M95

Quectel Cellular Engine

Hardware Design

M95_HD_V1.2

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0. Revision history

Revision	Date	Author	Description of change
1.0	2011-12-29	Luka WU	Initial
1.1	2012-05-18	Luka WU	1. Added the current consumption in GPRS communication mode. 2. Modified AT command **AT+QAUDCH** in charter 3.10. 3. Modified the Footprint of recommendation. 4. Updated M95 module's package type.
1.2	2012-09-19	Luka WU	1. Updated the module functional diagram 2. Updated the Voltage ripple during transmitting 3. Modified the level match reference circuits for 5V peripheral system 4. Updated the SIM card reference circuit 5. Added The module current consumption.

1. Introduction

This document defines Module M95 and describes its hardware interface which are connected with the customer application and the air interface.

This document can help customers quickly understand the interface specifications, electrical and mechanical details of M95. Associated with application notes and user guide, customers can use M95 to design and set up mobile applications quickly.

1.1. Related documents

Table 1: Related documents

SN	Document name	Remark
[1]	M95_ATC	AT command set
[2]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[3]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[4]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[5]	GSM 07.05	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[6]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[7]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[8]	GSM 03.38	Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information
[9]	GSM 11.10	Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification
[10]	GSM_UART_AN	UART port application notes
[11]	GSM_FW_Upgrade_Tool_Lite_GS2_UDG	GSM Firmware upgrade tool lite GS2 user guide
[12]	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

Li-Ion	Lithium-Ion
MO	Mobile Originated
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
RX	Receive Direction
SIM	Subscriber Identification Module
SMS	Short Message Service
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
VIHmax	Maximum Input High Level Voltage Value
VIHmin	Minimum Input High Level Voltage Value
VILmax	Maximum Input Low Level Voltage Value
VILmin	Minimum Input Low Level Voltage Value
VImax	Absolute Maximum Input Voltage Value
VImin	Absolute Minimum Input Voltage Value
VOHmax	Maximum Output High Level Voltage Value
VOHmin	Minimum Output High Level Voltage Value
VOLmax	Maximum Output Low Level Voltage Value
VOLmin	Minimum Output Low Level Voltage Value
Phonebook abbreviations	
FD	SIM Fix Dialing phonebook
LD	SIM Last Dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT Calls (missed calls)
ON	SIM (or ME) Own Numbers (MSISDNs) list
RC	Mobile Equipment list of Received Calls
SM	SIM phonebook

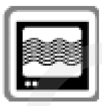
1.3. Safety caution

The following safety precautions must be observed during all phases of the operation, such as usage, service or repair of any cellular terminal or mobile incorporating M95 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

M95 is a Quad-band GSM/GPRS engine that works at frequencies of GSM850MHz, GSM900MHz, DCS1800MHz and PCS1900MHz. The M95 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 19.9mm × 23.6mm × 2.65mm, the module can meet the requirements of almost all M2M applications, including Tracking and Tracing, Industrial PDA, Wireless POS, Intelligent Measurement, Remote Controlling, etc.

M95 is an SMD type module with LCC package, which can be embedded in customer applications. It provides abundant hardware interfaces between the module and customer's host board.

The module is designed with power saving technique so that the current consumption is as low as 1.3 mA in SLEEP mode when DRX is 5.

M95 is integrated with Internet service protocols, which are TCP/IP, UDP, FTP and PPP. Extended AT commands have been developed for customer to use these Internet service protocols easily.

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

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: 1.3 mA @ DRX=5 1.2 mA @ DRX=9
Frequency bands	● Quad-band: GSM850, GSM900, DCS1800, PCS1900 ● The module can search these frequency bands automatically ● The frequency bands can be set by AT command ● Compliant with GSM Phase 2/2+
GSM class	Small MS
Transmitting power	● Class 4 (2W) at GSM850 and GSM900 ● 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

Temperature range	● Normal operation: -35 ℃ ~ +80 ℃ ● Restricted operation: -40 ℃ ~ -35 ℃ and +80 ℃ ~ +85 ℃ 1) ● Storage temperature: -45 ℃ ~ +90 ℃
DATA GPRS: CSD:	● GPRS data downlink transfer: max. 85.6 kbps ● GPRS data uplink transfer: max. 85.6 kbps ● Coding schemes: 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 ● Support Packet Switched Broadcast Control Channel (PBCCH) ● CSD transmission rates: 2.4, 4.8, 9.6, 14.4 kbps non-transparent ● Unstructured Supplementary Services Data (USSD) support
SMS	● Text and PDU mode ● SMS storage: SIM card
SIM interface	Support SIM card: 1.8V, 3V
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 ● Embedded one amplifier of class AB with maximum driving power up to 800mW
UART interface	UART Port: ● Seven lines on UART port interface ● Use for AT command, GPRS data and CSD data ● Multiplexing function ● Support autobauding from 4800 bps to 115200 bps Debug Port: ● Two lines on debug UART port interface： DBG_TXD and DBG_RXD ● Debug Port only used for software debugging
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	Implemented
Physical characteristics	Size: 19.9±0.15 ×23.6±0.15 ×2.65±0.2mm Weight: 3g
Firmware upgrade	Firmware upgrade via UART Port
Antenna interface	Connected via 50 Ohm antenna pad

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 the M95 module and illustrates the major functional parts:

- Power management
- Baseband
- The GSM radio frequency part
- The Peripheral interface
  —SIM interface
  —Audio interface
  —UART interface
  —Power supply
  —RF interface
  —Turn on/off interface
  —RTC interface

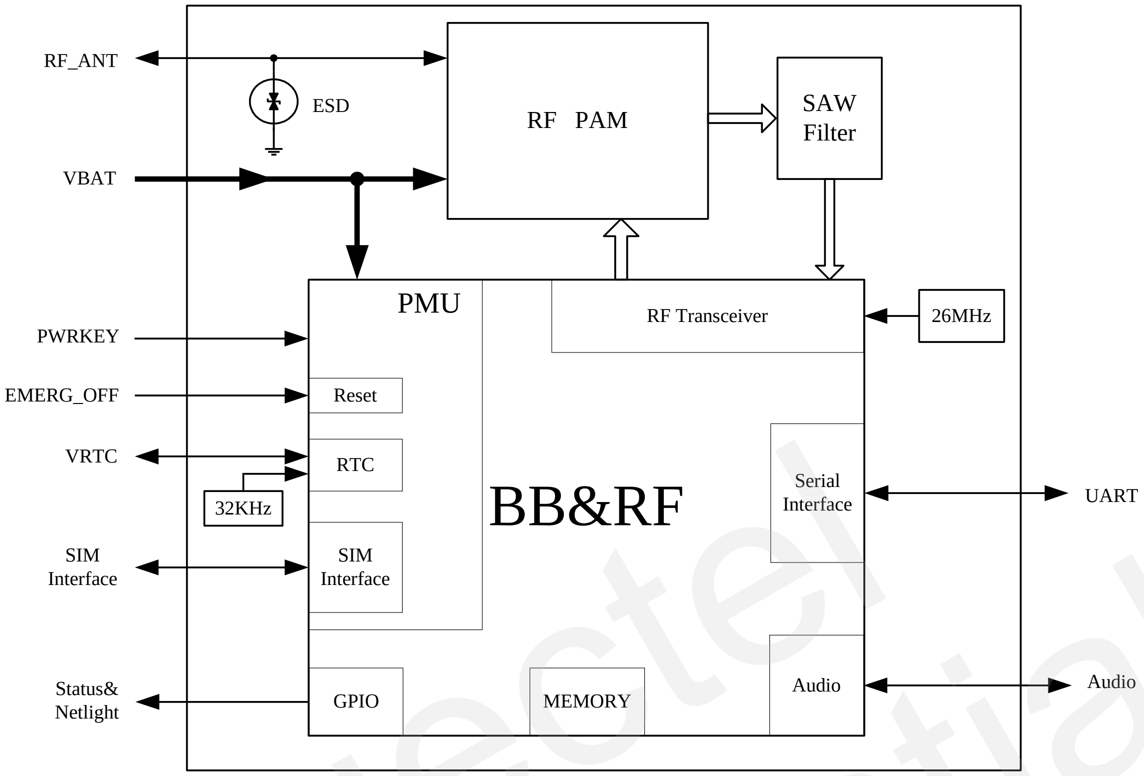


Figure 1: Module functional diagram

2.3. Evaluation board

In order to help customer to develop applications with M95, 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 [12]***.

3. Application interface

The module is equipped with 42 pin SMT pad and it adopts LCC package. Detailed descriptions on Sub-interfaces included in these pads are given in the following chapters:

- Power supply
- Turn on/off
- Power saving
- RTC
- UART interfaces
- Audio interfaces
- SIM interface

3.1. Pin

3.1.1. Pin assignment

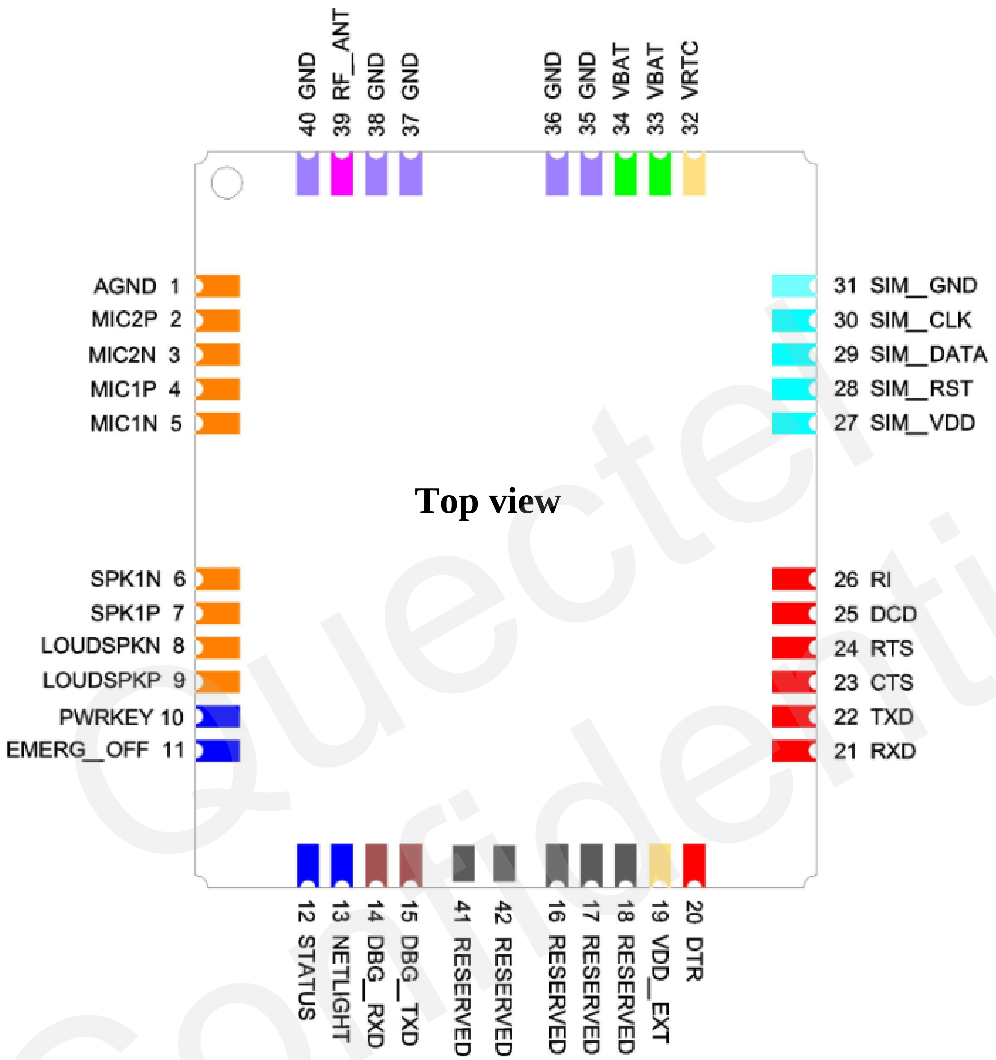


Figure 2: Pin assignment

Table 5: M95 pin assignment

PIN NO.	PIN NAME	I/O	PIN NO.	PIN NAME	I/O
1	AGND		2	MIC2P	I
3	MIC2N	I	4	MIC1P	I
5	MIC1N	I	6	SPK1N	O
7	SPK1P	O	8	LOUDSPKN	O
9	LOUDSPKP	O	10	PWRKEY	I
11	EMERG_OFF	I	12	STATUS	O

13	NETLIGHT	O	14	DBG_RXD	I
15	DBG_TXD	O	16	RESERVED	
17	RESERVED		18	RESERVED	
19	VDD_EXT	O	20	DTR	I
21	RXD	I	22	TXD	O
23	CTS	O	24	RTS	I
25	DCD	O	26	RI	O
27	SIM_VDD	O	28	SIM_RST	O
29	SIM_DATA	I/O	30	SIM_CLK	O
31	SIM_GND		32	VRTC	I/O
33	VBAT	I	34	VBAT	I
35	GND		36	GND	
37	GND		38	GND	
39	RF_ANT	I/O	40	GND	
41	RESERVED		42	RESERVED	

3.1.2. Pin description

Table 6: Pin description

Power supply					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
VBAT	33, 34	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 which typically rises to 1.6A.
VRTC	32	I/O	Power supply for RTC when VBAT is not supplied for the system. Charge 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	If unused, keep this pin open.
VDD_EXT	19	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 this pin for power supply.
GND	35, 36, 37, 38, 40		Ground		
Turn on/off					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
PWRKEY	10	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=VBAT	Pulled up to VBAT internally.
Emergency shutdown					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
EMERG_OFF	11	I	Emergency off. Pulled down for at least 20ms, which will turn off the module 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 indicator					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
STATUS	12	O	Indicate module's operating status. High level indicates module is power-on and low level indicates power-down.	VOHmin= 0.85×VDD_EXT VOLmax= 0.15×VDD_EXT	If unused, keep this pin open.
Audio interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
MIC1P MIC1N	4， 5	I	Channel 1 positive and negative		If unused, keep these pins open.

			voice-band input		
MIC2P MIC2N	2， 3	I	Channel 2 positive and negative voice-band input		
SPK1N SPK1P	6, 7	O	Channel 1 positive and negative voice-band output		If unused, keep these pins open.
AGND	1		Analog ground. Cooperate with LOUDSPKP		If unused, keep this pin open.
LOUDSPKN LOUDSPKP	8，9	O	Channel 2 positive and negative voice-band output		1. If unused, keep these pins open. 2. Embedded amplifier of class AB internally. 3. Support both Voice and ring.
Net status indicator					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
NETLIGHT	13	O	Network status indication	VOHmin= 0.85×VDD_EXT VOLmax= 0.15×VDD_EXT	If unused, keep this pin open.
Main UART port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
DTR	20	I	Data terminal ready	VILmin=-0.3V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.3V VOHmin= 0.85×VDD_EXT VOLmax= 0.15×VDD_EXT	If only use TXD, RXD and GND to communicate, recommended keeping other pins open, except RTS. Pull down RTS.
RXD	21	I	Receive data		
TXD	22	O	Transmit data		
CTS	23	O	Clear to send		
RTS	24	I	Request to send		
DCD	25	O	Data carrier detection		
RI	26	O	Ring indicator		
Debug UART port					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT

DBG_RXD	14	I	UART interface for debugging only.	VILmin=-0.3V VILmax= 0.25×VDD_EXT VIHmin= 0.75×VDD_EXT VIHmax= VDD_EXT+0.3V VOHmin= 0.85×VDD_EXT VOLmax= 0.15×VDD_EXT	If unused, keep these pins open.
DBG_TXD	15	O			
SIM interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
SIM_ VDD	27	O	Power supply for SIM card	The voltage can be selected by software automatically. Either 1.8V or 3V.	1. All signals of SIM interface should be protected against ESD with a TVS diode array. 2. Maximum trace length is 200mm from the module pad to SIM card holder.
SIM_RST	28	O	SIM reset	3V： VOLmax=0.36V VOHmin= 0.9×SIM_VDD 1.8V: VOLmax= 0.2×SIM_VDD VOHmin= 0.9×SIM_VDD	
SIM_ DATA	29	I/O	SIM data	3V： VOLmax=0.4V VOHmin= SIM_VDD-0.4V 1.8V: VOLmax= 0.15×SIM_VDD VOHmin= SIM1_VDD-0.4V	
SIM_CLK	30	O	SIM clock	3V： VOLmax=0.4V VOHmin= 0.9×SIM_VDD 1.8V: VOLmax= 0.12×SIM_VDD	

				VOHmin= 0.9×SIM_VDD	
SIM_GND	31		SIM ground		
RF interface					
PIN NAME	PIN NO.	I/O	DESCRIPTION	DC CHARACTERISTICS	COMMENT
RF_ANT	39	I/O	RF antenna pad	Impedance of 50Ω	

3.2. Operating modes

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

Table 7: 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 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, 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.	

1) Use the EMERG_OFF pin only while failing to turn off the module by the command "AT+QPOWD=1" and the PWRKEY pin. Please refer to Section 3.4.2.2.

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 M95 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.

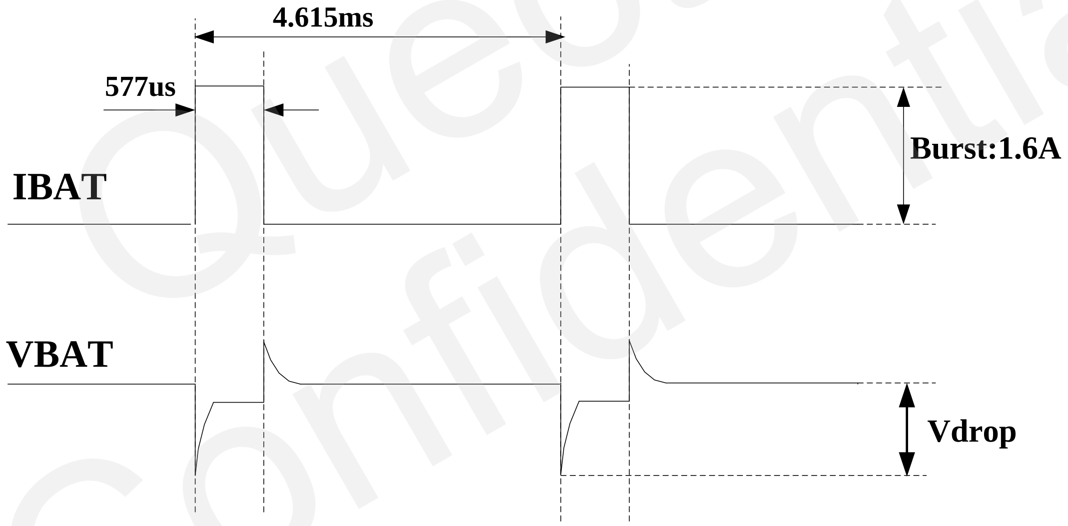


Figure 3: Voltage ripple during transmitting

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.

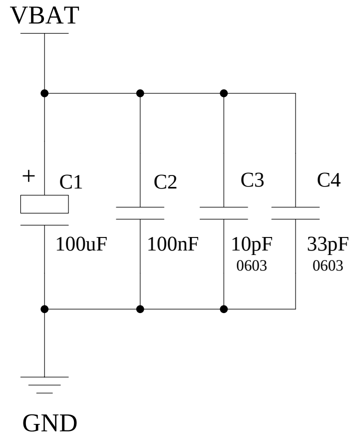


Figure 4: Reference circuit for the VBAT input

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 prefer 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.

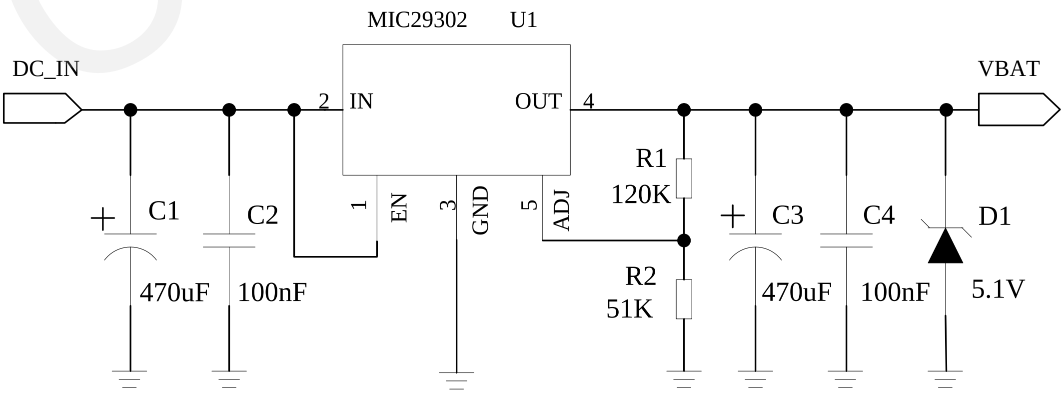


Figure 5: Reference circuit for power supply

3.3.4. Monitor power supply

To monitor the supply voltage, the "AT+CBC" command can be used 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 automatically measured in period of 5s. 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 on and down scenarios

3.4.1. Power on the module using the 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 module. Then an "AT+IPR=x;&W" should be sent to set a fixed baud rate for module and save the configuration to flash memory of module. After these configurations, the URC "RDY" would be received from the Serial Port of module every time when the module is powered on. Refer to Chapter "AT+IPR" in document [1].

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

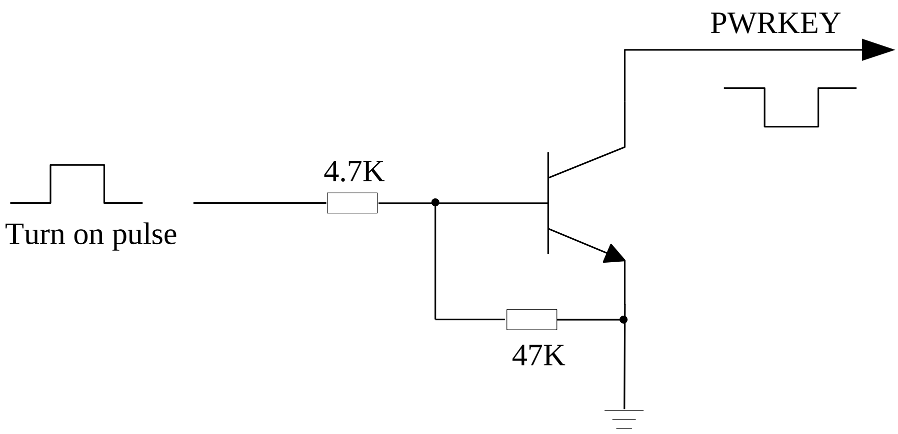


Figure 6: Turn on the module using driving circuit

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.

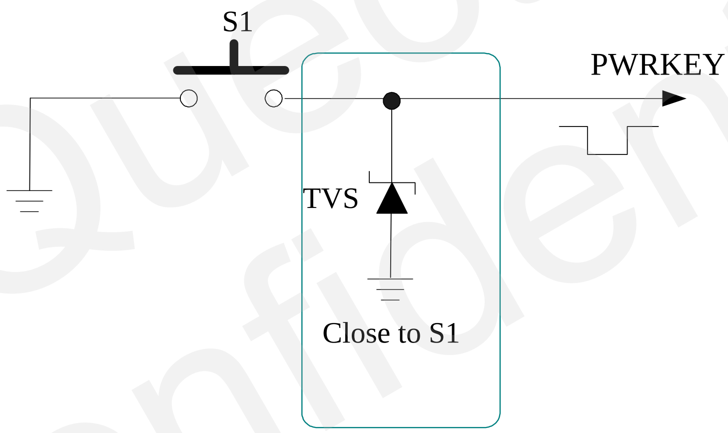


Figure 7: Turn on the module using keystroke

The power-on scenarios is illustrated as the following figure.

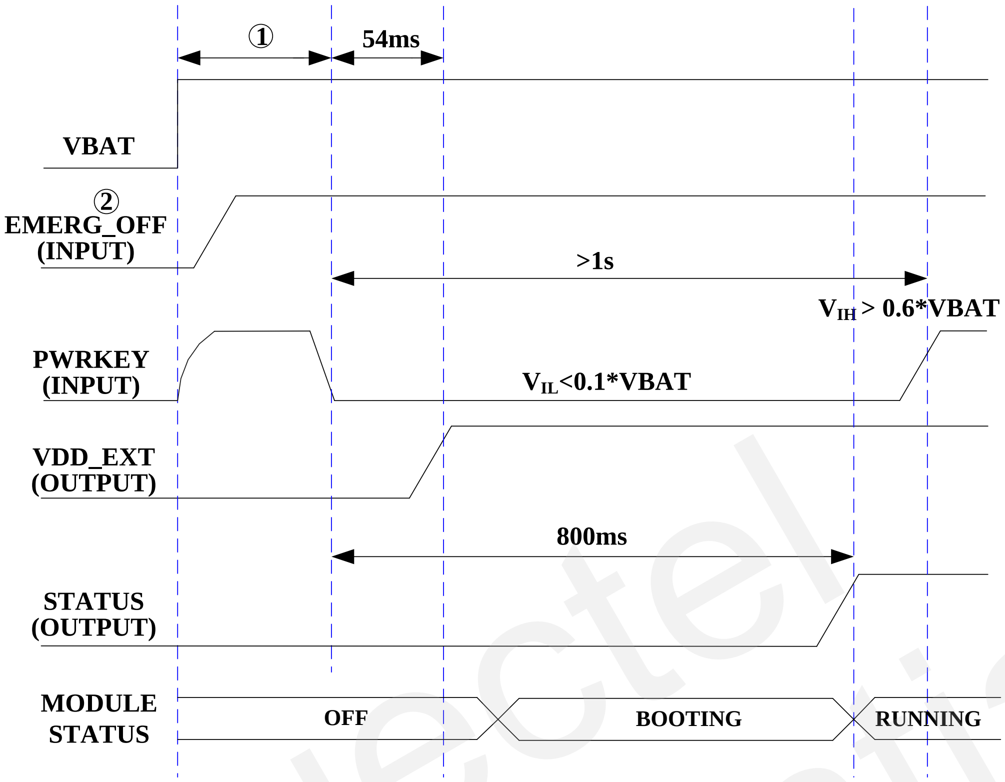


Figure 8: Timing of turning on system

① ***Make sure that VBAT is stable before pulling down PWRKEY pin. The 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 power-on. After the STATUS pin goes to high level, PWRKEY can 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 the PWRKEY pin

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

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

Before the completion of the power-down procedure, the module sends out the result code shown as 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 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.

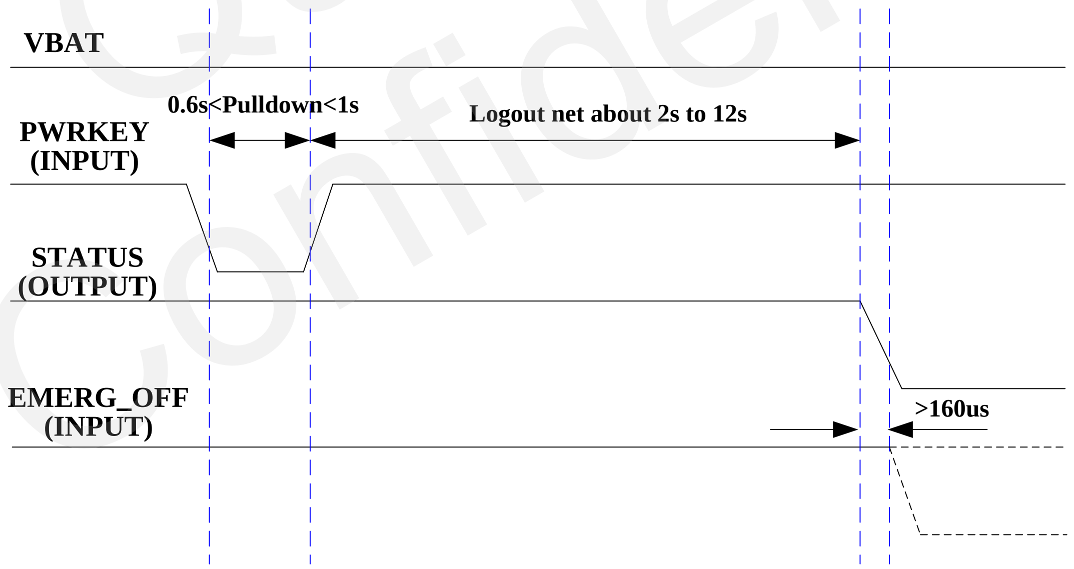


Figure 9: Timing of turning off the module

3.4.2.2. Power down the module using AT command

Customer's application can 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 software to save important data before completely disconnecting the power supply, thus it is a safe way.
Before the completion of the power-down procedure the module sends out the result code shown as 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. The POWER DOWN mode can also be indicated by STATUS pin, which is a low level voltage in this mode.

Please refer to ***document [1]*** for details about the AT command "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 uncritical voltage range is 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 don't appear when autobauding is active and DTE and DCE are not correctly synchronized after start-up. The module is recommended to set to a fixed baud rate.

After 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. 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 using EMERG_OFF pin

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

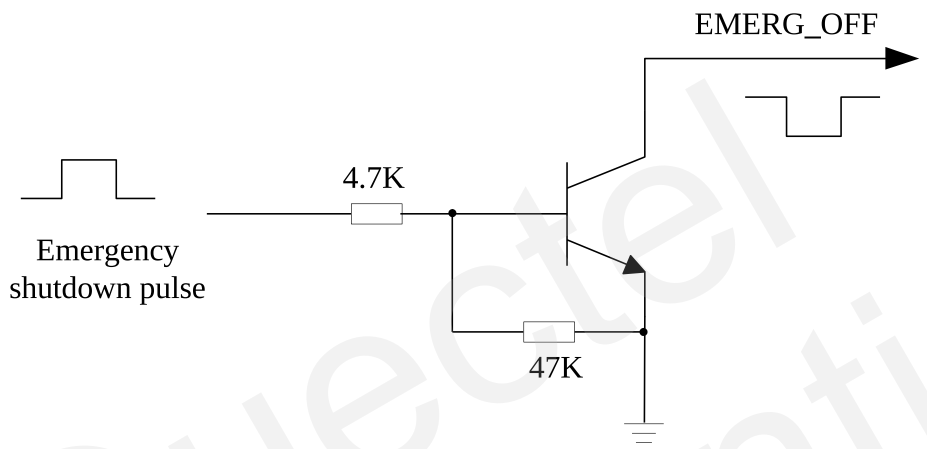


Figure 10: Reference circuit for EMERG_OFF by using driving circuit

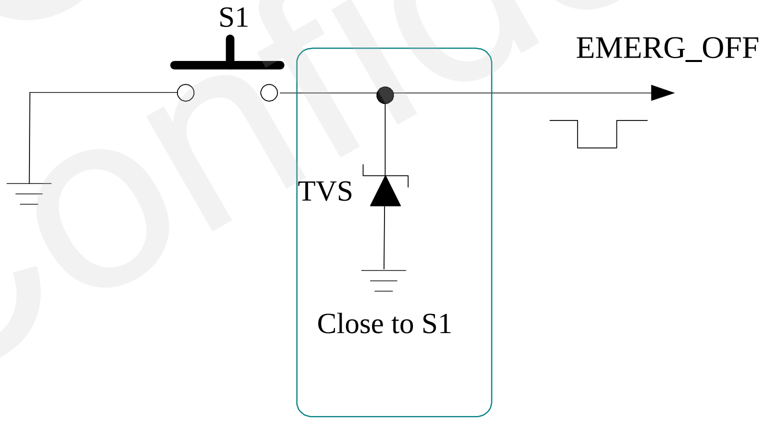


Figure 11: Reference circuit for EMERG_OFF by using button

Be cautious to use the pin EMERG_OFF. It should only be used under emergent situation. For instance, if the module is unresponsive or abnormal, the pin EMERG_OFF could be used to 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

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 of turning on module. Before restarting the module, at least 500ms should be delayed after detecting the low level of STATUS. The restart timing is illustrated as the following figure.

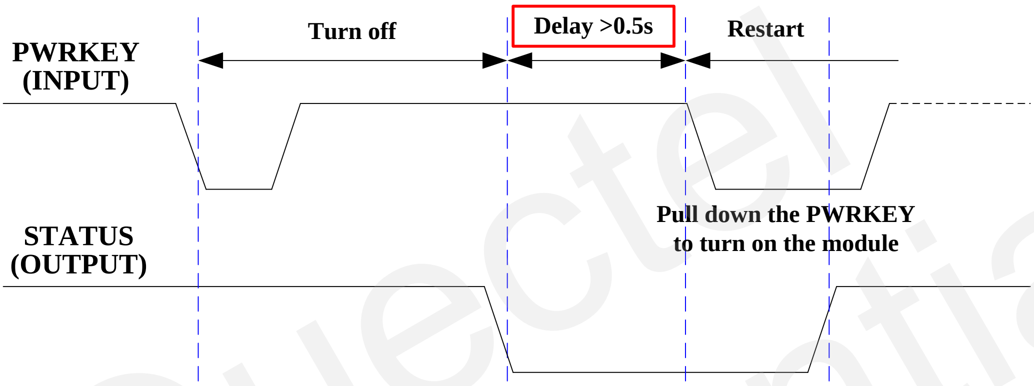


Figure 12: Timing of restarting system

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

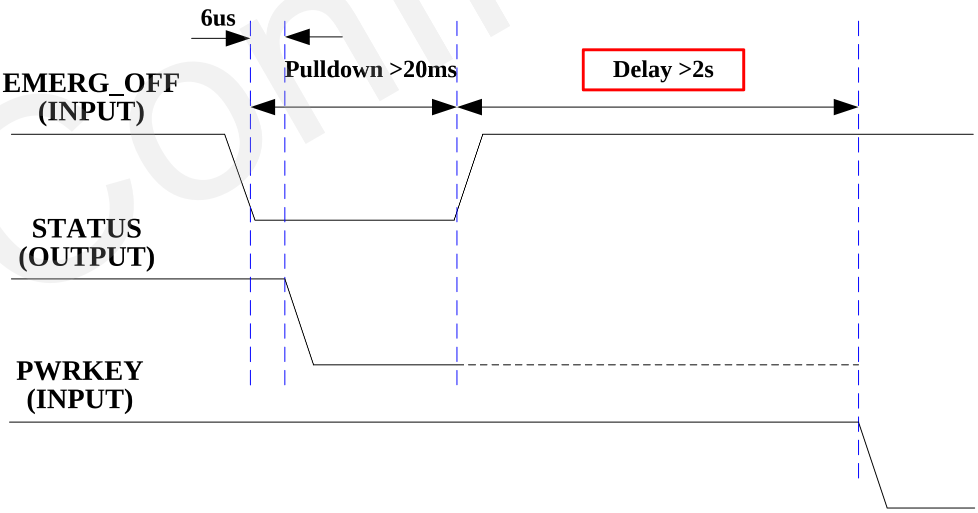


Figure 13: Timing of restarting system after emergency shutdown

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 disabled. In this case, the UART 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 disabled, but the UART 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

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 cannot enter SLEEP mode.

When “AT+QSCLK=1” is sent 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 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 is not accessible.

3.5.3. Wake up the 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 data call from network wakes up module.
- Receiving an SMS from network wakes up the module.

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

3.6. Summary of state transitions

Table 8: 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	

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 1.5 K resistor has been integrated in the module for current limiting. A coin-cell battery or a super-cap can be used to backup power supply for RTC.

The following figures show various sample circuits for RTC backup.

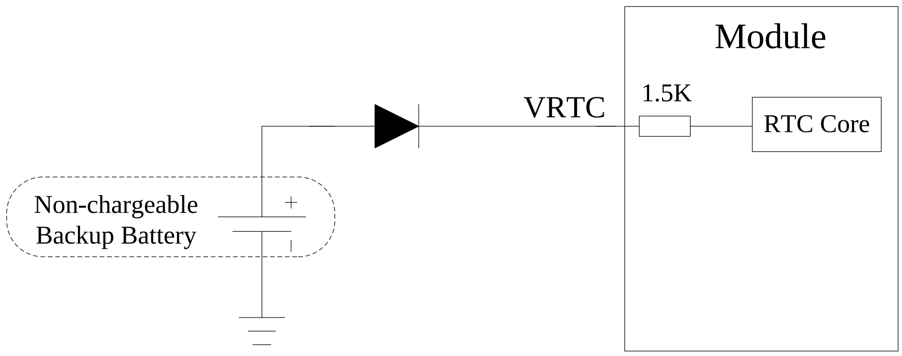


Figure 14: RTC supply from non-chargeable battery

Figure 15: RTC supply from rechargeable battery

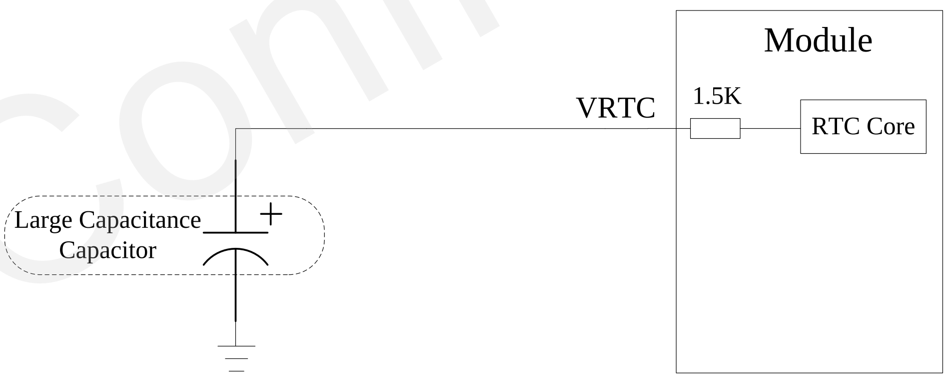


Figure 16: RTC supply from capacitor

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

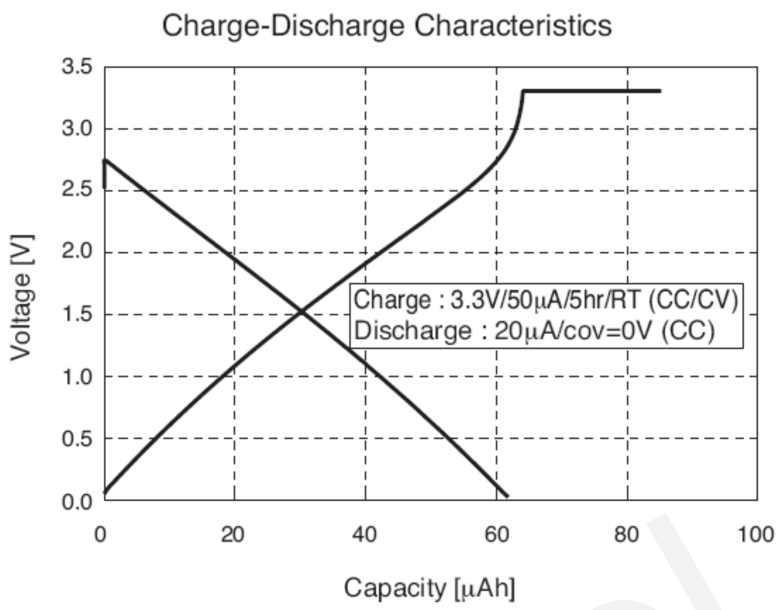


Figure 17: Seiko XH414H-IV01E Charge Characteristics

3.8. Serial interfaces

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

The 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 valid of this pin demonstrates the communication link is set up)

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 a debugging computer
- DBG_RXD: Receive data from the COM port of a debugging computer

The logic levels are described in the following table.

Table 9: Logic levels of the UART 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 10: Pin definition of the UART interfaces

Interface	Name	Pin	Function
Debug Port	DBG_RXD	14	Receive data of the debug port
	DBG_TXD	15	Transmit data of the debug port
UART Port	DTR	20	Data terminal ready
	RXD	21	Receive data of the UART port
	TXD	22	Transmit data of the UART port
	CTS	23	Clear to send
	RTS	24	Request to send
	DCD	25	Data carrier detection
	RI	26	Ring indicator

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, 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. Support the following baud rates for autobauding function:
  4800, 9600, 19200, 38400, 57600, 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 with "OK".

Autobauding allows the module to detect the baud rate by receiving the string "AT" or "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:

Synchronization between DTE and DCE:

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

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

Restrictions on autobauding operation

- The 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.

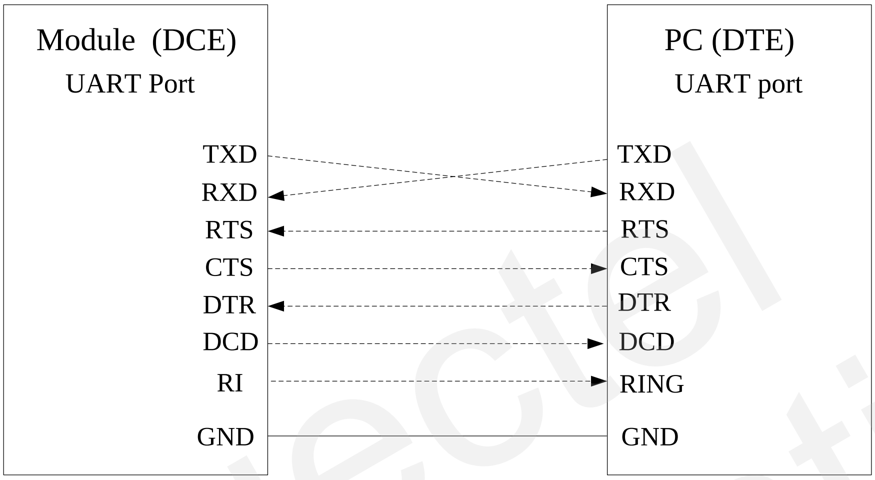


Figure 18: Connection of all functional UART port

Three lines connection is shown as below.

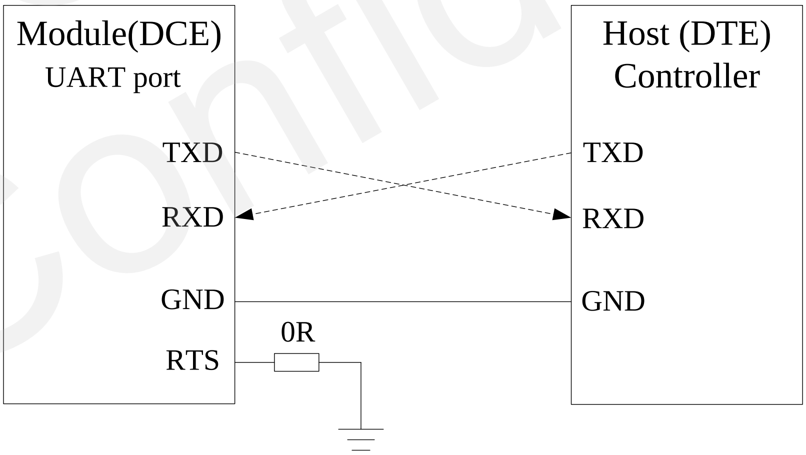


Figure 19: Connection of three lines UART port

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

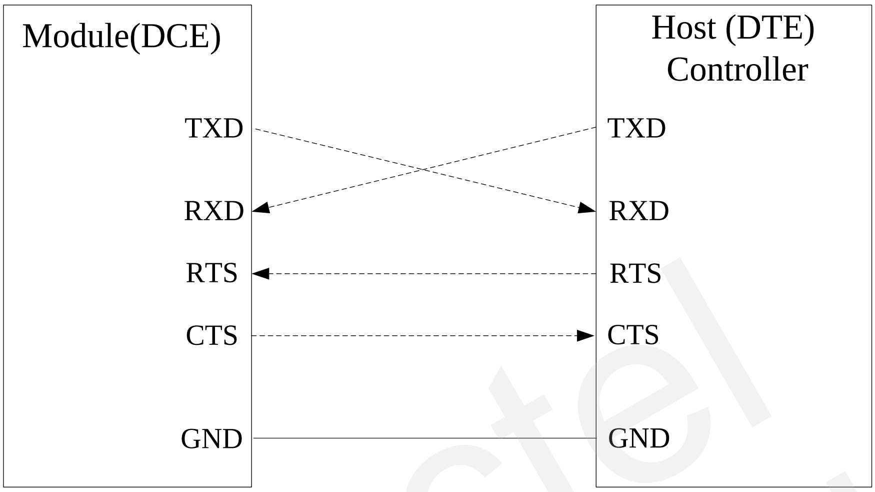


Figure 20: Connection of UART port associated hardware flow control

3.8.1.3. Firmware upgrade

The TXD, RXD can be used to upgrade software. The PWRKEY pin must be pulled down before the firmware upgrades. Please refer to the following figures for firmware upgrade.

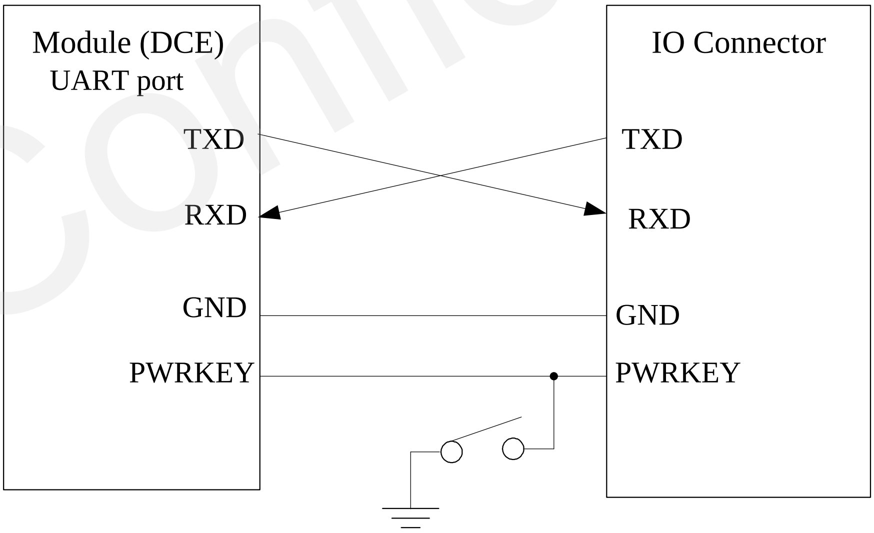


Figure 21: Connection of firmware upgrade

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.

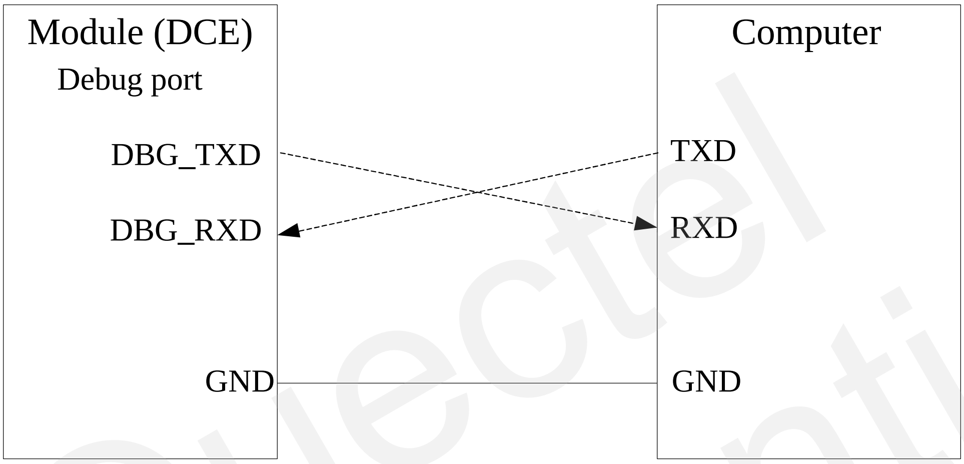


Figure 22: Connection of software debug

3.8.3. 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.

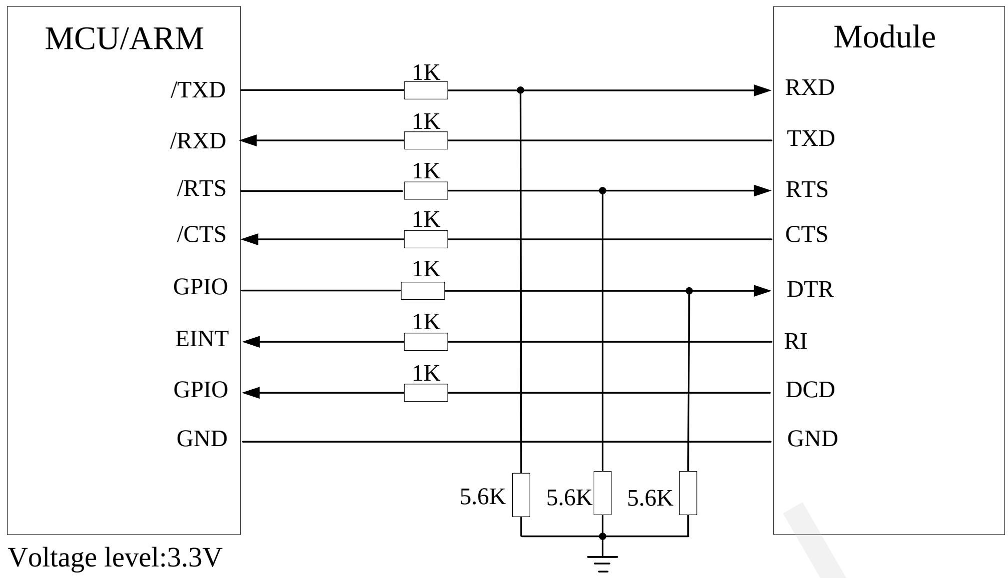


Figure 23: 3.3V level match circuit

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 module should refer to input solid line of the module. Output dotted line of module should refer to output solid line of the module.

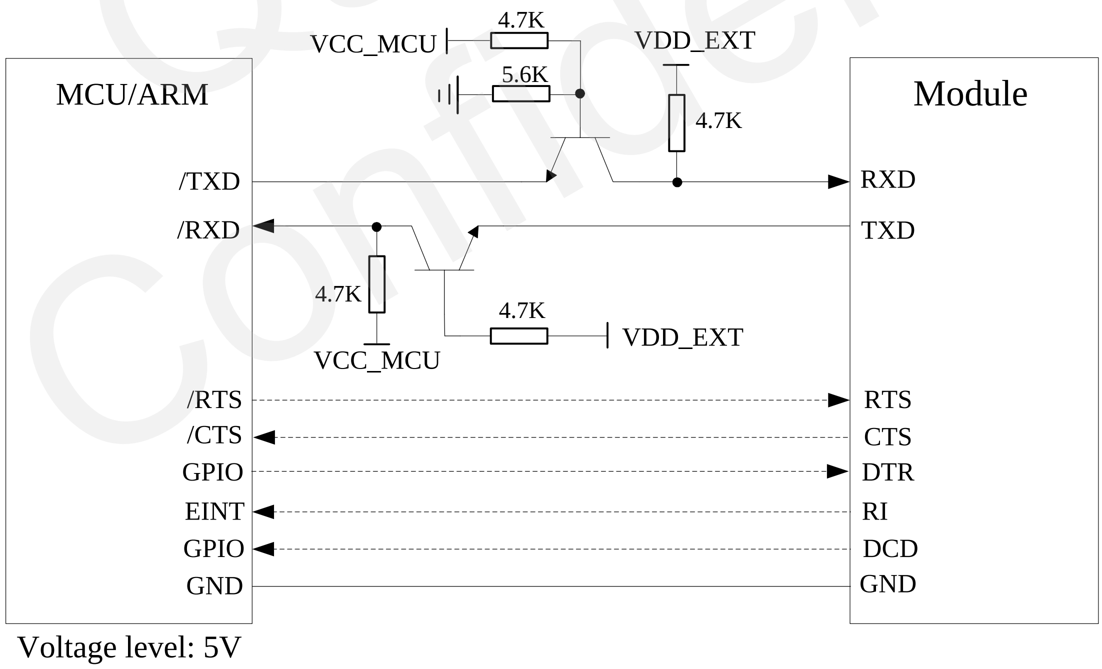


Figure 24: 5V level match circuit

The following picture is an example of connection between module and PC. A RS_232 level shifter IC or circuit must be inserted between module and PC, since UART ports do not support the RS_232 level, while support the CMOS level only.

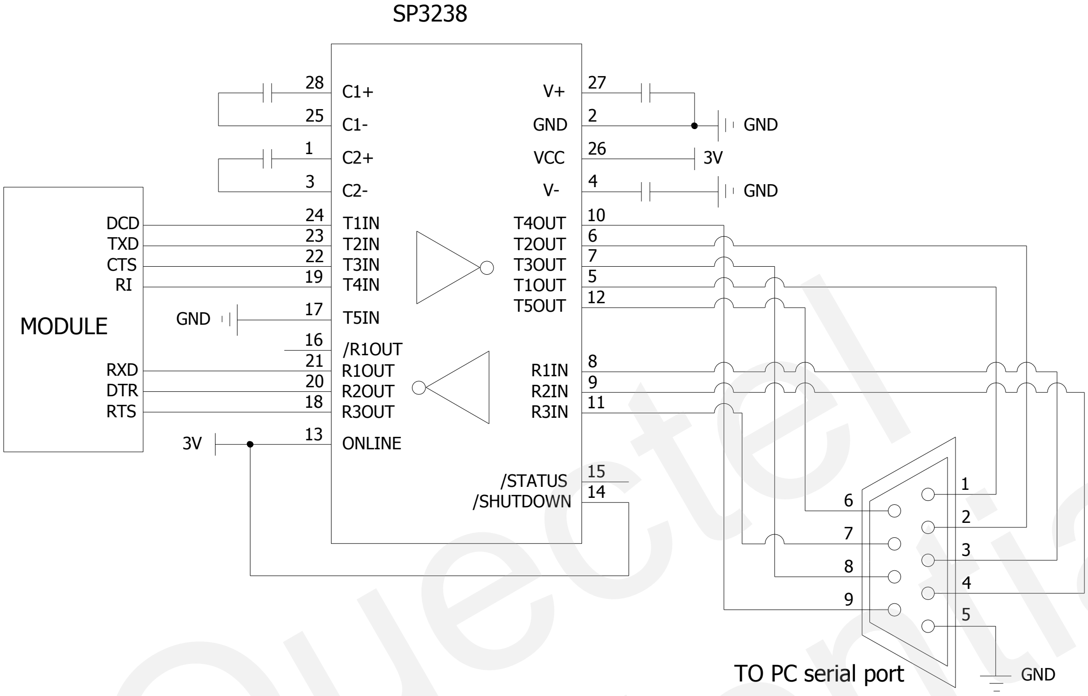


Figure 25: RS232 level match circuit

3.9. Audio interfaces

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

Table 11: Pin definition of Audio interface

Interface	Name	Pin	Function
AIN1/AOUT1	MIC1P	4	Channel 1 Microphone positive input
	MIC1N	5	Channel 1 Microphone negative input
	SPK1N	6	Channel 1 Audio negative output
	SPK1P	7	Channel 1 Audio positive output
AIN2/AOUT2	MIC2P	2	Channel 2 Microphone positive input
	MIC2N	3	Channel 2 Microphone negative input
	AGND	1	Cooperate with LOUDSPKP
	LOUDSPKP	9	Channel 2 Audio positive output
	LOUDSPKN	8	Channel 2 Audio negative output

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. If it is used as a speaker, an amplifier should be employed.

AOUT2 is used for loud speaker output as it is embedded an amplifier of class AB whose maximum drive power is 800mW. AOUT2 is a differential channel.

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

Both AOUT1 and AOUT2 support voice and ringtone 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, the default value is 0.
- 1--AIN2/AOUT2, this channel is always used for earphone.
- 2--AIN2/AOUT2, this channel is always used for loud speaker.

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

Table 12: AOUT2 output characteristics

Item	Condition	min	type	max	unit
RMS power	8ohm load VBAT=4.3V THD+N=1%		800		mW
	8ohm load VBAT=3.7V THD+N=1%		700		mW
Gain adjustment range		0		18	dB
Gain adjustment steps			3		dB

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. 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, customer would have to discuss with its capacitor vendor to choose the most suitable capacitor for filtering out GSM850MHz, GSM900MHz, 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, 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 the audio interfaces. 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 design

AIN1/IN2 channels come with internal bias supply for external electret microphone. A reference circuit is shown in Figure 26.

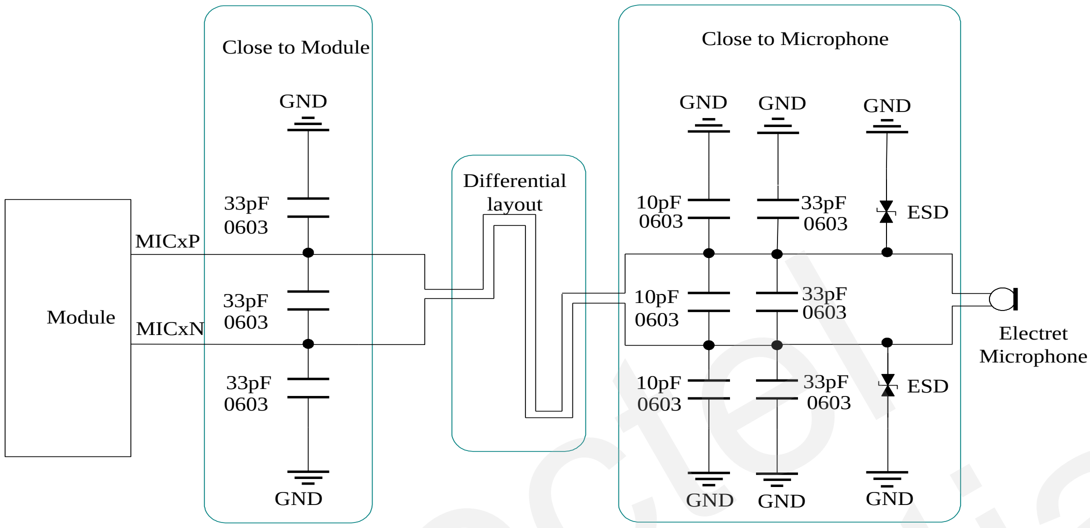


Figure 26: Microphone interface design of AIN1&AIN2

3.9.3. Receiver interface design

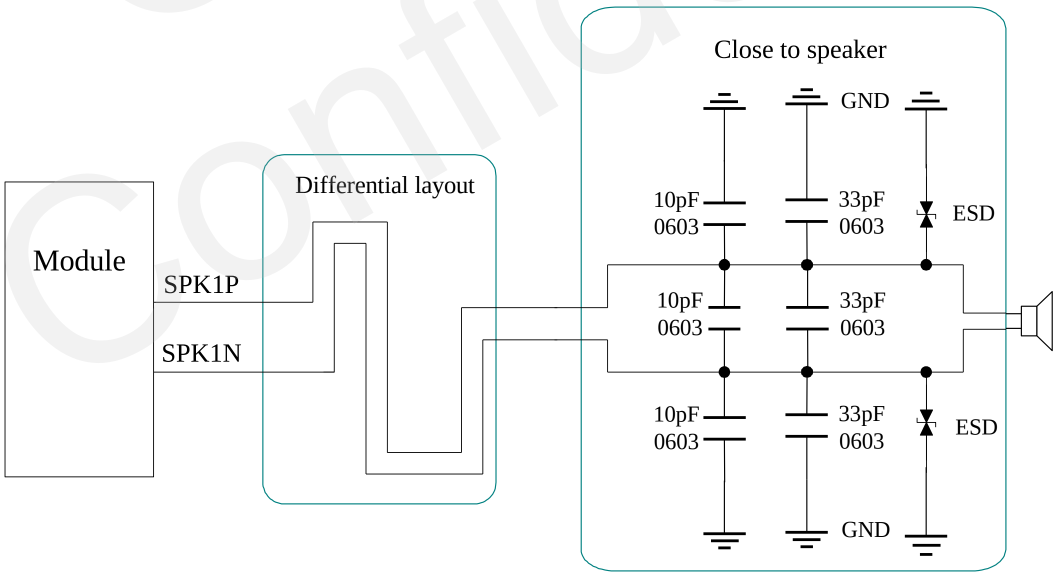


Figure 27: Receiver interface design of AOUT1

3.9.4. Earphone interface design

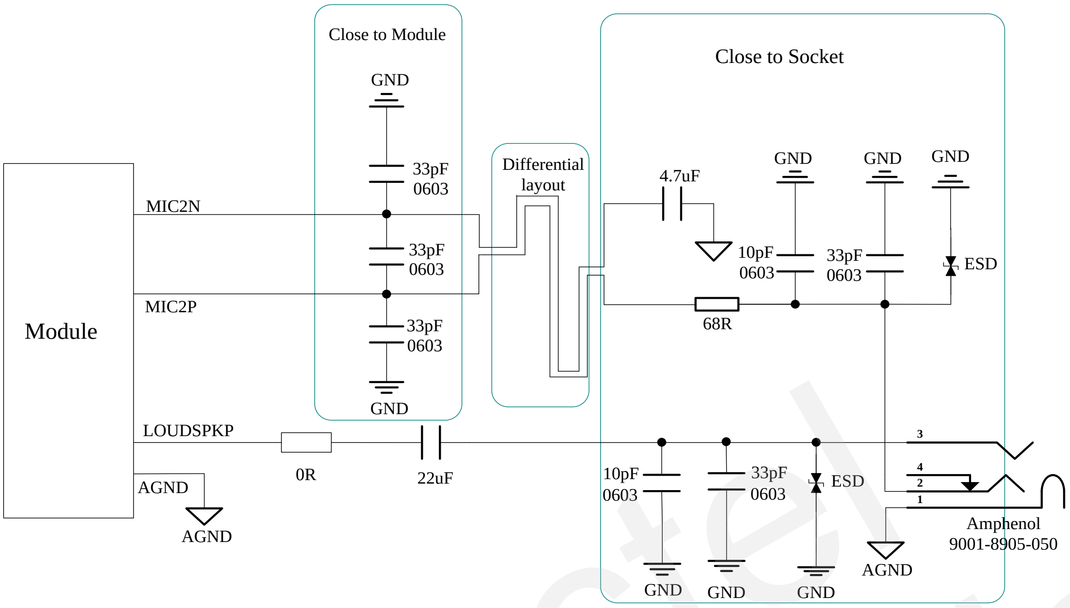


Figure 28: Earphone interface design

3.9.5. Loud speaker interface design

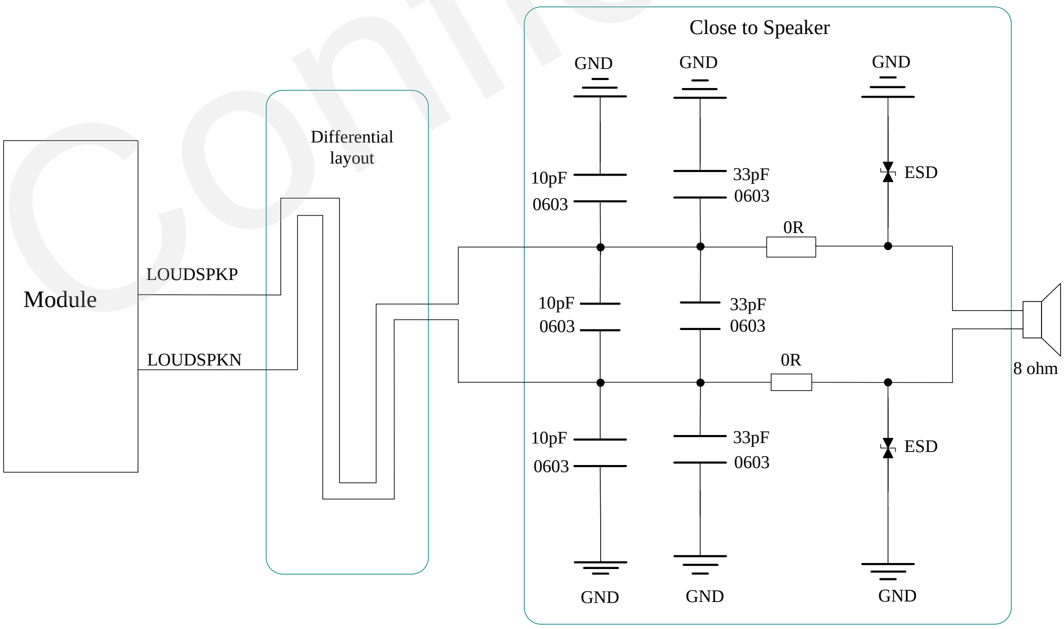


Figure 29: Loud speaker interface design

3.9.6. Audio characteristics

Table 13: 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		k Ohm

Table 14: Typical speaker characteristics

Parameter			Min	Typ	Max	Unit
Normal Output (AOUT1)	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 (AOUT2)	Single Ended	Load Resistance		8		Load Resistance
		Ref level	0		VBAT	Vpp
	Differential	Load Resistance		8		Load Resistance
		Ref level	0		2×VBAT	Vpp

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 15: Pin definition of the SIM interface

Name	Pin	Function
SIM_VDD	27	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_RST	28	SIM Card reset
SIM_DATA	29	SIM Card data I/O
SIM_CLK	30	SIM Card clock
SIM_GND	31	SIM Card ground

The reference circuit using a 6-pin SIM card holder is illustrated as the following figure.

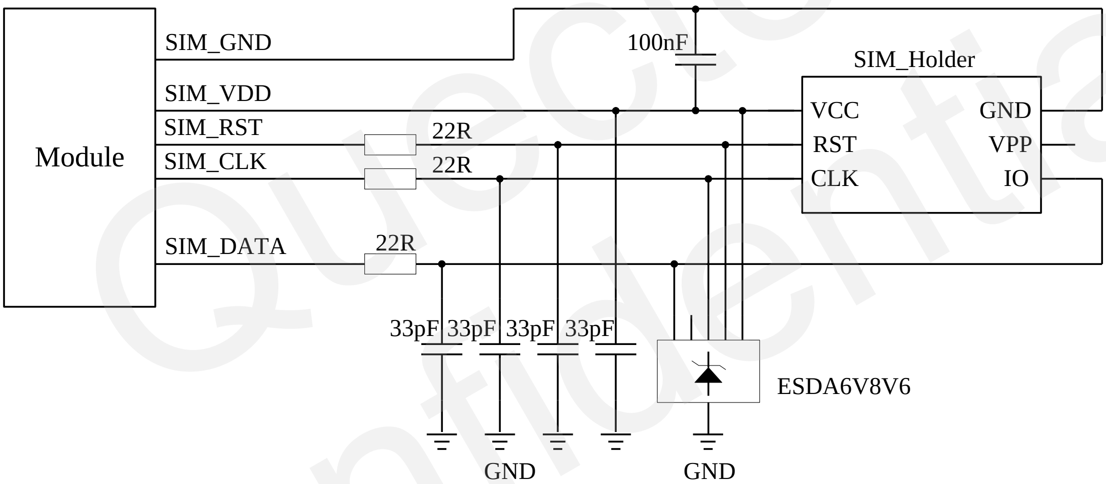


Figure 30: Reference circuit of the 6 pins SIM card

The following design rules can optimize the SIM interface performance and protect the SIM card effectively. The rules should be taken into account in designing the circuit.

- Place the SIM card holder close to module as close as possible. Ensure the trace length of SIM signals keeps less than 200mm.
- Keep the SIM signals far away from VBAT power and RF trace.
- The width of SIM_VDD and SIM_GND 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 traces are not placed closely next to each other. The traces of SIM_CLK, SIM_DATA and SIM_RST are recommended to be around with GND independently.

- All signals of SIM interface should be protected against ESD with a TVS diode array. It is recommended to add TVS diode such as WILL (http://www.willsemi.com) ESDA6V8AV6. The parasitic capacitance of TVS diode 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.
- All the peripheral components are recommended to place near the SIM card holder.

3.10.2. 6 Pin SIM cassette

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.

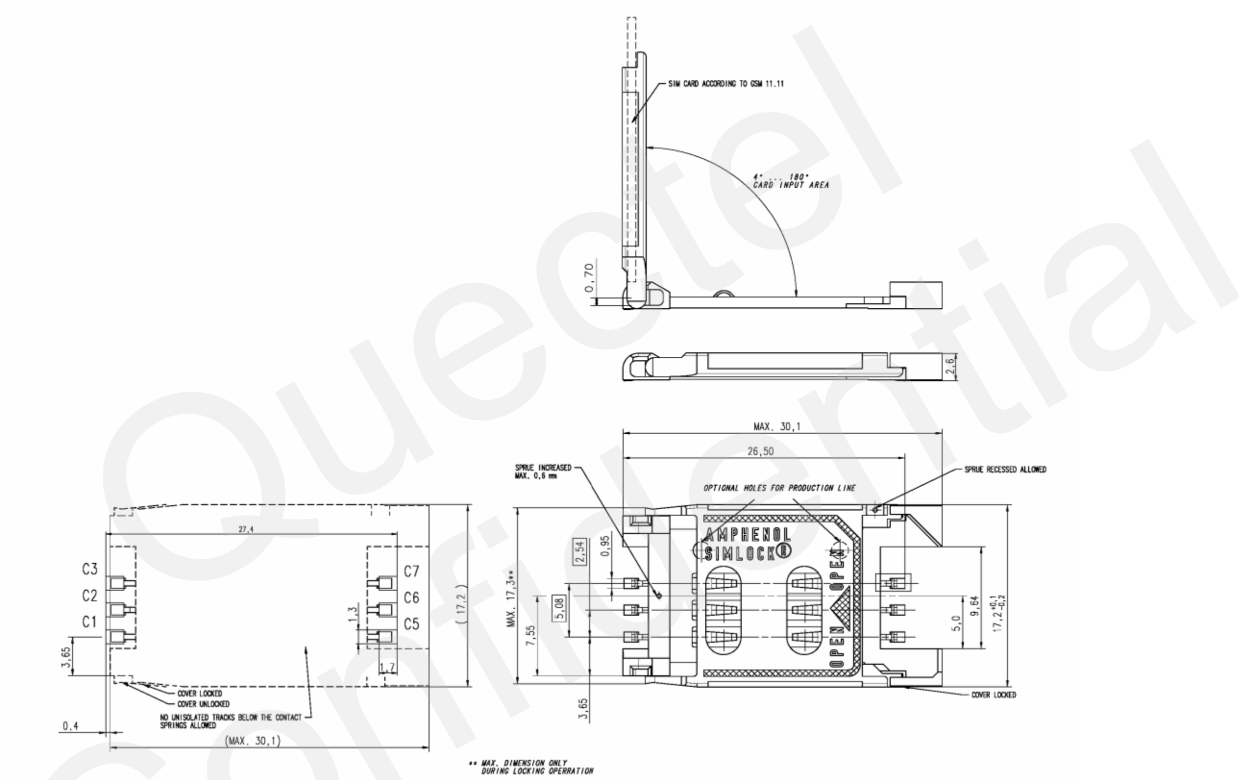


Figure 31: Amphenol C707 10M006 512 2 SIM card holder

Table 16: 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

3.11. Behaviors of the RI

Table 17: 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.

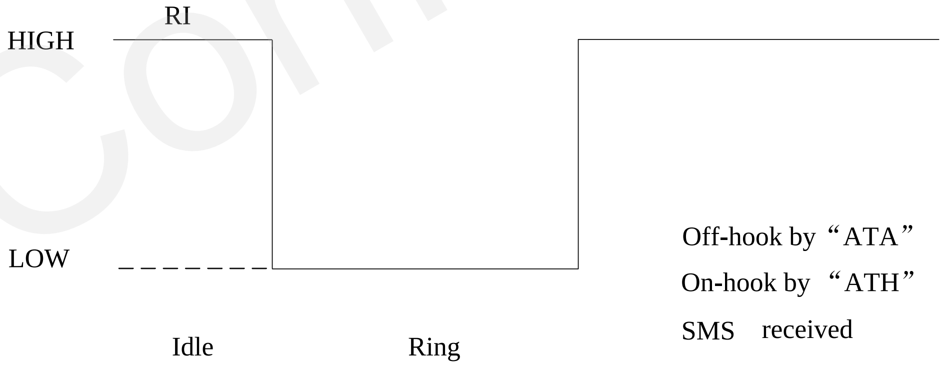


Figure 32: RI behaviour of voice calling as a receiver

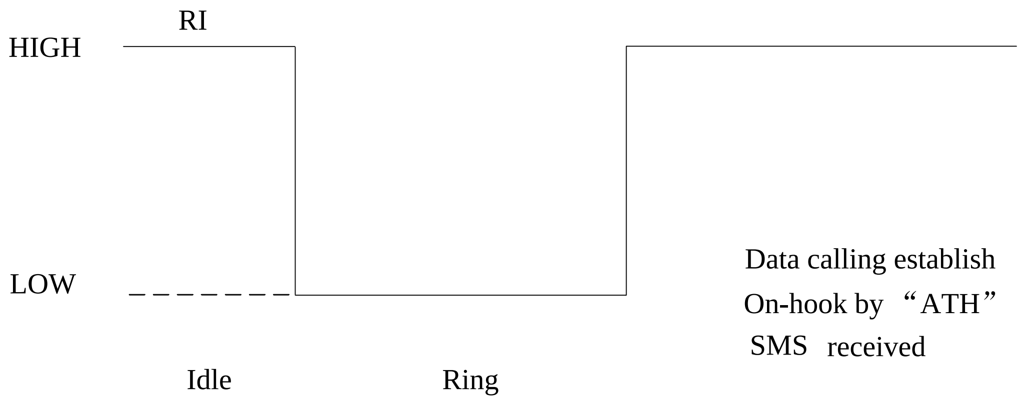


Figure 33: RI behaviour of data calling as a receiver

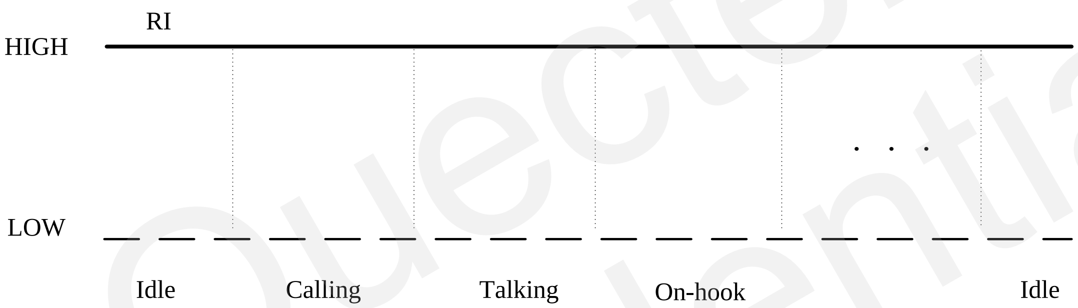


Figure 34: RI behaviour as a caller

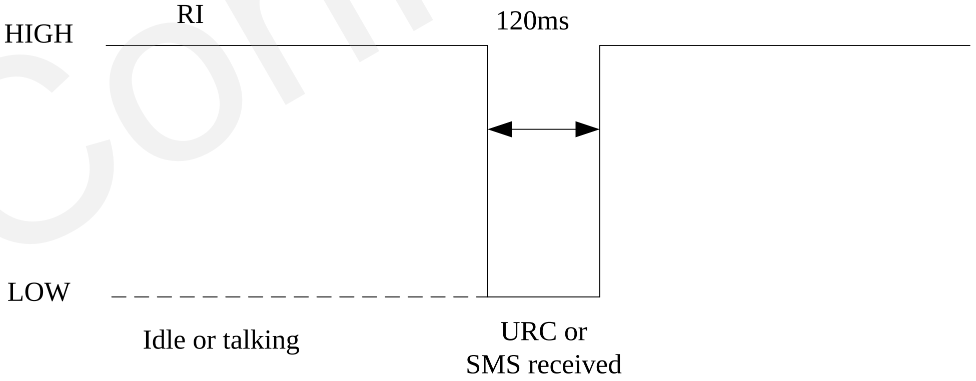


Figure 35: RI behaviour of URC or SMS received

3.12. Network status indication

The NETLIGHT signal can be used to drive a network status indication LED. The working state of this pin is listed in Table 18.

Table 18: Working state of the NETLIGHT

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

A reference circuit is shown in Figure 36.

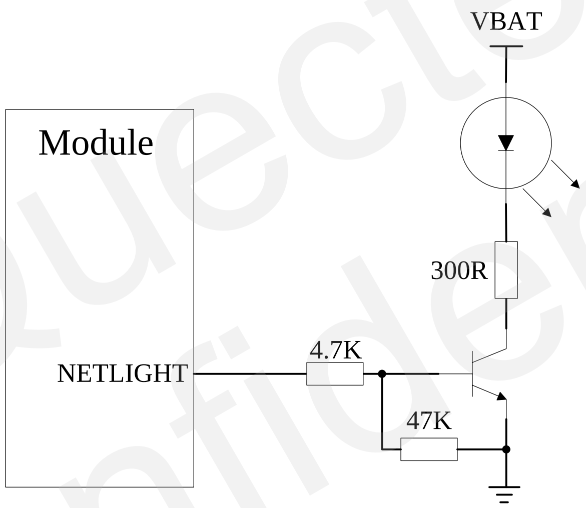


Figure 36: Reference circuit of the NETLIGHT

3.13. Operating status indication

The STATUS pin is set as an output pin and can be used to judge whether module is power-on. In customer's 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 37.

Table 19: Pin definition of the STATUS

Name	Pin	Function
STATUS	12	Indication of module operating status

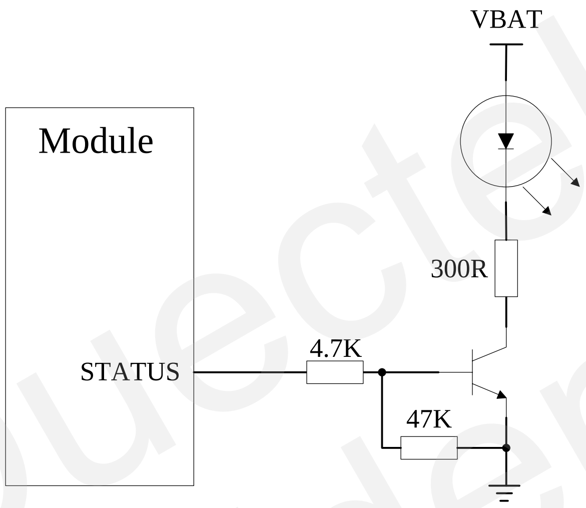


Figure 37: Reference circuit of the STATUS

4. Antenna interface

The Pin 39 is the RF antenna pad. The RF interface has an impedance of 50Ω.

Table 20: Pin definition of the Antenna interface

Name	Pin	Function
GND	37	ground
GND	38	ground
RF_ANT	39	RF antenna pad
GND	40	ground

4.1. RF reference design

The RF external circuit is recommended as below:

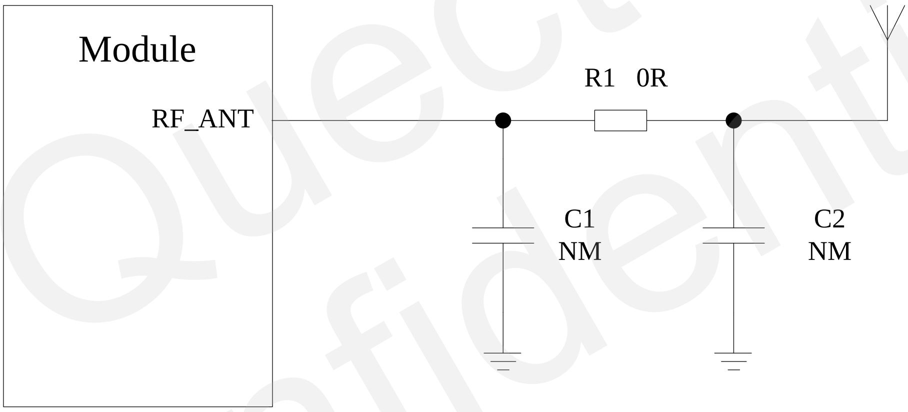


Figure 38: Reference circuit of RF

M95 provides an RF antenna PAD for customer's antenna connection. The RF trace in host PCB connected to the module RF antenna pad should be micro-strip line or other types of RF trace, whose characteristic impendence should be close to 50Ω. M95 comes with grounding pads which are next to the antenna pad in order to give a better grounding.

To minimize the loss on the RF trace and RF cable, take design into account carefully. It is recommended that the insertion loss should meet the following requirements:

- GSM850/EGSM900 is <1dB.
- DCS1800/PCS1900 is <1.5dB.

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	< -108.5dBm
EGSM900	< -108.5dBm
DCS1800	< -108.5dBm
PCS1900	< -108.5dBm

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. 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.

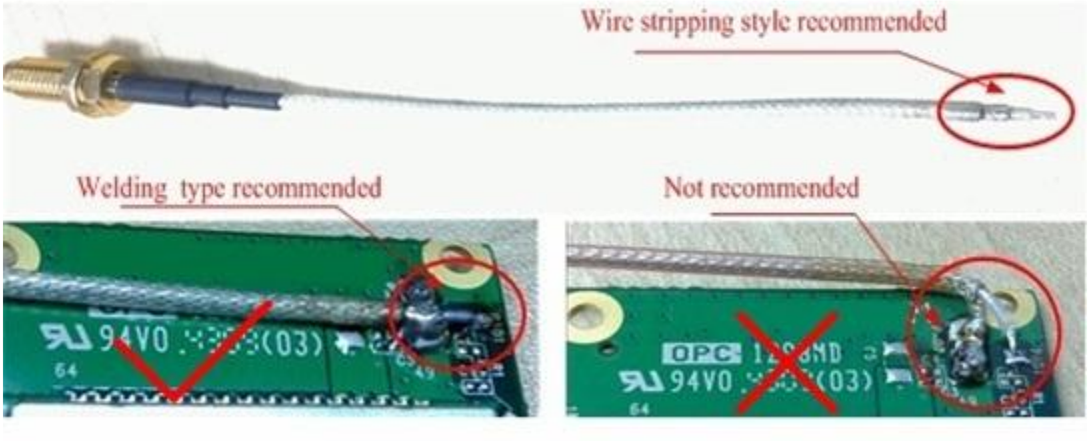


Figure 39: RF soldering sample

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 24: 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 25: Operating temperature

Parameter	Min	Typ	Max	Unit
Normal Temperature	-35	25	80	℃
Restricted Operation[1)]	-40 ~ -35		80 ~ 85	℃
Storage Temperature	-45		90	℃

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

5.3. Power supply ratings

Table 26: 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	Maximum power control level on GSM850 and GSM900.			400	mV

	transmitting burst					
	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		30 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
		TALK mode GSM850/EGSM 900[1)] DCS1800/PCS1900[2)]		246/243 179/188		mA mA
		DATA mode, GPRS(3Rx,2Tx) GSM850/EGSM 900[1)] DCS1800/PCS1900[2)]		404/378 261/285		mA mA
		DATA mode, GPRS(2Rx,3Tx) GSM850/EGSM 900[1)] DCS1800/PCS1900[2)]		541/533 353/390		mA mA
		DATA mode, GPRS(4Rx,1Tx) GSM850/EGSM 900[1)] DCS1800/PCS1900[2)]		244/216 161/173		mA mA
		DATA mode, GPRS(1Rx,4Tx) GSM850/EGSM 900[1)] DCS1800/PCS1900[2)]		557/538 434/484		mA mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM850 and GSM900.		1.6	2	A

[1)] ***Power control level PCL 5***

[2)] ***Power control level PCL 0***

5.4. Current consumption

The values of current consumption are shown in Table 27.

Table 27: The module current consumption

Condition	Current Consumption
Voice Call	
GSM850	@power level #5 <300mA,Typical 246mA @power level #12,Typical 120mA @power level #19,Typical 93mA
GSM900	@power level #5 <300mA,Typical 243mA @power level #12,Typical 115mA @power level #19,Typical 92mA
DCS1800	@power level #0 <250mA,Typical 179mA @power level #7,Typical 103mA @power level #15,Typical 89mA
PCS1900	@power level #0 <250mA,Typical 188mA @power level #7,Typical 103mA @power level #15,Typical 89mA
GPRS Data	
DATA mode, GPRS (1 Rx,1 Tx) CLASS8 & CLASS 12	
GSM850	@power level #5 <350mA,Typical 229mA @power level #12,Typical 109mA @power level #19,Typical 90mA
EGSM 900	@power level #5 <350mA,Typical 216mA @power level #12,Typical 111mA @power level #19,Typical 89mA
DCS 1800	@power level #0 <300mA,Typical 161mA @power level #7,Typical 100mA @power level #15,Typical 86mA
PCS 1900	@power level #0 <300mA,Typical 173mA @power level #7,Typical 97mA @power level #15,Typical 86mA
DATA mode, GPRS (3 Rx, 2 Tx) CLASS 12	
GSM850	@power level #5 <550mA,Typical 404mA @power level #12,Typical 165mA @power level #19,Typical 114mA
EGSM 900	@power level #5 <550mA,Typical 378mA @power level #12,Typical 158mA @power level #19,Typical 114mA
DCS 1800	@power level #0 <450mA,Typical 261mA @power level #7,Typical 134mA

	@power level #15,Typical 106mA
PCS 1900	@power level #0 <450mA,Typical 285mA @power level #7,Typical 129mA @power level #15,Typical 106mA
DATA mode, GPRS (2 Rx, 3 Tx) CLASS 12	
GSM850	@power level #5 <640mA,Typical 541mA @power level #12,Typical 209mA @power level #19,Typical 134mA
EGSM 900	@power level #5 <600mA,Typical 533mA @power level #12,Typical 199mA @power level #19,Typical 133mA
DCS 1800	@power level #0 <490mA,Typical 353mA @power level #7,Typical 162mA @power level #15,Typical 120mA
PCS 1900	@power level #0 <480mA,Typical 390mA @power level #7,Typical 156mA @power level #15,Typical 121mA
DATA mode, GPRS (4 Rx,1 Tx) CLASS 12	
GSM850	@power level #5 <350mA,Typical 244mA @power level #12,Typical 115mA @power level #19,Typical 90mA
EGSM 900	@power level #5 <350mA,Typical 216mA @power level #12,Typical 111mA @power level #19,Typical 89mA
DCS 1800	@power level #0 <300mA,Typical 161mA @power level #7,Typical 101mA @power level #15,Typical 86mA
PCS 1900	@power level #0 <300mA,Typical 173mA @power level #7,Typical 97mA @power level #15,Typical 86mA
DATA mode, GPRS (1 Rx, 4 Tx) CLASS 12	
GSM850	@power level #5 <660mA,Typical 557mA @power level #12,Typical 243mA @power level #19,Typical 144mA
EGSM 900	@power level #5 <660mA,Typical 538mA @power level #12,Typical 230mA @power level #19,Typical 144mA
DCS 1800	@power level #0 <530mA,Typical 434mA @power level #7,Typical 181mA @power level #15,Typical 126mA
PCS 1900	@power level #0 <530mA,Typical 484mA @power level #7,Typical 172mA @power level #15,Typical 126mA

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), 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 28: The ESD endurance (Temperature:25℃,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

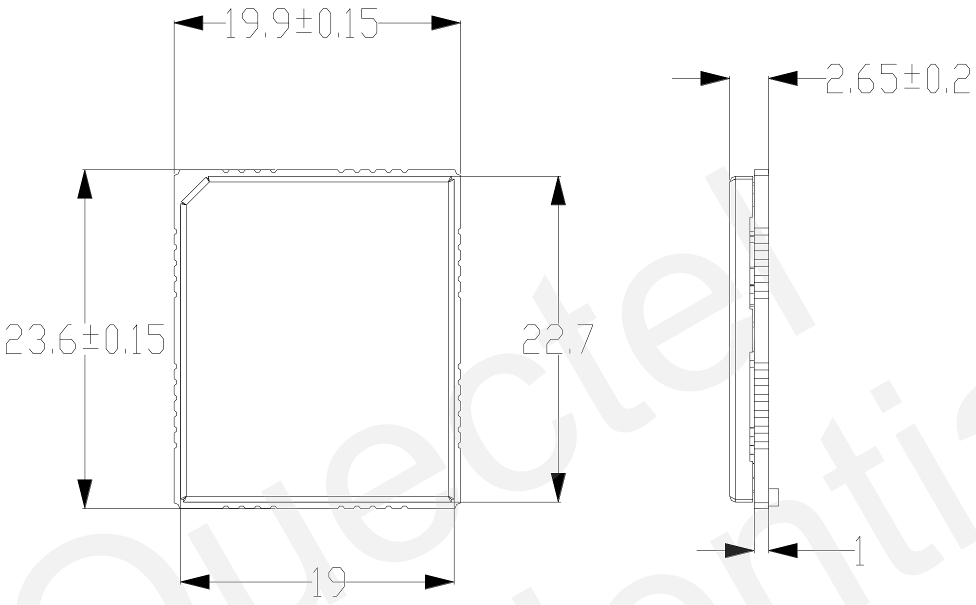


Figure 40: M95 top and side dimensions（Unit: mm）

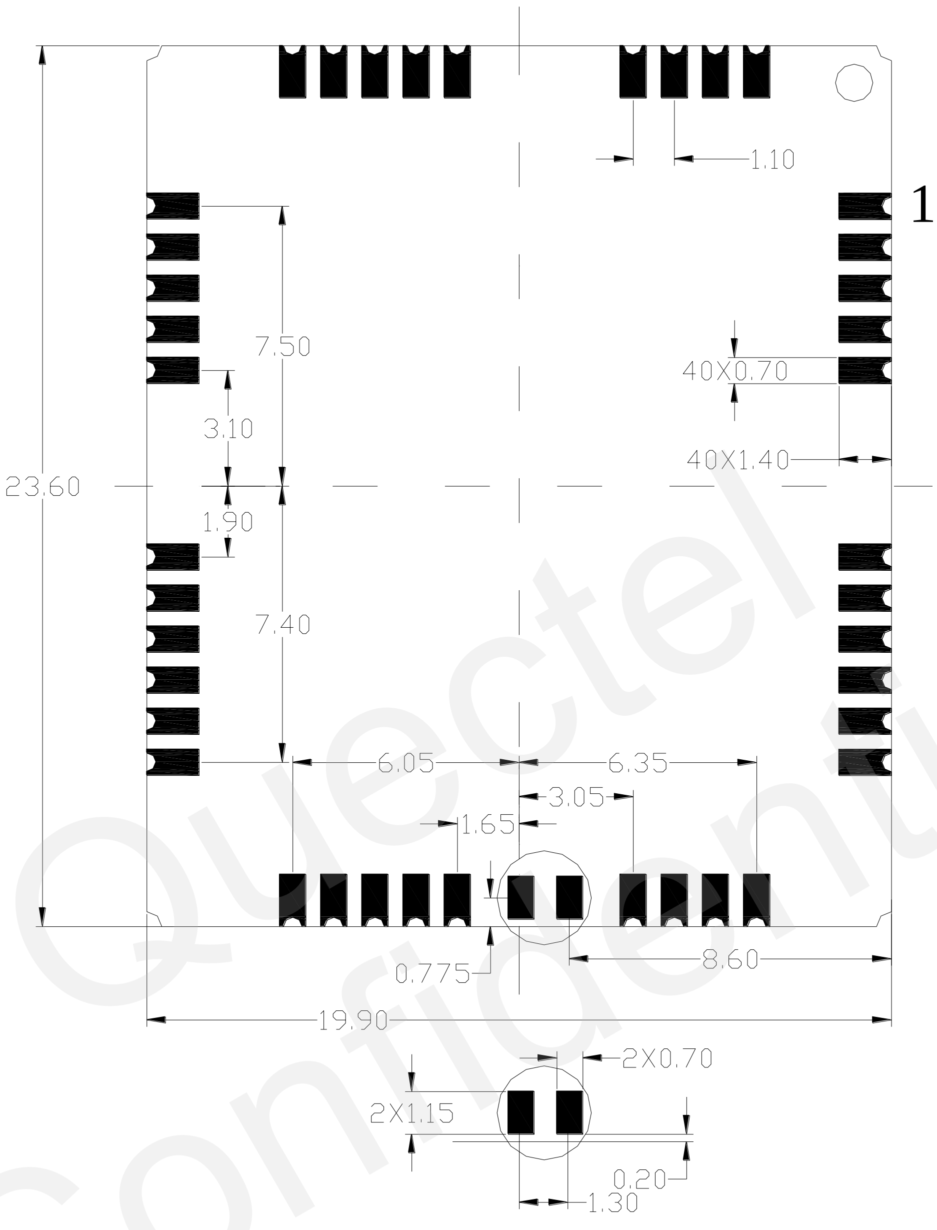


Figure 41: M95 bottom dimensions（Unit: mm）

6.2. Footprint of recommendation

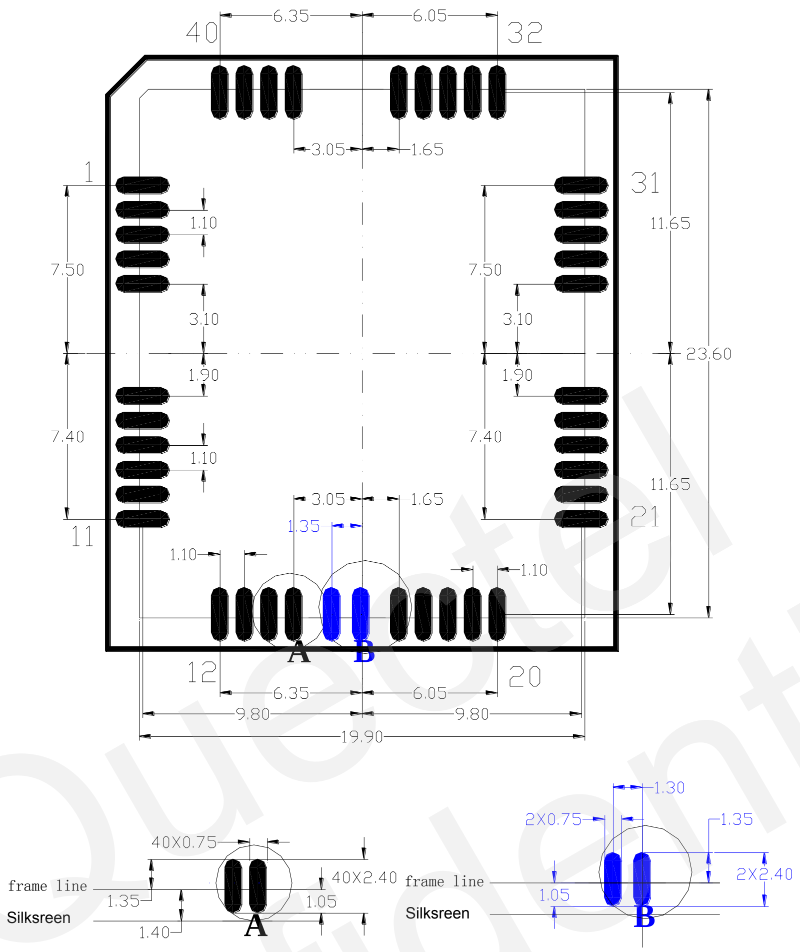


Figure 42: Footprint of recommendation（Unit: mm）

Note：

1. The blue pads are used for reserved pins customs can design the PCB decal without them.

2. To maintain the module, keep about 3mm away between the module and other components in host PCB.

6.3. Top view of the module

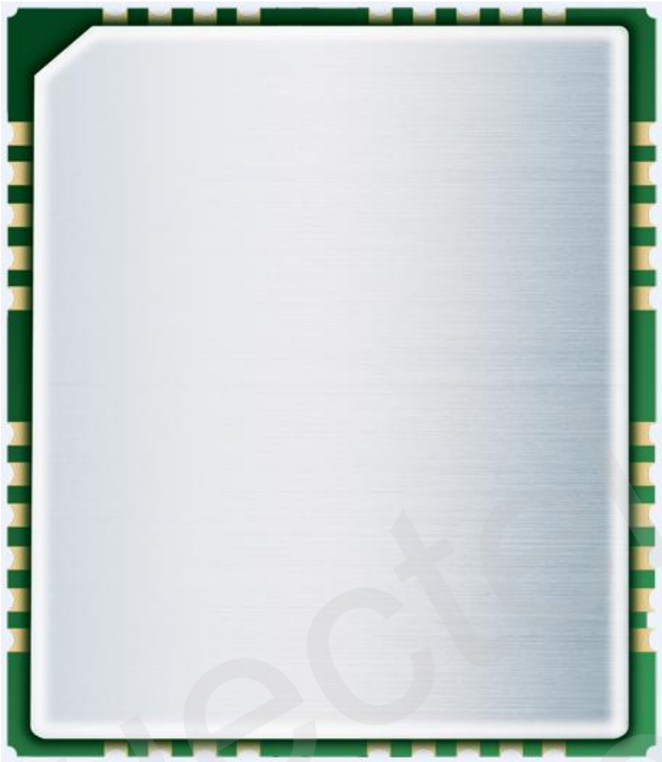


Figure 43: Top view of the module

6.4. Bottom view of the module

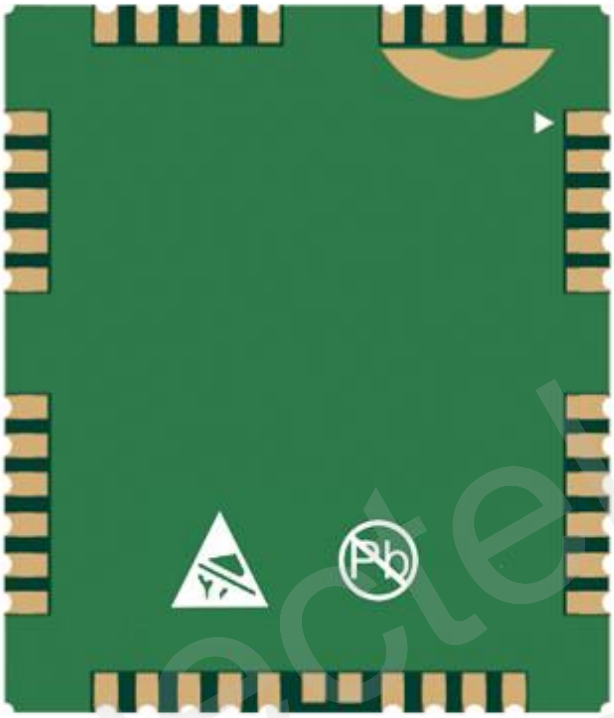


Figure 44: Bottom view of the module

7. Storage and Manufacturing

7.1. Storage

M95 is distributed in vacuum-sealed bag. The restriction of storage condition is shown as below.

Shelf life in sealed bag: 12 months at <40 ℃ / 90%RH

After this bag is opened, devices that will be subjected to reflow solder or other high temperature process must be:

- Mounted within 72 hours at factory conditions of ≤30 ℃ /60% RH
- Stored at <10% RH

Devices require bake, before mounting, if:

- Humidity indicator card is >10% when read 23 ℃±5 ℃
- Mounted for more than 72 hours at factory conditions of ≤30 ℃ /60% RH

If baking is required, devices may be baked for 48 hours at 125 ℃±5 ℃

Note: As plastic container cannot be subjected to high temperature, devices must be removed prior to high temperature (125 ℃) bake. If shorter bake times are desired, please refer to 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 0.2mm for M95.

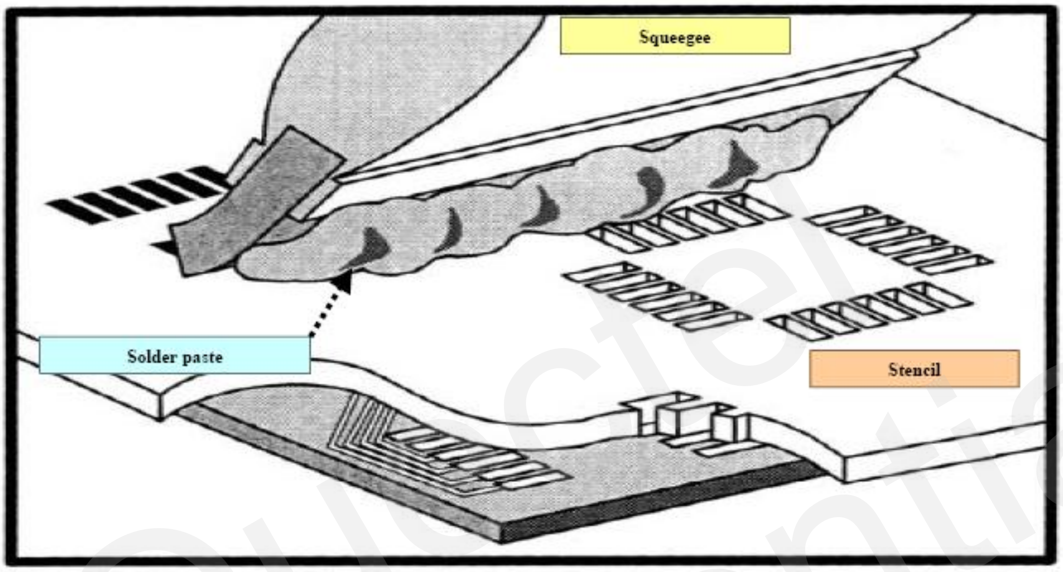


Figure 45: Paste application

Suggest peak reflow temperature is from 235 ℃ to 245 ℃ (for SnAg3.0Cu0.5 alloy). Absolute max reflow temperature is 260 ℃. 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.

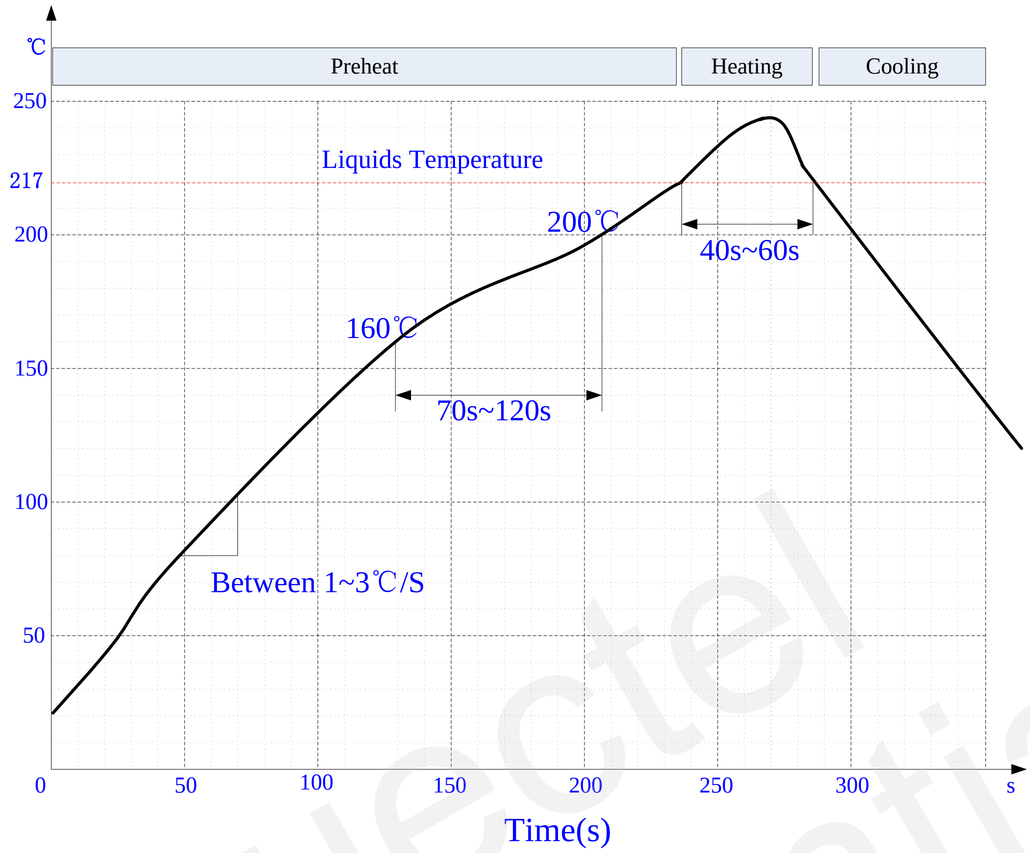


Figure 46: **Ramp-Soak-Spike reflow profile**

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.

There are two packaging types: reel and tray.

7.3.1 Tape and Reel packaging

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

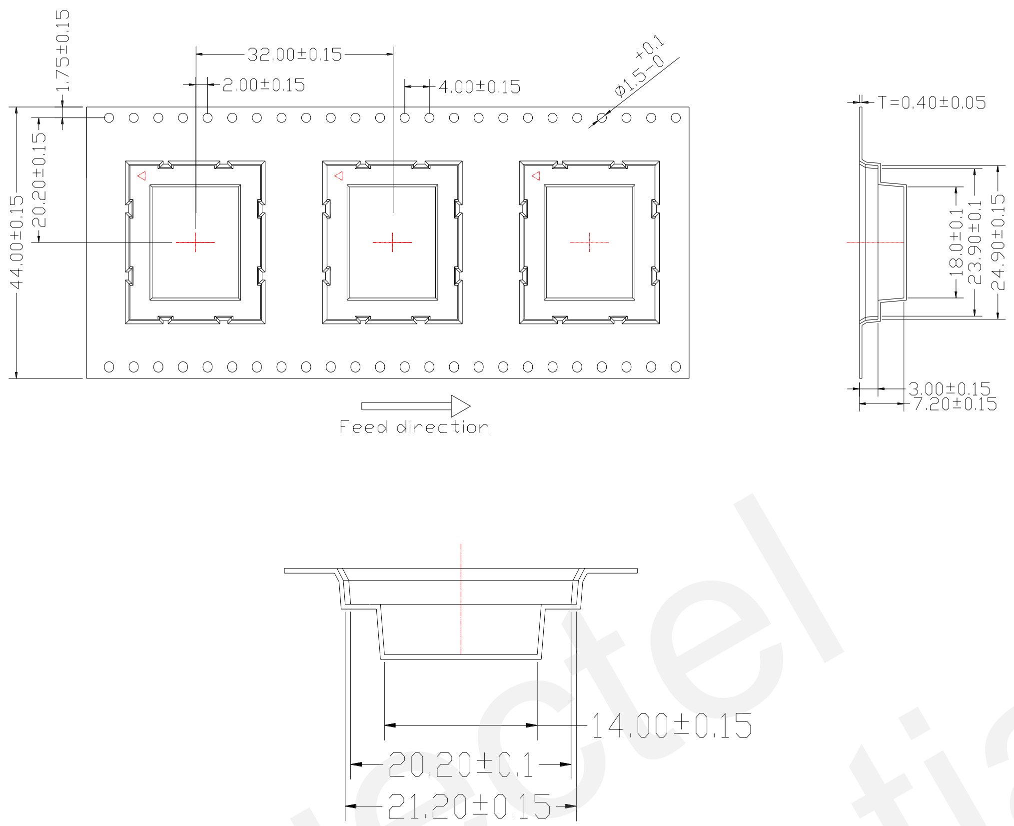


Figure 47: Tape and reel specification

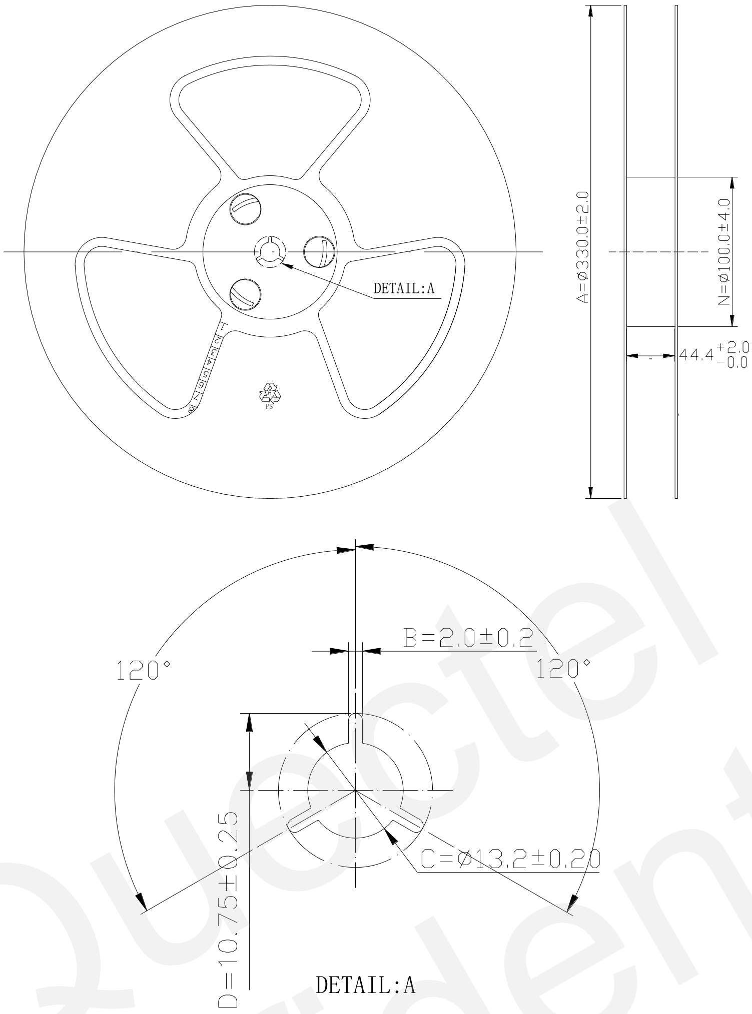


Figure 48: Dimensions of reel

7.3.2 Tray packaging

Each tray contains 25 pieces modules.

Figure 49: Module tray

Appendix A: GPRS coding schemes

Four coding schemes are used in GPRS protocol. The differences between them are shown in Table 29.

Table 29: Description of different coding schemes

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

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

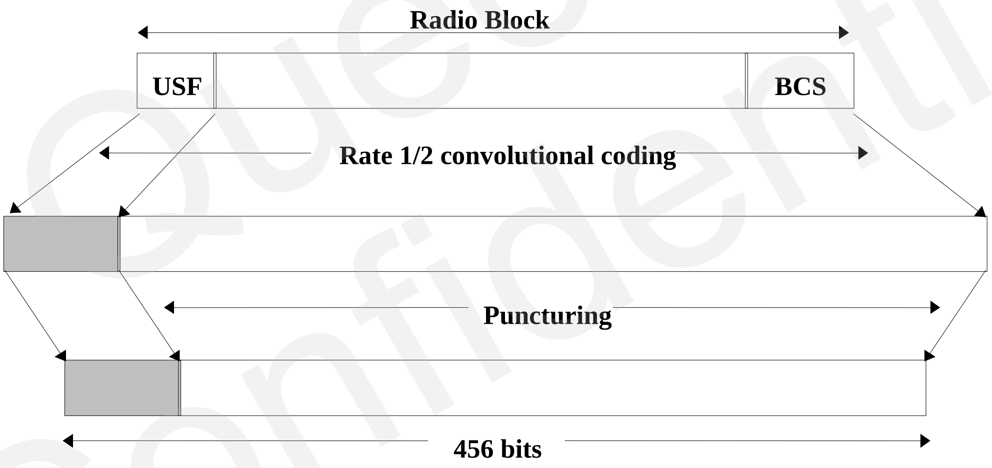


Figure 50: Radio block structure of CS-1, CS-2 and CS-3

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

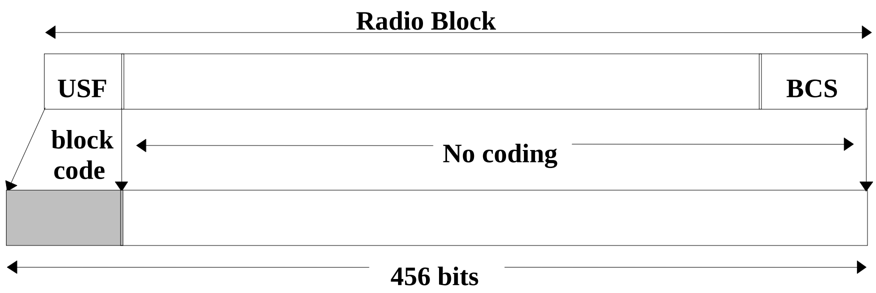


Figure 51: Radio block structure of CS-4

Appendix B: GPRS multi-slot classes

Twenty-nine classes of GPRS multi-slot modes are defined for MS in GPRS specification. Multi-slot classes are product dependant, and determine the maximum achievable data rates in both the uplink and downlink directions. Written as 3+1 or 2+2, the first number indicates the amount of downlink timeslots, while the second number indicates the amount of uplink timeslots. The active slots determine the total number of slots the GPRS device can use simultaneously for both uplink and downlink communications. The description of different multi-slot classes is shown in Table 30.

Table 30: 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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