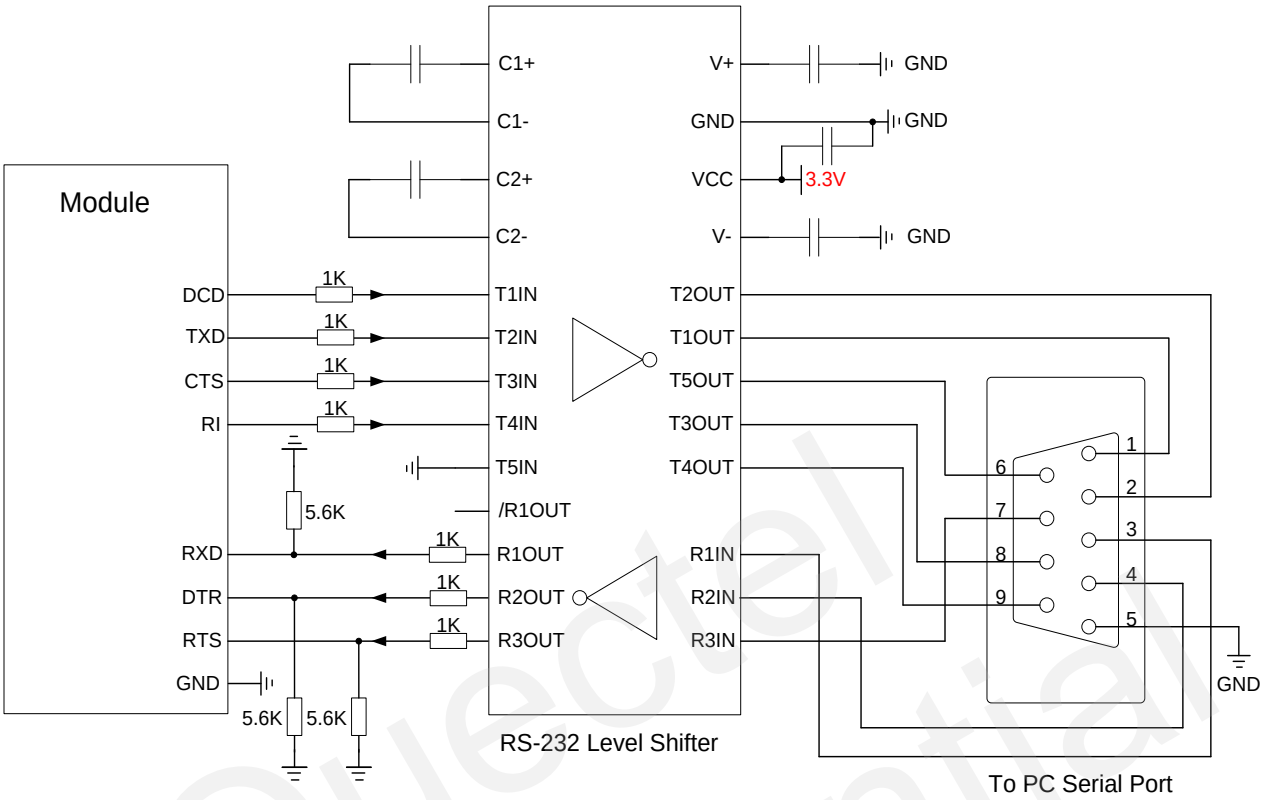

Figure 24: Sketch Map for RS-232 Interface Match

Please visit vendor website to select the suitable RS-232 level shifter IC, such as: http://www.maximintegrated.com and http://www.exar.com/.

3.8. Audio Interfaces

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

Table 8: Pin Definition of Audio Interfaces

Interfaces	Pin Name	Pin NO.	Description
AIN1/AOUT1	MIC1P	23	Channel 1 Microphone positive input
	MIC1N	24	Channel 1 Microphone negative input
	SPK1P	22	Channel 1 Audio positive output
	SPK1N	21	Channel 1 Audio negative output

AIN2/AOUT2	MIC2P	25	Channel 2 Microphone positive input
	MIC2N	26	Channel 2 Microphone negative input
	SPK2P	20	Channel 2 Audio positive output
	AGND	19	Form a pseudo-differential pair with SPK2P

AIN1 and AIN2 can be used for input of microphone and line. An electret microphone is usually used. AIN1 and AIN2 are both differential input channels.

AOUT1 is used for output of the receiver. This channel is typically used for a receiver built into a handset. AOUT1 channel is a differential channel.

AOUT2 is typically used with earphone. It is a single-ended and mono channel. SPK2P and AGND can establish a pseudo differential mode.

AOUT2 also can be used for output of earphone, which can be used as a single-ended channel. AOUT2 and AGND can establish a pseudo differential mode.

All of these two audio channels support voice and ringtone output, and so on, and can be switched by "AT+QAUDCH" command. For more details, please refer to the ***document [1]***.

Use AT command "AT+QAUDCH" to select audio channel:

- 0--AIN1/AOUT1, the default value is 0.
- 1--AIN2/AOUT2, this channel is always used for earphone.

For each channel, you can use AT+QMIC to adjust the input gain level of microphone. You can also use "AT+CLVL" to adjust the output gain level of receiver and speaker. "AT+QSIDET" is used to set the side-tone gain level. For more details, please refer to the ***document [1]***.

3.8.1. Decrease TDD Noise and Other Noise

The 33pF capacitor is applied for filtering out 900MHz RF interference when the module is transmitting at EGSM900MHz. Without placing this capacitor, TDD noise could be heard. 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, you would have to discuss with its capacitor vendor to choose the most suitable capacitor for filtering out GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz 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, you 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.

3.8.2. Microphone Interfaces Design

AIN1 and AIN2 channels come with internal bias supply for external electret microphone. A reference circuit is shown in the following figure.

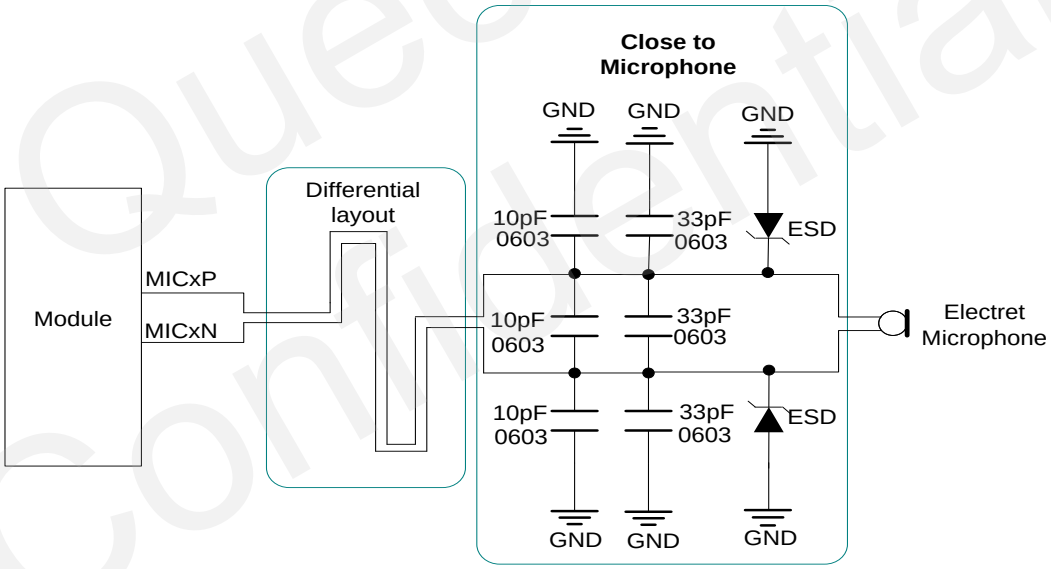

Figure 25: Reference Design for AIN1&AIN2

3.8.3. Receiver and Speaker Interfaces Design

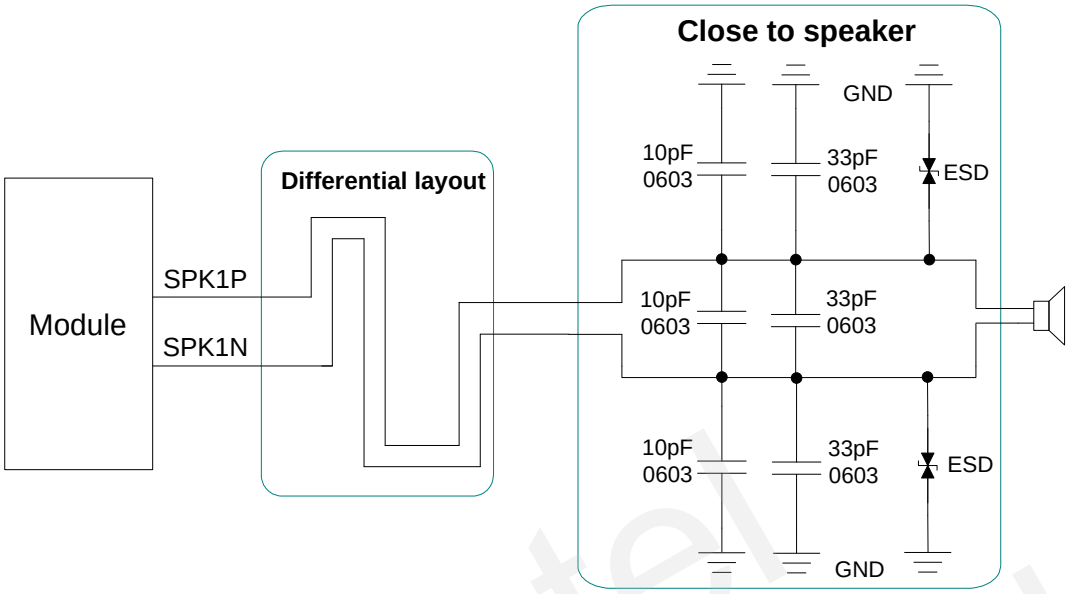

Figure 26: Handset Interface Design for AOUT1

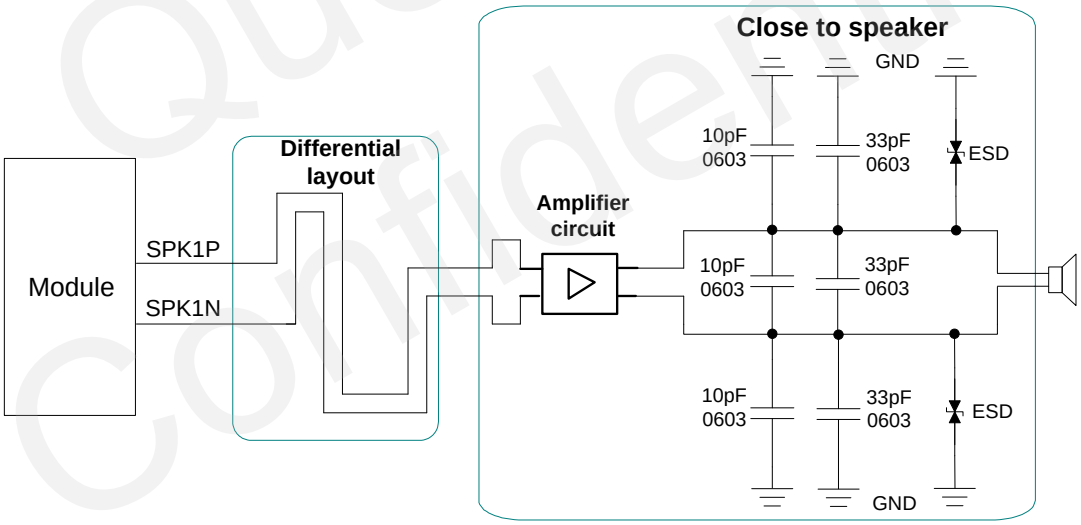

Figure 27: Speaker Interface Design with an Amplifier for AOUT1

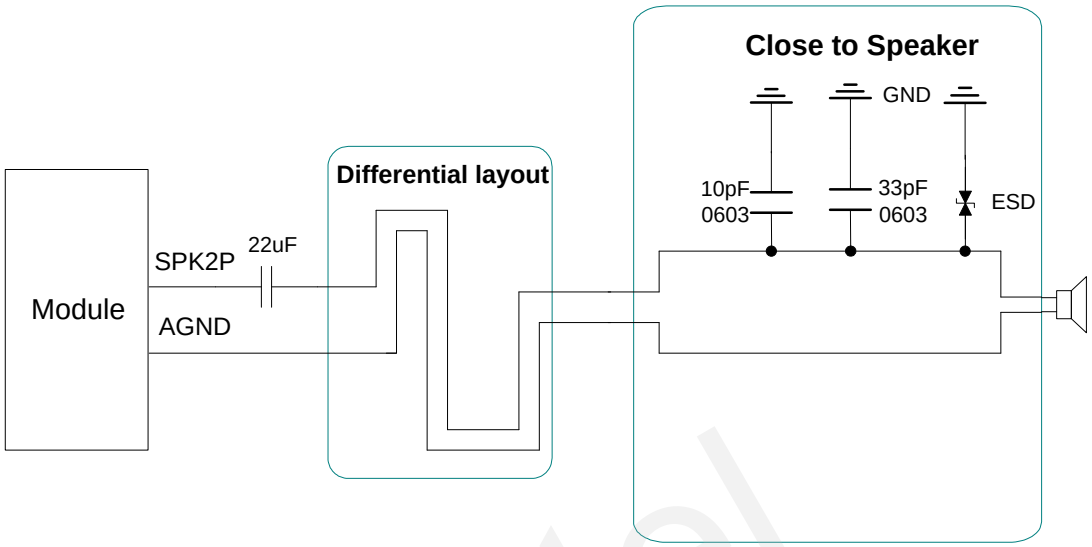

Figure 28: Handset Interface Design for AOUT2

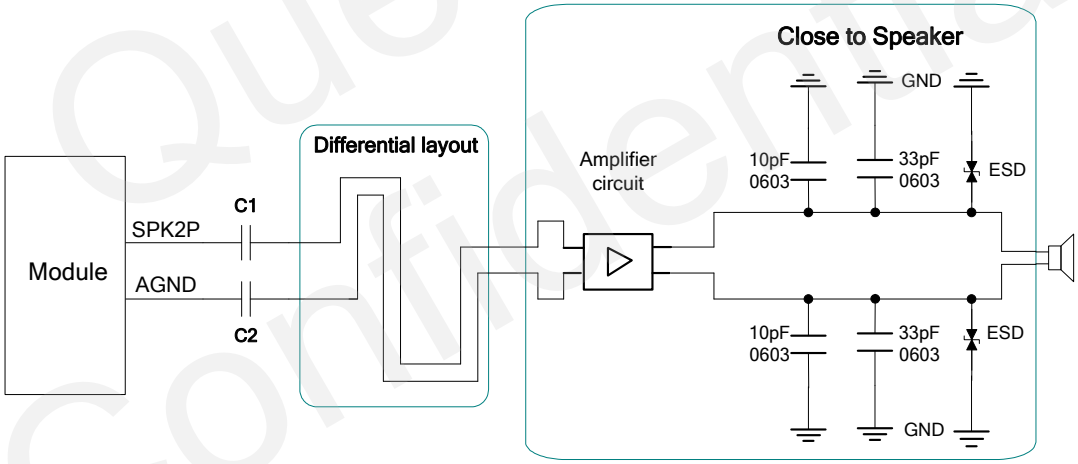

Figure 29: Speaker Interface Design with an Amplifier for AOUT2

The suitable differential audio amplifier can be chosen from the Texas Instrument's website (http://www.ti.com/). There are other excellent audio amplifier vendors in the market too.

NOTE

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

3.8.4. Earphone Interface Design

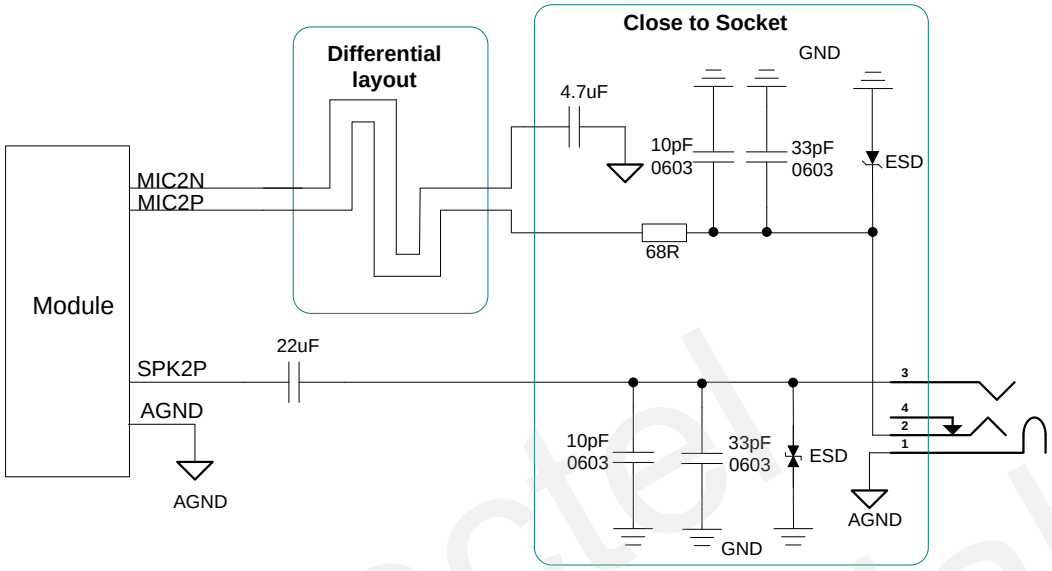

Figure 30: Earphone Interface Design

3.8.5. Audio Characteristics

Table 9: Typical Electret Microphone Characteristics

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		kΩ

Table 10: Typical Speaker Characteristics

Parameter			Min.	Typ.	Max.	Unit
AOUT1 Output	Single-ended	Load resistance		32		Ohm
		Ref level	0		2.4	Vpp
	Differential	Load resistance		32		Ohm
		Ref level	0		4.8	Vpp

AOUT2 Output	Single-ended	Load resistance		32	Ohm
		Ref level	0	2.4	Vpp

3.9. SIM Card Interface

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 64kbps SIM card, which is intended to use with a SIM application Tool-kit.

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

Table 11: Pin Definition of the SIM Interface

Pin Name	Pin NO.	Description
SIM_VDD	12	Supply power for SIM card. Automatic detection of SIM card voltage. 3.0V±5% and 1.8V±5%. 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

The following figure is the reference design 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. Your application can use "**AT+QSIMDET=1,0**" and "**AT+QSIMDET=0,0**" to switch on and 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 INSERTED

When the tray with SIM card is inserted into SIM socket again and the module finishes reinitializing SIM card, the following URC will be presented:

+CPIN: READY

Call Ready

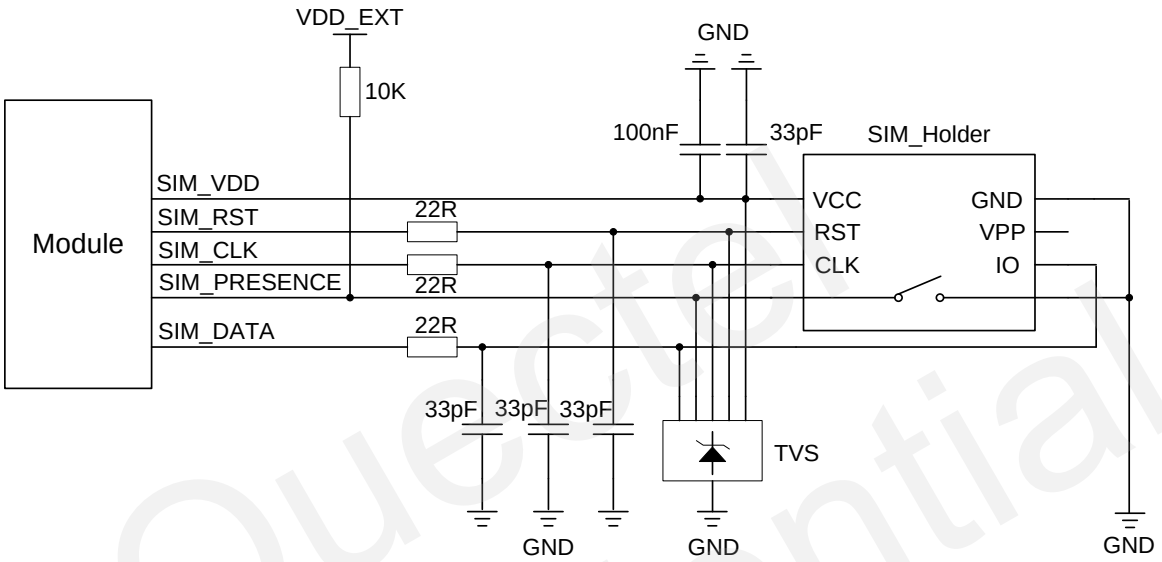

Figure 31: Reference Circuit for SIM Interface with 8-pin SIM Card Holder

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

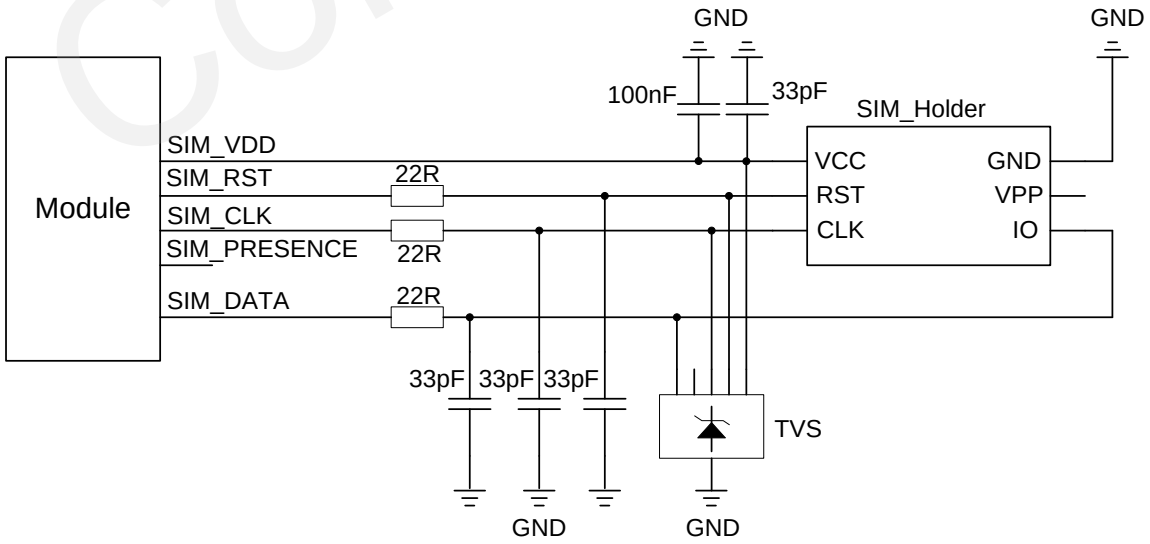

Figure 32: Reference Circuit for SIM Interface with the 6-pin SIM Card Holder

For more information of SIM card holder, please visit http://www.amphenol.com and http://www.molex.com .

In order to enhance the reliability and availability of the SIM card in application. Please follow the below criterion in the SIM circuit design.

- Keep layout of SIM card as close as possible to the module. Assure the possibility of the length of the trace is less than 200mm.
- Keep SIM card signals away from RF and VBAT alignment.
- Assure the ground between module and SIM cassette short and wide. Keep the width of ground no less than 0.5mm to maintain the same electric potential. The decouple capacitor of SIM_VDD is less than 1uF and must be near to SIM cassette.
- To avoid cross talk between SIM_DATA and SIM_CLK. Keep them away with each other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array. For more information of TVS diode, please visit http://www.onsemi.com/. The most important rule is to place the ESD protection device close to the SIM card socket and make sure the nets being protected will go through the ESD device first and then lead to module. The 22Ω resistors should be connected in series between the module and the SIM card so as to suppress the EMI spurious transmission and enhance the ESD protection. Please to be noted 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 signal lines for improving EMI.

3.10. ADC

The module provides two auxiliary ADC interfaces to measure the values of two analog inputs. AT command "**AT+QADC?**" is used to read the voltage value applied on ADC0 pin. AT command "**AT+QEADC?**" is used to read the voltage value applied on ADC1 pin. It is suggested that ADC0 channel is preferred in the use of ADC channel. For details of these AT commands, please refer to the ***document [1]*.** In order to improve the accuracy of ADC, the layout of ADC should be surrounded by ground.

Table 12: Pin Definition of the ADC

Pin Name	Pin NO.	Description
ADC0	41	Analog to digital converter
ADC1	40	Analog to digital converter

Table 13: Characteristics of the ADC

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

3.11. Behaviors of The RI

Table 14: Behaviors of the RI

State	RI Response
Standby	HIGH
Voice Calling	Change to LOW, then: 1. Change 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. Change to HIGH when SMS is received.
SMS	When a new SMS comes, the RI changes to LOW and holds low level for about 120ms, then changes to HIGH.
URC	Certain URCs can trigger 120ms low level on RI.

NOTE

If URC of SMS is disabled, the RI will not change.

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.

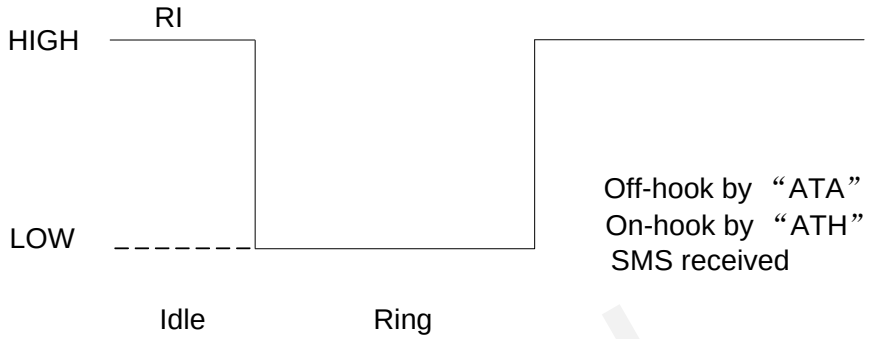

Figure 33: RI Behavior of Voice Calling as a Receiver

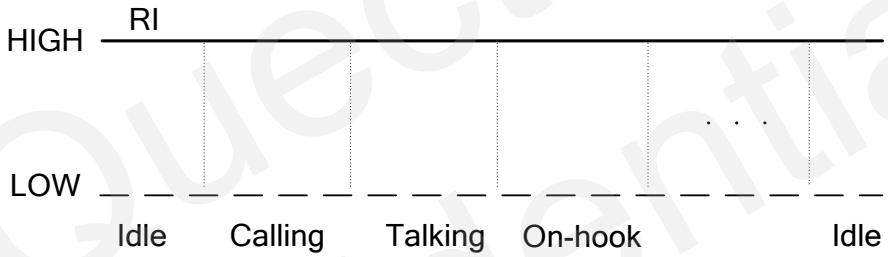

Figure 34: RI Behavior as a Caller

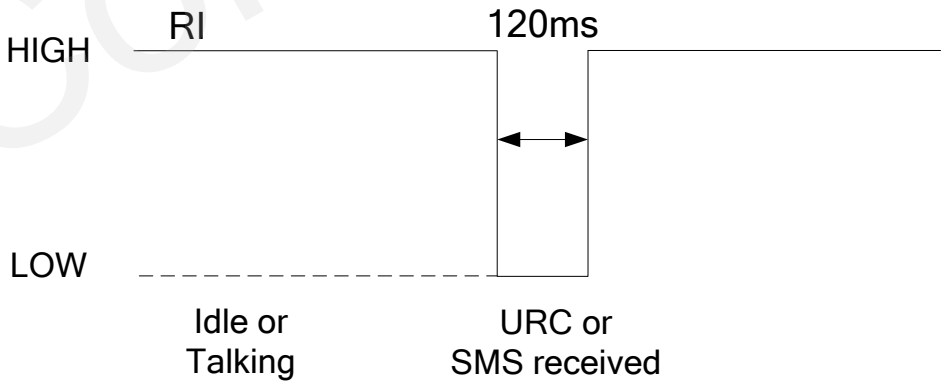

Figure 35: RI Behavior of URC or SMS Received

3.12. 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 the following table.

Table 15: Working State of the NETLIGHT

State	Module function
Off	The module is not running.
64ms On/800ms Off	The module is not synchronized with network.
64ms On/2000ms Off	The module is synchronized with network.
64ms On/600ms Off	The GPRS data transmission after dialing the PPP connection.

A reference circuit is shown as below.

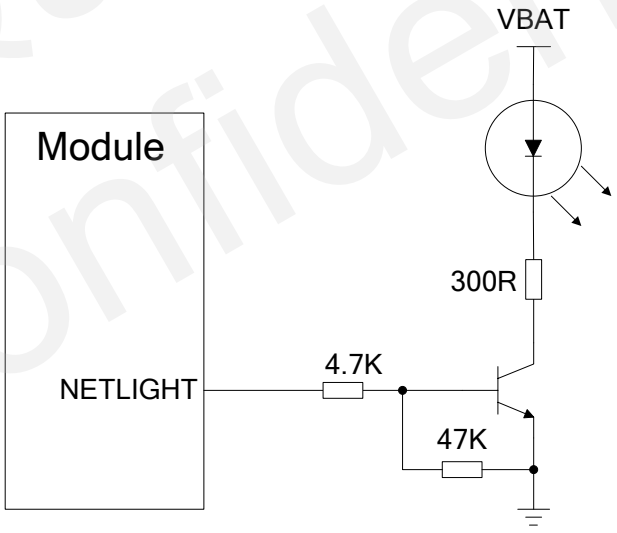

Figure 36: Reference Design for NETLIGHT

3.13. Operating Status Indication

The STATUS pin will output a high level after the module being turned on, but it is not recommended connecting this pin to a MCU's GPIO to judge whether the module is turn-on or not. The following LED indicator circuit for STATUS pin can be used to indicate the state after the module has been turned on.

Table 16: Pin Definition of the STATUS

Pin Name	Pin NO.	Description
STATUS	54	Indicate module operating status

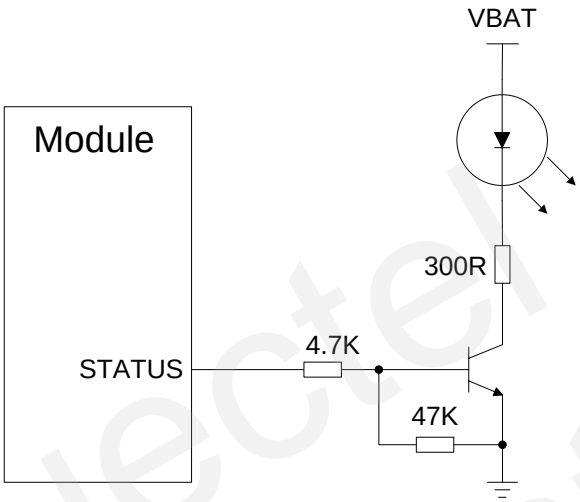

Figure 37: Reference Design for STATUS

3.14. 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 17: Pin Definition of the GPIO Interfaces

Pin Name	Pin NO.	PU/PD	Description
GPIO0	64	PD	General Purpose Input/Output Port
GPIO1	38	PD	General Purpose Input/Output Port

NOTE

Please refer to ***document [5]*** to design the digital IO.

3.15. 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.
- Not support the SPI mode for SD memory card.
- Not support multiple SD memory cards.
- Not support hot plug.
- The data rate up to 48MHz in serial mode.
- Up to 32GB maximum memory card capacity.

With the SD card interface features and reference circuit shown as below, you 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 18: Pin Definition of the SD Card Interface

Pin Name	Pin NO.	Description
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

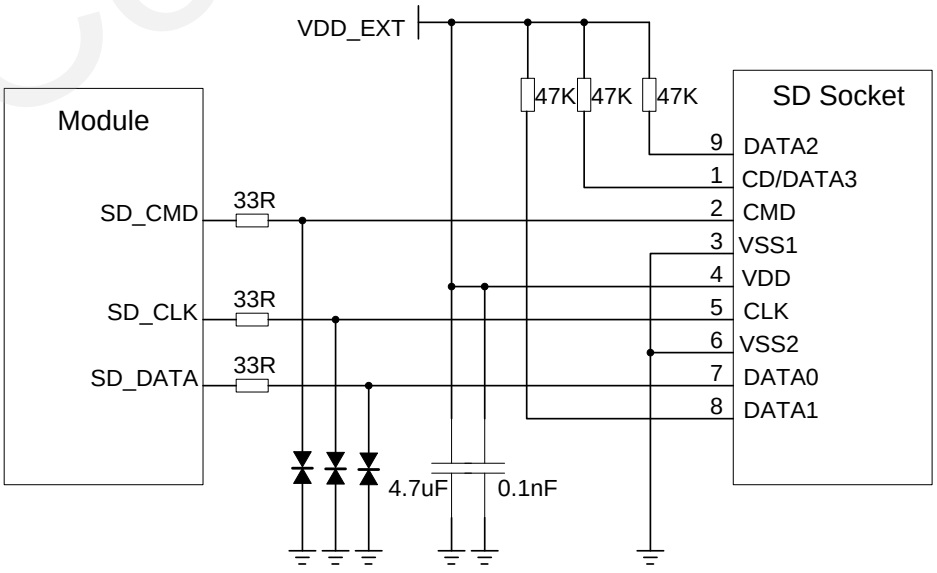

Figure 38: Reference Design for SD Card Interface

Table 19: 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, the following design principles should be complied with:

- Keep all the SD card signals 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 offer good ESD protection, it is recommended to add TVS on signals with the capacitance less than 15pF.
- Reserve external pull-up resistors 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.

Table 20: Pin Definition of the RF_ANT

Pin Name	Pin NO.	Description
GND	42	Ground
RF_ANT	43	RF antenna pad
GND	44	Ground

4.1. RF Reference Design

The reference design for RF is shown as below.

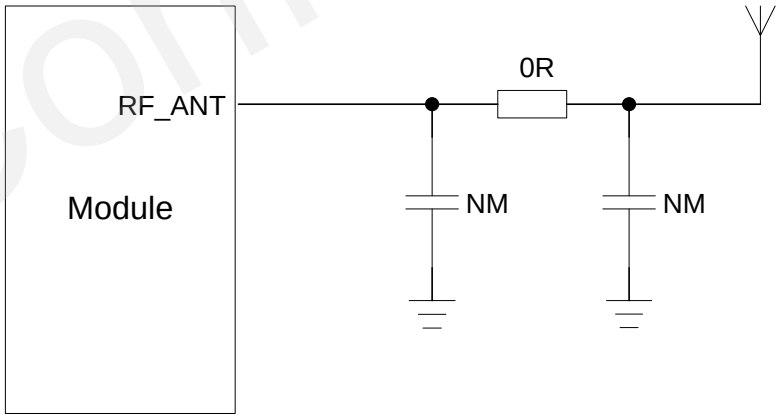

Figure 39: Reference Design for RF

M10 provides an RF antenna pad for antenna connection. The RF trace in host PCB connected to the module RF antenna pad should be coplanar waveguide line or microstrip line, whose characteristic impedance should be close to 50Ω. M10 comes with grounding pads which are next to the antenna pad in order to give a better grounding. Besides, a π type match circuit is suggested to be used to adjust the RF performance.

4.2. RF Output Power

Table 21: The Module Conducted RF Output Power

Frequency	Max.	Min.
GSM850	33dBm±2dB	5dBm±5dB
EGSM900	33dBm±2dB	5dBm±5dB
DCS1800	30dBm±2dB	0dBm±5dB
PCS1900	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 22: The Module Conducted RF Receiving Sensitivity

Frequency	Receive Sensitivity
GSM850	< -109dBm
EGSM900	< -109dBm
DCS1800	< -109dBm
PCS1900	< -109dBm

4.4. Operating Frequencies

Table 23: The Module Operating Frequencies

Frequency	Receive	Transmit	ARFCH
GSM850	869~894MHz	824~849MHz	128~251
EGSM900	925~960MHz	880~915MHz	0~124, 975~1023
DCS1800	1805~1880MHz	1710~1785MHz	512~885
PCS1900	1930~1990MHz	1850~1910MHz	512~810

4.5. Antenna Requirement

The following table shows the requirement on GSM antenna.

Table 24: Antenna Cable Requirements

Type	Requirements
GSM850/EGSM900	Cable insertion loss <1dB
DCS1800/PCS1900	Cable insertion loss <1.5dB

Table 25: Antenna Requirements

Type	Requirements
Frequency Range	GSM850/EGSM900/DCS1800/PCS1900MHz.
VSWR	≤ 2
Gain (dBi)	1
Max Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Vertical

4.6. RF Cable Soldering

Soldering the RF cable to RF pad of module correctly will reduce the loss on the path of RF, please refer to the following example of RF soldering.

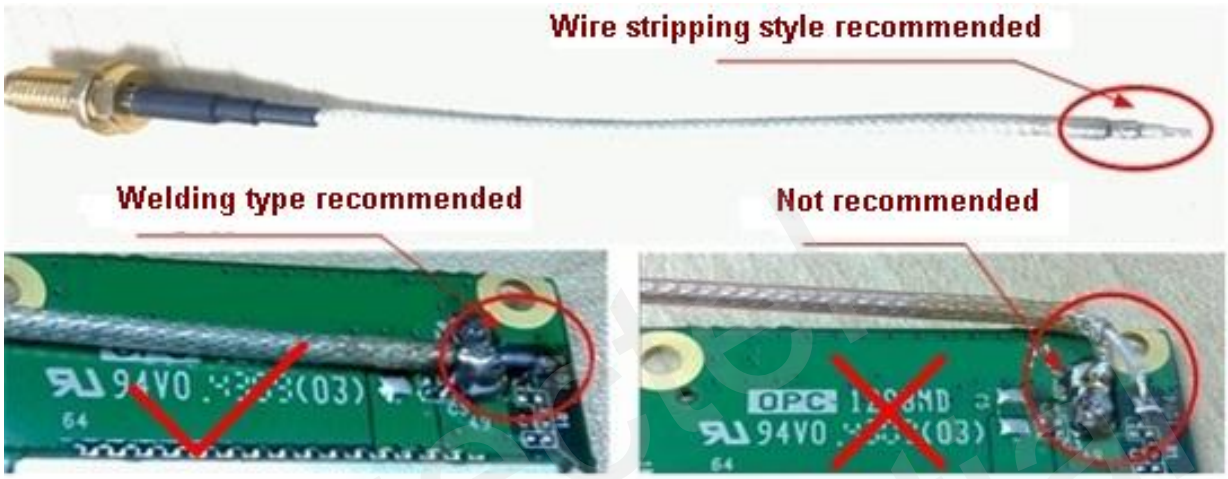

Figure 40: RF Soldering Sample

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 26: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT	-0.3	+4.73	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	3.08	V
Voltage at Analog Pins	-0.3	3.08	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 27: Operating Temperature

Parameter	Min.	Typ.	Max.	Unit
Normal Temperature	-35	+25	+80	℃

Restricted Operation[1)]	-40 ~ -35	+80 ~ +85	℃
Storage Temperature	-45	+90	℃

NOTE

[1)] When the module works within this temperature range, the deviation from the GSM specification may occur. For example, the frequency error or the phase error will be increased.

5.3. Power Supply Ratings

Table 28: 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 EGSM900.			400	mV
I_{VBAT}	Average supply current	Power down mode		150		uA
		SLEEP mode @DRX=5		1.3		mA
		Minimum functionality mode AT+CFUN=0				
		IDLE mode		13		mA
		SLEEP mode		0.98		mA
		AT+CFUN=4				
		IDLE mode		13		mA
		SLEEP mode		1.0		mA
		TALK mode				
		GSM850/EGSM900[1)]		223/219		mA
		DCS1800/PCS1900[2)]		153/151		mA
		DATA mode, GPRS (3Rx,2Tx)				
		GSM850/EGSM900[1)]		363/393		mA
		DCS1800/PCS1900[2)]		268/257		mA
		DATA mode, GPRS (2Rx,3Tx)				
		GSM850/EGSM900[1)]		506/546		mA
		DCS1800/PCS1900[2)]		366/349		mA

		DATA mode, GPRS (4Rx,1Tx) GSM850/EGSM900[1)] DCS1800/PCS1900[2)]	 217/234 172/170		 mA mA
		DATA mode, GPRS (1Rx,4Tx) GSM850/EGSM900[1)] DCS1800/PCS1900[2)]	 458/485 462/439		 mA mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM850 and EGSM900.	1.6	2	A

NOTES

1. [1)] Power control level PCL 5.
2. [2)] Power control level PCL 0.
3. Under the EGSM900 spectrum，the power of 1Rx and 4Tx has been reduced.

5.4. Current Consumption

The values of current consumption are shown as below.

Table 29: The Module Current Consumption

Condition	Current Consumption
Voice Call	
GSM850	@power level #5 <300mA, Typical 223mA @power level #12, Typical 83mA @power level #19, Typical 62mA
EGSM900	@power level #5 <300mA, Typical 219mA @power level #12, Typical 83mA @power level #19, Typical 63mA
DCS1800	@power level #0 <250mA, Typical 153mA @power level #7, Typical 73mA @power level #15, Typical 60mA
PCS1900	@power level #0 <250mA, Typical 151mA @power level #7, Typical 76mA @power level #15, Typical 61mA
GPRS Data	

DATA Mode, GPRS (3Rx, 2Tx) CLASS 12	
GSM850	@power level #5 <550mA, Typical 363mA @power level #12, Typical 131mA @power level #19, Typical 91mA
EGSM900	@power level #5 <550mA, Typical 393mA @power level #12, Typical 132mA @power level #19, Typical 92mA
DCS1800	@power level #0 <450mA, Typical 268mA @power level #7, Typical 112mA @power level #15, Typical 88mA
PCS1900	@power level #0 <450mA, Typical 257mA @power level #7, Typical 119mA @power level #15, Typical 89mA
DATA Mode, GPRS (2Rx,3Tx) CLASS 12	
GSM850	@power level #5 <640mA, Typical 506mA @power level #12, Typical 159mA @power level #19, Typical 99mA
EGSM900	@power level #5 <600mA, Typical 546mA @power level #12, Typical 160mA @power level #19, Typical 101mA
DCS1800	@power level #0 <490mA, Typical 366mA @power level #7, Typical 131mA @power level #15, Typical 93mA
PCS1900	@power level #0 <480mA, Typical 348mA @power level #7, Typical 138mA @power level #15, Typical 94mA
DATA Mode, GPRS (4Rx, 1Tx) CLASS 12	
GSM850	@power level #5 <350mA, Typical 216mA @power level #12, Typical 103mA @power level #19, Typical 83mA
EGSM900	@power level #5 <350mA, Typical 233mA @power level #12, Typical 104mA @power level #19, Typical 84mA
DCS1800	@power level #0 <300mA, Typical 171mA @power level #7, Typical 96mA @power level #15, Typical 82mA
PCS1900	@power level #0 <300mA, Typical 169mA @power level #7, Typical 98mA @power level #15, Typical 83mA
DATA Mode, GPRS (1Rx, 4Tx) CLASS 12	

GSM850	@power level #5 <660mA, Typical 457mA @power level #12, Typical 182mA @power level #19, Typical 106mA
EGSM900	@power level #5 <660mA, Typical 484mA @power level #12, Typical 187mA @power level #19, Typical 109mA
DCS1800	@power level #0 <530mA, Typical 461mA @power level #7, Typical 149mA @power level #15, Typical 97mA
PCS1900	@power level #0 <530mA, Typical 439mA @power level #7, Typical 159mA @power level #15, Typical 99mA

NOTE

GPRS Class 12 is the default setting. The module can be configured from GPRS Class 1 to Class 12. 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 Electro-static 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 30: The ESD Endurance (Temperature: 25ºC, Humidity: 45%)

Tested Point	Contact Discharge	Air Discharge
VBAT, GND	±5KV	±10KV
RF_ANT	±5KV	±10KV
TXD, RXD	±2KV	±4KV
Others	±0.5KV	±1KV

6 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module.

6.1. Mechanical Dimensions of Module

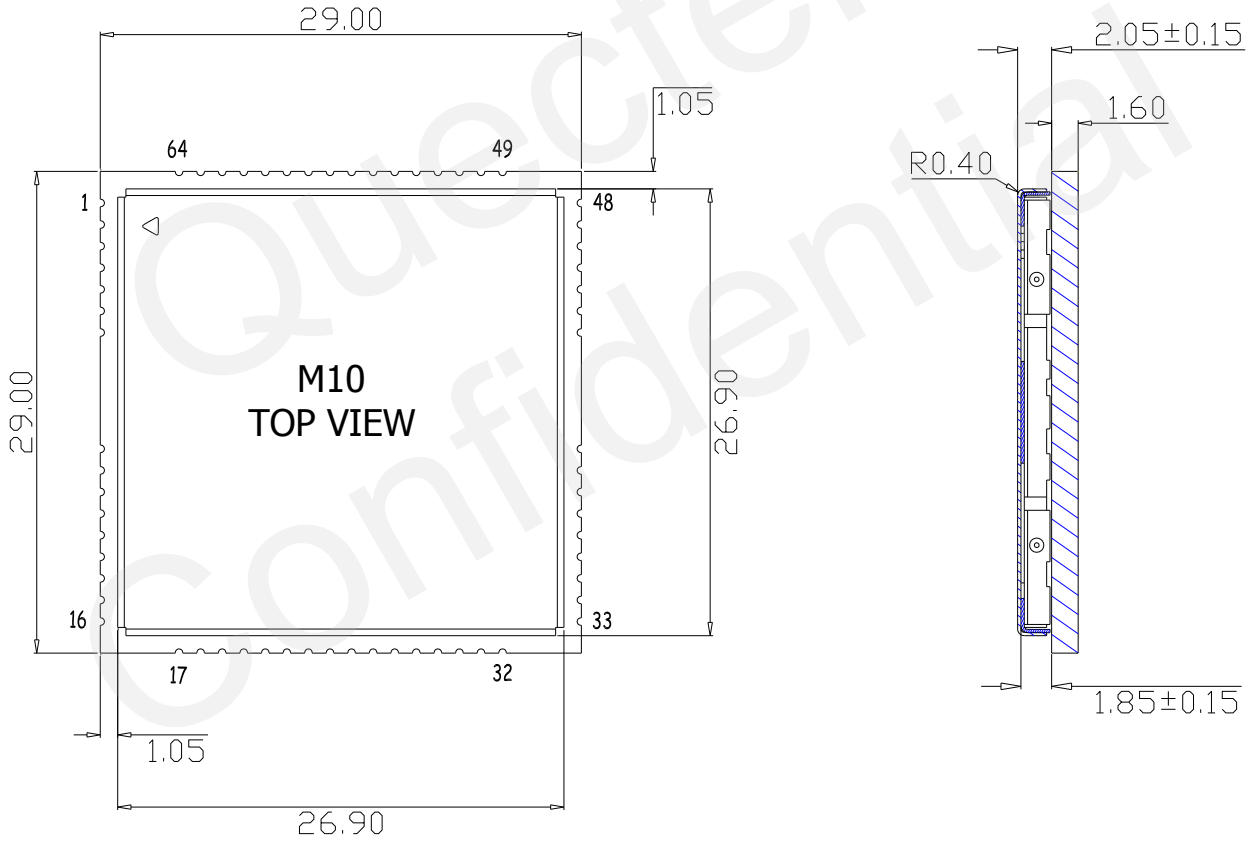

Figure 41: M10 Module Top and Side Dimensions (Unit: mm)

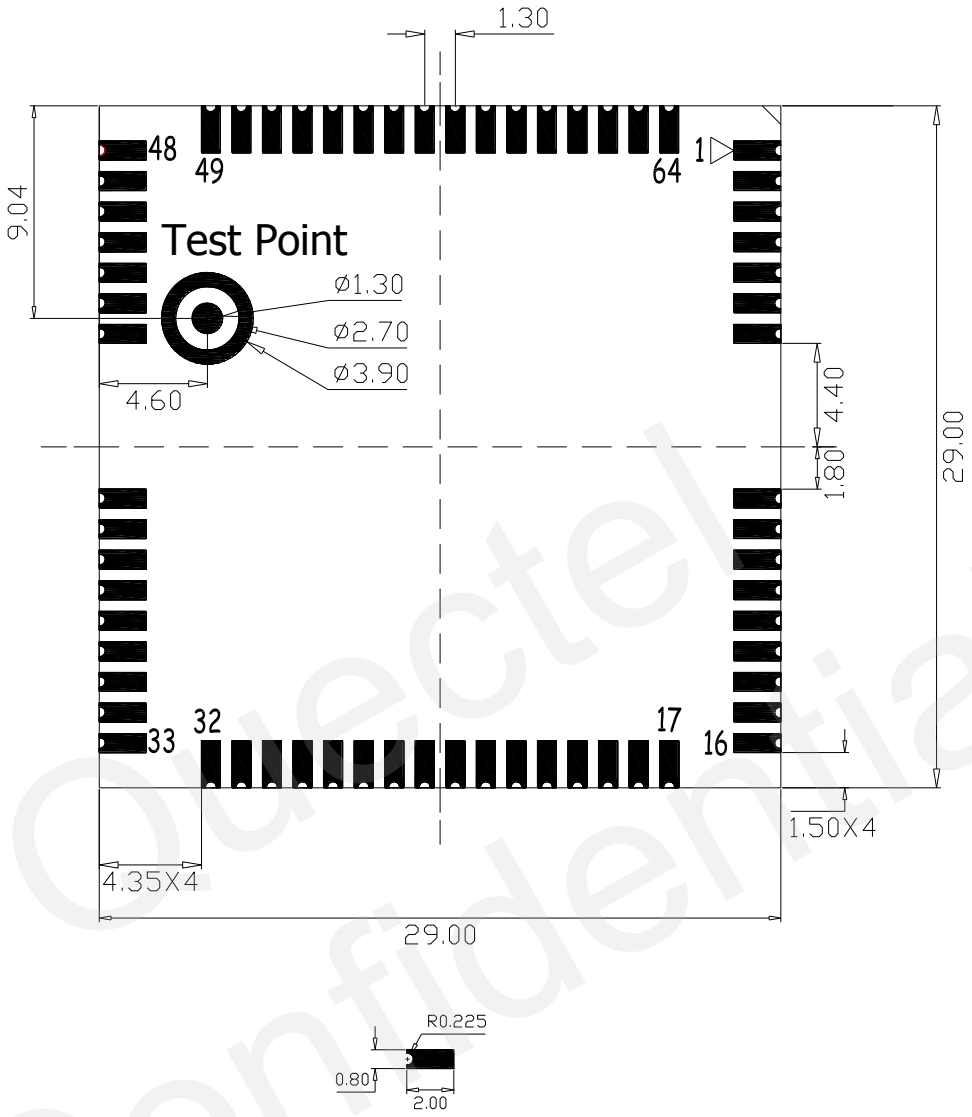

Figure 42: M10 Module Bottom Dimensions (Unit: mm)

6.2. Recommended Footprint

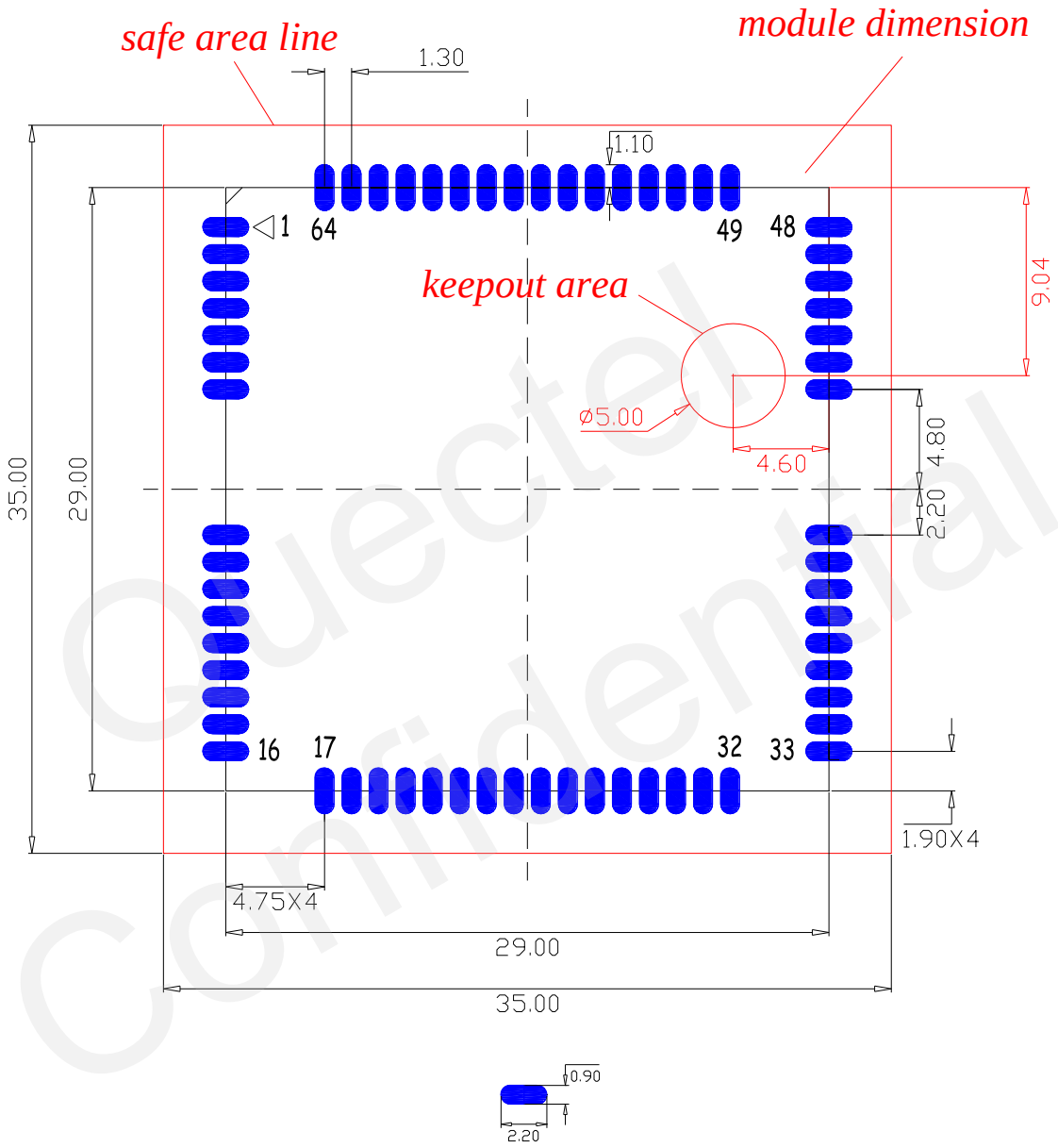

Figure 43: Recommended Footprint (Unit: mm)

NOTES

1. The module should be kept about 3mm away from other components in the host PCB.
2. The circular test points with a diameter of 5mm in the above recommended footprint should be treated as keepout areas ("keepout" means do not pour copper on the mother board).

6.3. Top View of the Module

Figure 44: Top View of the Module

6.4. Bottom View of the Module

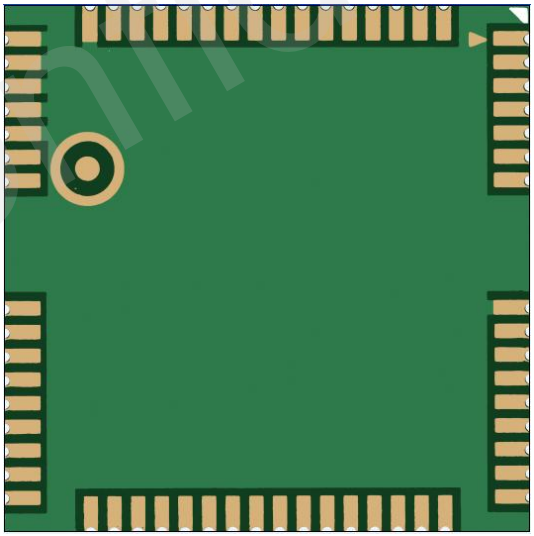

Figure 45: Bottom View of the Module

7 Storage and Manufacturing

7.1. Storage

M10 module is distributed in a vacuum-sealed bag. The restriction for storage is shown as below.

Shelf life in the vacuum-sealed bag: 12 months at environments of <40ºC temperature and <90%RH.

After the vacuum-sealed bag is opened, devices that need to be mounted directly must be:

- Mounted within 72 hours at the factory environment of ≤30ºC temperature and <60% RH.
- Stored at <10% RH.

Devices require baking before mounting, if any circumstance below occurs.

- When the ambient temperature is 23ºC±5ºC, humidity indication card shows the humidity is >10% before opening the vacuum-sealed bag.
- If ambient temperature is <30ºC and the humidity is <60%, the devices have not been mounted during 72hours.
- Stored at >10% RH.

If baking is required, devices should be baked for 48 hours at 125ºC±5ºC.

NOTE

As plastic container cannot be subjected to high temperature, devices must be removed prior to high temperature (125ºC) bake. If shorter bake times are desired, refer to the IPC/JEDECJ-STD-033 for bake procedure.

7.2. Soldering

The squeegee should push the paste on the surface of the stencil that makes the paste fill the stencil openings and penetrate to the PCB. The force on the squeegee should be adjusted so as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, the thickness of stencil at the hole of the module pads should be 0.2 mm for M10. For more details, please refer to ***document [3]***.

It is suggested that peak reflow temperature is from 235ºC to 245ºC (for SnAg3.0Cu0.5 alloy). Absolute max reflow temperature is 260ºC. To avoid damage to the module when it was repeatedly heated, it is suggested that the module should be mounted after the first panel has been reflowed. The following picture is the actual diagram which we have operated.

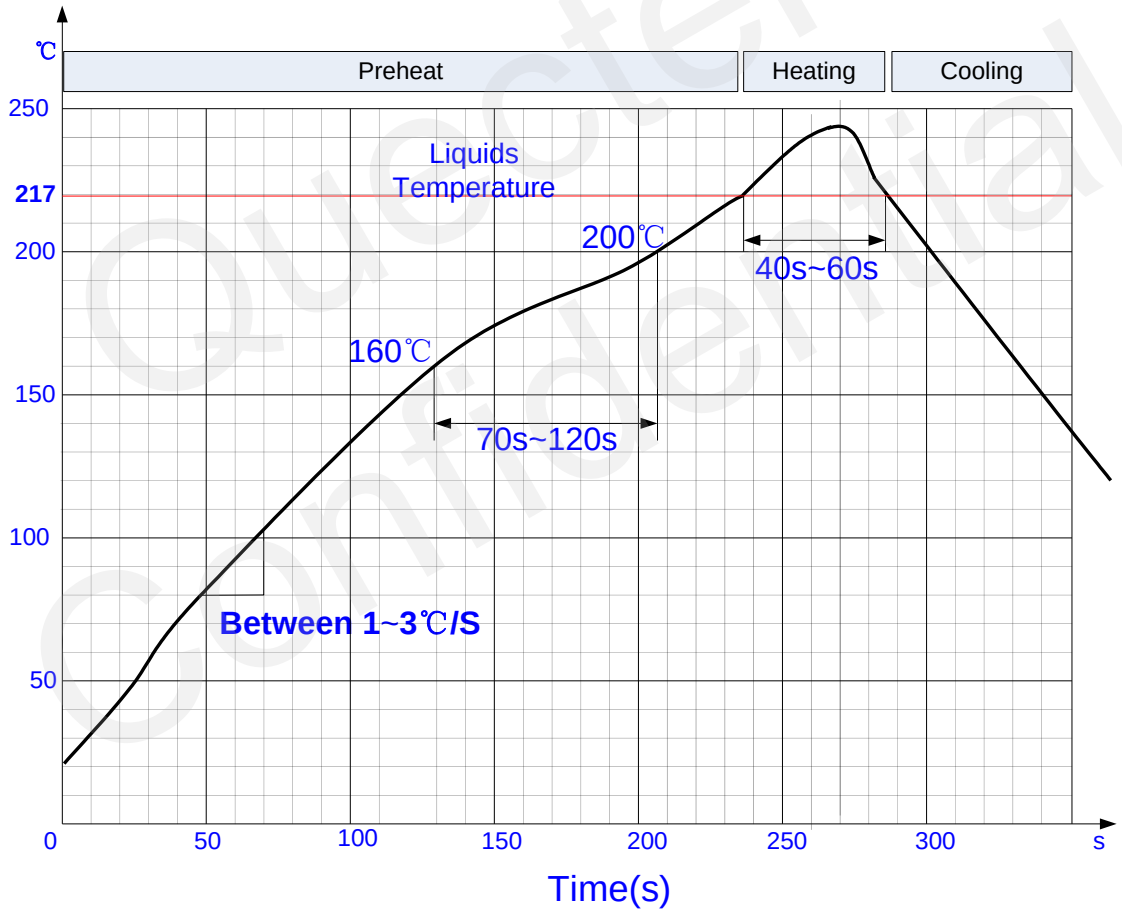

Figure 46: Ramp-Soak-Spike Reflow Profile

7.3. Packaging

The modules are stored inside a vacuum-sealed bag which is ESD protected. It should not be opened until the devices are ready to be soldered onto the application.

The reel is 330mm in diameter and each reel contains 250 modules.

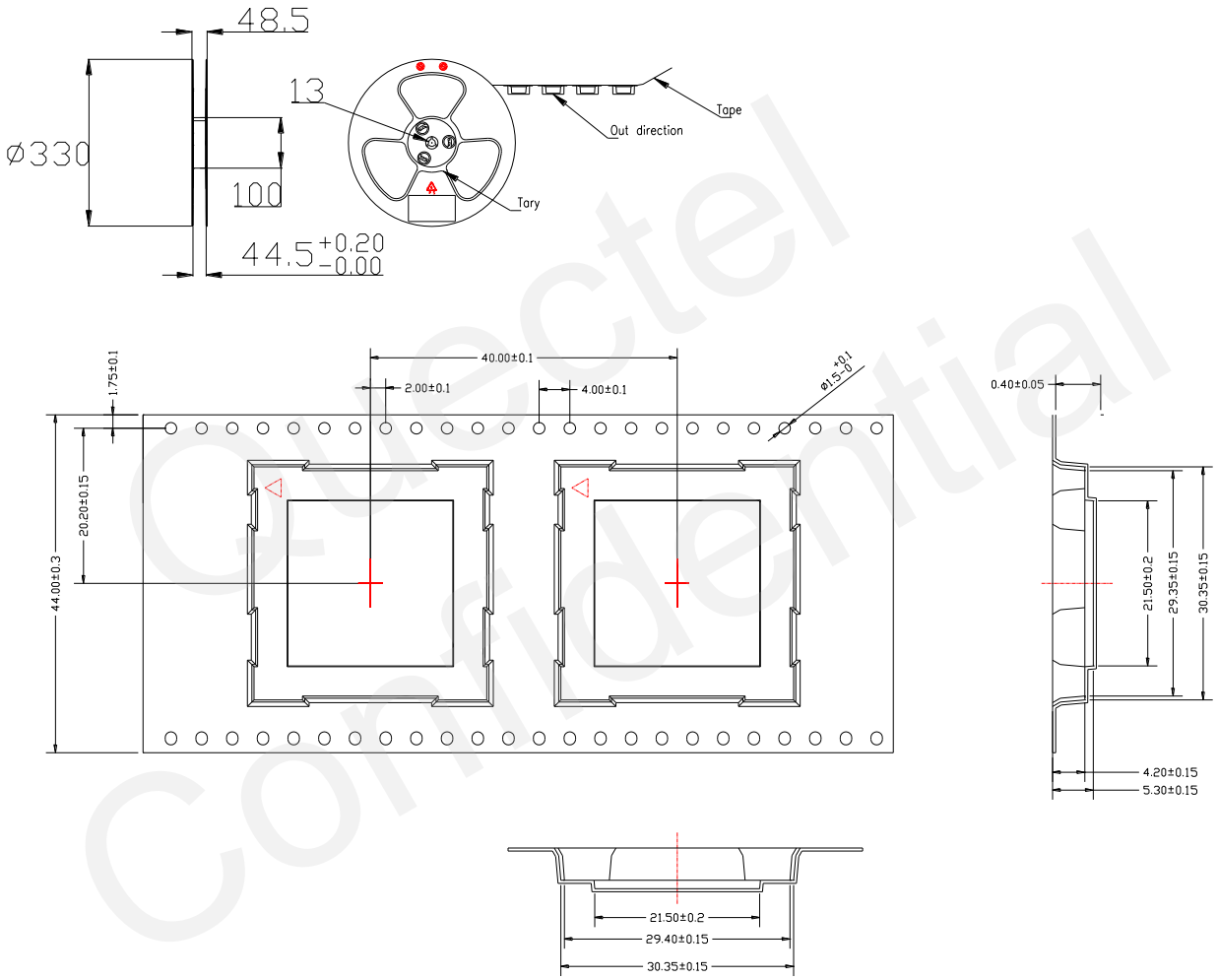

Figure 47: Tape and Reel Specification (Unit: mm)

Table 31: Reel Packing

Model Name	MOQ for MP	Minimum Package: 250pcs	Minimum Package×4=1000pcs
M10	250pcs	Size: 370 × 350 × 56mm^3 N.W: 1.4kg G.W: 2.3kg	Size: 380 × 250 × 365mm^3 N.W: 5.7kg G.W: 9.7kg

8 Appendix A Reference

Table 32: Related Documents

SN	Document Name	Remark
[1]	Quectel_M10_AT_Commands_Manual	AT commands manual
[2]	GSM_UART_Application_Note	UART port application note
[3]	Module_Secondary_SMT_User_Guide	Module secondary SMT user guide
[4]	GSM_EVB_User_Guide	GSM EVB user guide
[5]	Quectel_GSM_Module_Digital_IO_Application_Note	GSM module digital IO application note
[6]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[7]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[8]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[9]	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)
[10]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[11]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[12]	GSM 03.38	Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information

[13] GSM 11.10	Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification

Table 33: 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
G.W	Gross Weight
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
Imax	Maximum Load Current
Inorm	Normal Current
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
MO	Mobile Originated
MOQ	Minimum Order Quantity
MP	Manufacture Product
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
N.W	Net Weight

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	
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

9 Appendix B GPRS Coding Scheme

Four coding schemes are used in GPRS protocol. The differences between them are shown in the following table.

Table 34: 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 the figure below:

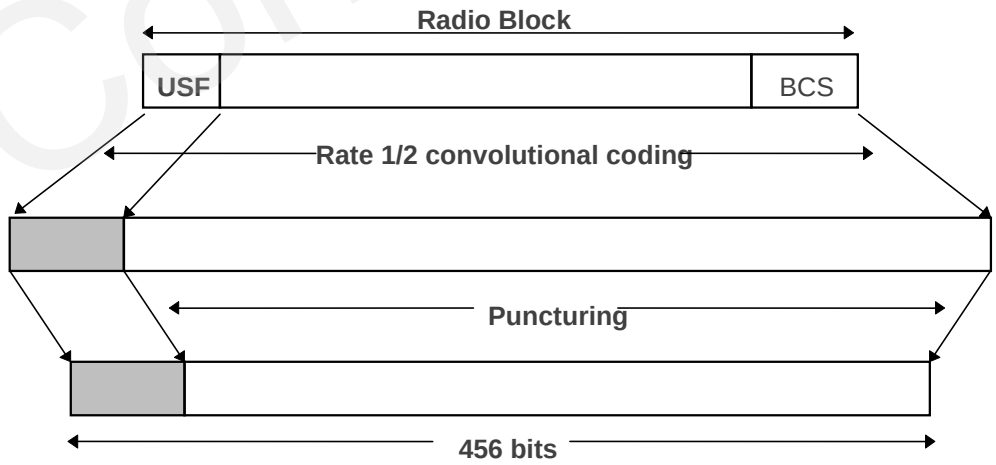

Figure 48: Radio Block Structure of CS-1, CS-2 and CS-3

Radio block structure of CS-4 is shown as the following figure.

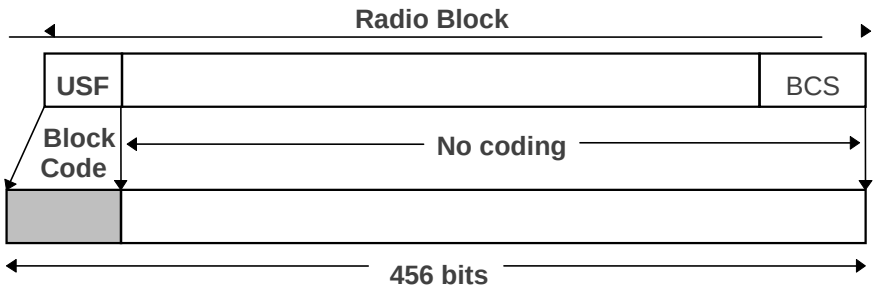

Figure 49: Radio Block Structure of CS-4

10 Appendix C GPRS Multi-slot Class

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 the following table.

Table 35: 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