

M95 Hardware Design

GSM/GPRS Module Series

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About the Document

History

| Revision | Date | Author | Description |
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| 1.0 | 2011-12-29 | Luka WU | Initial |
| 1.1 | 2012-05-18 | Luka WU | <ol style="list-style-type: none"> 1. Added current consumption in GPRS communication mode. 2. Modified AT command AT+QAUDCH in Chapter 3.10. 3. Modified the Footprint of recommendation. 4. Updated module package type. |
| 1.2 | 2012-09-19 | Luka WU | <ol style="list-style-type: none"> 1. Updated module functional diagram. 2. Updated Voltage ripple during transmitting. 3. Modified level match reference circuits for 5V peripheral system. 4. Updated SIM card reference circuit. 5. Added module current consumption. |
| 1.3 | 2013-09-03 | Winter CHEN | <ol style="list-style-type: none"> 1. Updated information on module's packaging. 2. Used the new technical document template. |
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| | | | |
|-----|------------|-----------|---|
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1 Introduction

This document defines M95 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of M95 module. To facilitate its application in different fields, relevant reference design is also provided for customers' reference. Associated with application note and user guide, customers can use M95 module to design and set up mobile applications easily.

1.1. Safety Information

The following safety precautions must be observed during all phases of 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 incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' 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 mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.



Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.



Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.



The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.



In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include 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, etc.

2 Product Concept

2.1. General Description

M95 is a quad-band GSM/GPRS engine that works at frequencies of GSM850, EGSM900, DCS1800 and PCS1900. 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 B & C**.

With a tiny profile of 19.9mm × 23.6mm × 2.65mm, the module can meet almost all the requirements for M2M applications, including Vehicles and Personal Tracking, Security System, Wireless POS, Industrial PDA, Smart Metering, and Remote Maintenance & Control, etc.

M95 is an SMD type module with LCC package, which can be easily embedded into applications. It provides abundant hardware interfaces which will be described in **Chapter 3**.

Designed with power saving technology, the current consumption of M95 is as low as 1.3mA in SLEEP mode when DRX is 5.

M95 is integrated with Internet service protocols, such as TCP/UDP, FTP and PPP. Extended AT commands have been developed 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 M95 module.

Table 1: Module Key Features

| Features | Description |
|--------------------|--|
| 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 | <ul style="list-style-type: none"> ● 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 | <ul style="list-style-type: none"> ● Class 4 (2W) at GSM850 and EGSM900 ● Class 1 (1W) at DCS1800 and PCS1900 |
| GPRS Connectivity | <ul style="list-style-type: none"> ● GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● GPRS mobile station class B |
| DATA GPRS | <ul style="list-style-type: none"> ● 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 Packet Broadcast Control Channel (PBCCH) ● Support Unstructured Supplementary Service Data (USSD) |
| Temperature Range | <ul style="list-style-type: none"> ● Operation temperature range: -35°C ~ +75°C¹⁾ ● Extended temperature range: -40°C ~ +85°C²⁾ ● Storage temperature range: -40°C~ +90°C |
| SMS | <ul style="list-style-type: none"> ● Text and PDU mode ● SMS storage: (U)SIM card |
| (U)SIM Interfaces | Support SIM/USIM card: 1.8V, 3V |
| Audio Features | Speech codec modes: <ul style="list-style-type: none"> ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10) |

| | |
|--------------------------|--|
| | <ul style="list-style-type: none"> ● 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 870mW |
| UART Interfaces | <p>Main UART Port:</p> <ul style="list-style-type: none"> ● Seven lines on UART port interface ● Used for AT command communication and GPRS data transmission ● Multiplexing function ● Support autobauding from 4800bps to 115200bps <p>Debug UART Port:</p> <ul style="list-style-type: none"> ● Two lines on debug port interface DBG_TXD and DBG_RXD ● Debug port can be used for firmware 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 | Supported |
| Physical Characteristics | Dimensions: (19.9±0.15)mm × (23.6±0.15)mm × (2.65±0.2)mm Weight: Approx. 2.5g |
| Firmware Upgrade | Firmware upgrade via main UART port |
| Antenna Interface | Connected to antenna pad with 50Ω impedance |

NOTES

- 1) Within operation temperature range, the module is 3GPP compliant.
- 2) Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operation temperature levels, the module will meet 3GPP specifications again.

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 M95 and illustrates the major functional parts.

- Radio frequency part
- Power management
- The Peripheral interface
 - Power supply
 - Turn-on/off interface
 - UART interfaces
 - RTC interface
 - Audio interfaces
 - PCM interface
 - (U)SIM interfaces
 - RF interface

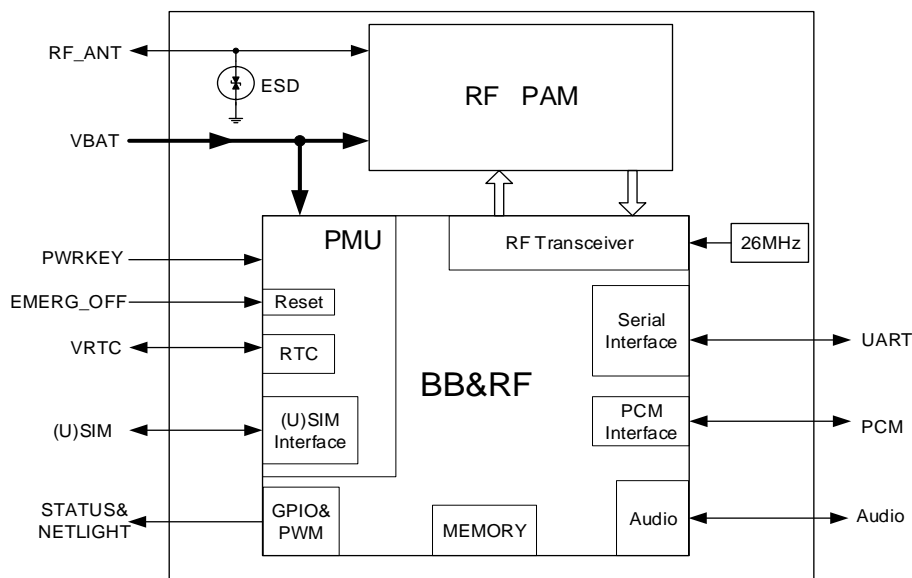


Figure 1: Module Functional Diagram

2.4. Evaluation Board

In order to help customers 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 **document [4]**.

3 Application Interfaces

3.1. General Description

M95 is equipped with 42 LCC pads that can be connected to cellular application platform. The subsequent chapters will provide detailed descriptions of the following interfaces/functions.

- Power supply
- RTC
- Serial interfaces
- Audio interfaces
- PCM interface
- (U)SIM interfaces
- RI
- NETLIGHT
- STATUS

3.2. Pin Assignment

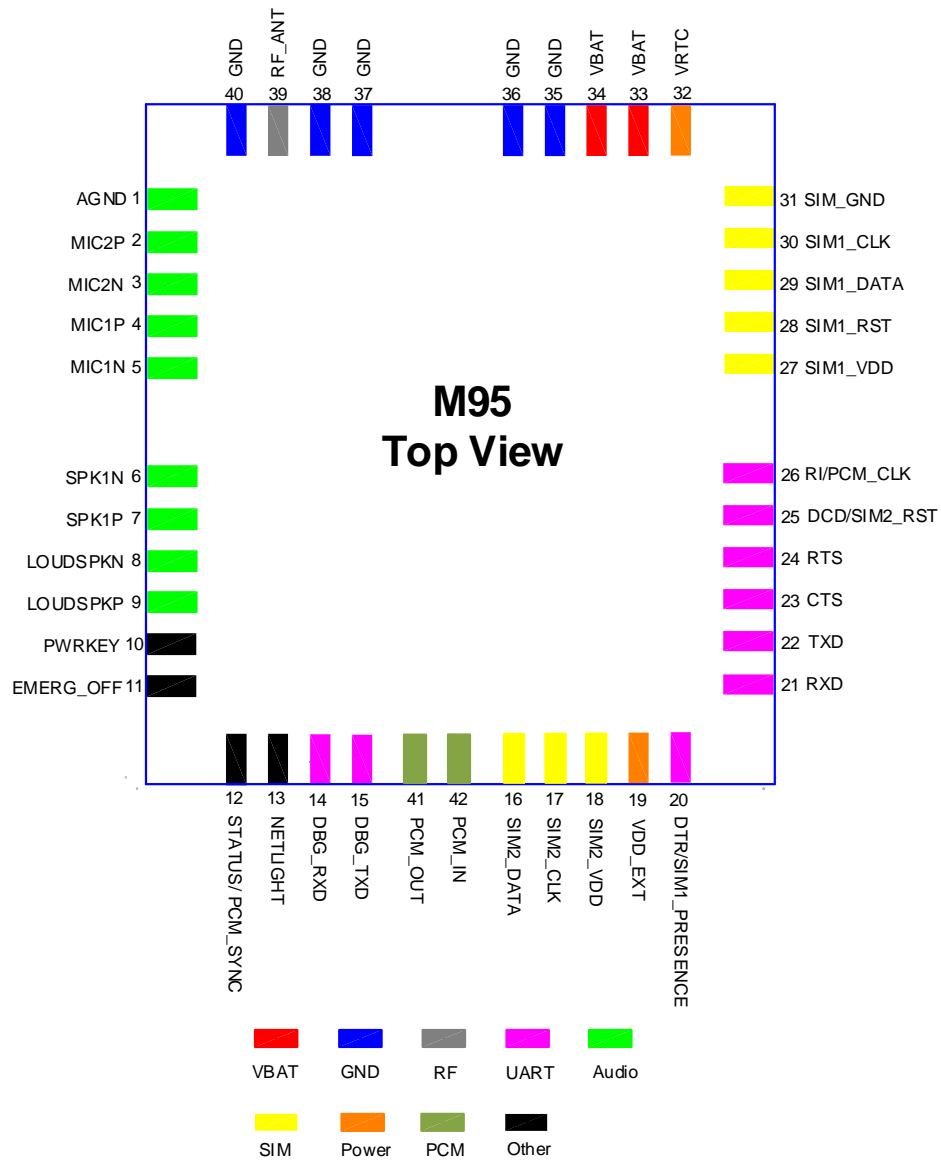


Figure 2: Pin Assignment (Top View)

3.3. Pin Description

The following tables show the pin definition of M95 module.

Table 3: IO Parameters Definition

| Type | Description |
|------|----------------|
| AI | Analog Input |
| AO | Analog Output |
| DI | Digital Input |
| DO | Digital Output |
| IO | Bidirectional |
| PI | Power Input |
| PO | Power Output |

Table 4: Pin Description

| Power Supply | | | | | |
|--------------|---------|-----|---|---|---|
| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
| VBAT | 33, 34 | PI | Main power supply for the module: VBAT=3.3V~4.6V | V _{max} =4.6V V _{min} =3.3V V _{norm} =4.0V | It is necessary to ensure the power supply during the RF transmission because the burst current can reach 1.6A. |
| VRTC | 32 | IO | Power supply for RTC when VBAT is not supplied for the system. Charging for backup battery or golden capacitor when the VBAT is applied. | V _I max=3.3V V _I min=1.5V V _I norm=2.8V V _O max=3V V _O min=2V V _O norm=2.8V I _{out} (max)=2mA I _{in} ≈10uA | If unused, keep this pin open. |

| | | | | | |
|-------------|----|----|---|---|--|
| VDD_ EXT | 19 | PO | Supply 2.8V voltage for external circuit. | V _{max} =2.9V V _{min} =2.7V V _{norm} =2.8V I _{max} =20mA | <ol style="list-style-type: none"> 1. If unused, keep this pin open. 2. It is recommend to add a 2.2μF~4.7μF 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 | DI | Power on/off key. PWRKEY should be pulled down for a moment to turn on or turn off the system. | V _{ILmax} = 0.1×VBAT V _{IHmin} = 0.6×VBAT V _I max=3.1V | |

Emergency Shutdown

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|---------------|---------|-----|---|--|---|
| EMERG_ OFF | 11 | DI | 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. | V _{ILmax} =0.45V V _{IHmin} =1.35V V _{openmax} =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 | 12 | DO | Indicate module's operating status. Output high level when module turns on, while output | V _O Hmin= 0.85×VDD_EXT V _O Lmax= 0.15×VDD_EXT | If unused, keep these pins open. |

low level when module
turns off.

Audio Interfaces

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|----------|--|------------------------------|--|
| MIC1P | 4 | AI | Channel 1 positive and negative voice input | Refer to Chapter 3.10 | If unused, keep these pins open. |
| MIC1N | 5 | | | | |
| MIC2P | 2 | AI | Channel 2 positive and negative voice input | | |
| MIC2N | 3 | | | | |
| SPK1P | 6 | AO | Channel 1 positive and negative voice output | | 3. If unused, keep these pins open. |
| SPK1P | 7 | | | | 4. Support both voice and ringtone output. |
| LOUDSPKN | 8 | AO AO | Channel 3 positive and negative voice output | | 1. If unused, keep these pins open. |
| | | | | | 2. Integrate a Class- AB amplifier internally. |
| LOUDSPKP | 9 | | | | 3. Support both voice and ringtone output. |
| AGND | 1 | | Analog ground. Separate ground connection for external audio circuits. | | |

Network Status Indicator

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|---------------------------|--|--------------------------------|
| NETLIGHT | 13 | DO | Network status indication | $V_{OHmin} = 0.85 \times VDD_EXT$ $V_{OLmax} = 0.15 \times VDD_EXT$ | If unused, keep this pin open. |

Main UART Port

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|------------------------|----------------------------------|---|
| DTR | 20 | DI | Data terminal ready | $V_{ILmin}=0V$ | If only use TXD, RXD and GND to communicate, recommended connecting RTS to GND via 0R resistor and keeping other pins open. |
| RXD | 21 | DI | Receive data | $V_{ILmax}=0.25 \times VDD_EXT$ | |
| TXD | 22 | DO | Transmit data | $V_{IHmin}=0.75 \times VDD_EXT$ | |
| RTS | 24 | DI | Request to send | $V_{IHmax}=VDD_EXT+0.2$ | |
| CTS | 23 | DO | Clear to send | $V_{OHmin}=0.85 \times VDD_EXT$ | |
| RI | 26 | DO | Ring indication | $V_{OLmax}=0.15 \times VDD_EXT$ | |
| DCD | 25 | DO | Data carrier detection | | |

Debug UART Port

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|---------------|--|----------------------------------|
| DBG_TXD | 15 | DO | Transmit data | $V_{ILmin}=0V$ $V_{ILmax}=0.25 \times VDD_EXT$ $V_{IHmin}=0.75 \times VDD_EXT$ | If unused, keep these pins open. |
| DBG_RXD | 14 | DI | Receive data | $V_{IHmax}=VDD_EXT+0.2$ $V_{OHmin}=0.85 \times VDD_EXT$ $V_{OLmax}=0.15 \times VDD_EXT$ | |

(U)SIM Interfaces

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|-----------|---------|-----|-------------------------------|---|--|
| SIM1_VDD | 27 | DO | Power supply for (U)SIM1 card | The voltage can be selected by software automatically. Either 1.8V or 3V. | All signals of (U)SIM interfaces should be protected against ESD with a TVS diode array. Maximum trace length is 200mm from the module pad to (U)SIM card connector. |
| SIM1_CLK | 30 | DO | (U)SIM1 clock | $V_{OLmax}=0.15 \times SIM1_VDD$ $V_{OHmin}=0.85 \times SIM1_VDD$ | |
| SIM1_DATA | 29 | IO | (U)SIM1 data | $V_{OLmax}=0.15 \times SIM1_VDD$ $V_{OHmin}=0.85 \times SIM1_VDD$ | |

| | | | | |
|---------------|----|----|-------------------------------|--|
| SIM1_RST | 28 | DO | (U)SIM1 reset | $V_{OLmax} = 0.15 \times SIM1_VDD$ $V_{OHmin} = 0.85 \times SIM1_VDD$ |
| SIM1_PRESENCE | 20 | DI | (U)SIM1 card detection. | $V_{ILmin} = 0V$ $V_{ILmax} = 0.25 \times VDD_EXT$ $V_{IHmin} = 0.75 \times VDD_EXT$ $V_{IHmax} = VDD_EXT + 0.2$ |
| SIM_GND | 31 | | (U)SIM card ground | |
| SIM2_VDD | 18 | PO | Power supply for (U)SIM2 card | The voltage can be selected by software automatically. Either 1.8V or 3V. |
| SIM2_CLK | 17 | DO | (U)SIM2 clock | $V_{OLmax} = 0.15 \times SIM2_VDD$ $V_{OHmin} = 0.85 \times SIM2_VDD$ |
| SIM2_DATA | 16 | IO | (U)SIM2 data | $V_{OLmax} = 0.15 \times SIM2_VDD$ $V_{OHmin} = 0.85 \times SIM2_VDD$ |
| SIM2_RST | 25 | DO | (U)SIM2 reset | $V_{OLmax} = 0.15 \times SIM2_VDD$ $V_{OHmin} = 0.85 \times SIM2_VDD$ |

RF Interface

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|----------------|--------------------|---------------|
| RF_ANT | 39 | IO | RF antenna pad | | 50Ω impedance |

PCM Interface

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|----------|---------|-----|-----------------|---|---|
| PCM_SYNC | 12 | DO | PCM sync signal | $V_{ILmin} = -0.3V$ $V_{ILmax} = 0.25 \times VDD_EXT$ | The default function is STATUS after startup. |

| | | | | | |
|---------|----|----|------------------------|--|---|
| PCM_CLK | 26 | DO | PCM clock signal | $V_{IHmin}=0.75 \times VDD_EXT$ $V_{IHmax}=VDD_EXT+0.2$ | The default function is RI after startup. |
| PCM_OUT | 41 | DO | PCM serial data output | $V_{OHmin}=0.85 \times VDD_EXT$ $V_{OLmax}=0.15 \times VDD_EXT$ | |
| PCM_IN | 42 | DI | PCM serial data input | | If unused, keep these pins open. |

Table 5: Multiplexing Functions

| Pin Name | Pin No. | Function After Reset | Multiplexing Function ¹⁾ |
|-------------------|---------|----------------------|-------------------------------------|
| STATUS/PCM_SYNC | 12 | STATUS | PCM_SYNC |
| DTR/SIM1_PRESENCE | 20 | DTR | SIM1_PRESENCE |
| DCD/SIM2_RST | 25 | DCD | SIM2_RST |
| RI/PCM_CLK | 26 | RI | PCM_CLK |

NOTE

¹⁾ The Multiplexing function can be configured through AT command. For details, please refer to **Chapter 3.9** and **3.10**.

3.4. Operating Modes

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

Table 6: 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 be reduced 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 (U)SIM card will not be accessible, or both RF part and (U)SIM card will be disabled, but the UART port is still accessible. The power consumption in this case is very low. |

NOTE

¹⁾ 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 **Chapter 3.6.2.4**.

3.5. Power Supply

3.5.1. 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 4.615ms, 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 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.

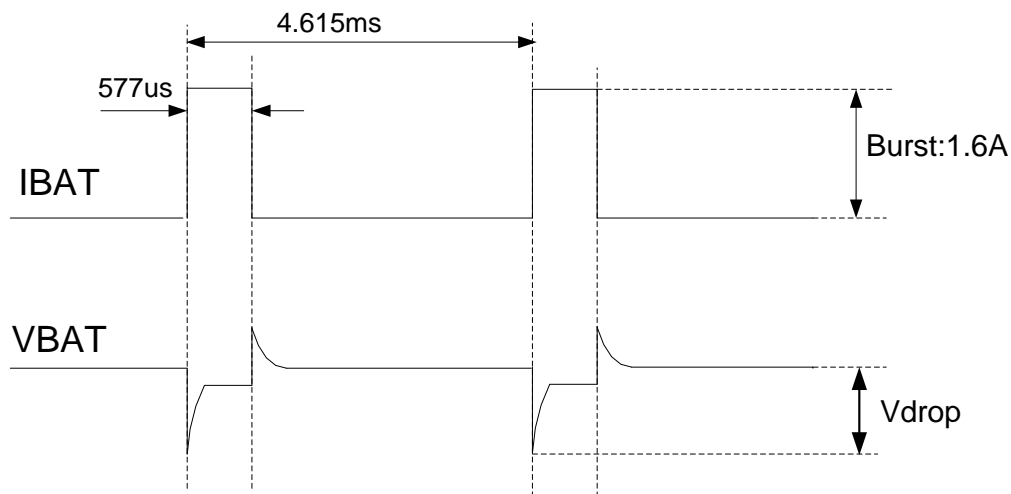


Figure 3: Voltage Ripple during Transmitting

3.5.2. 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 100μF 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 the following figure.

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.

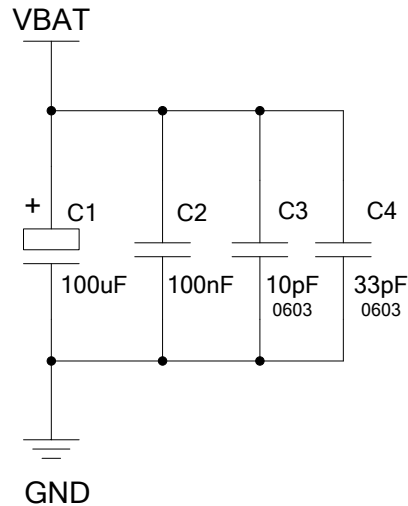


Figure 4: Reference Circuit for the VBAT Input

3.5.3. 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 be used as a power supply.

Figure 5 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 of which reverse zener voltage is 5.1V and dissipation power is more than 1W.

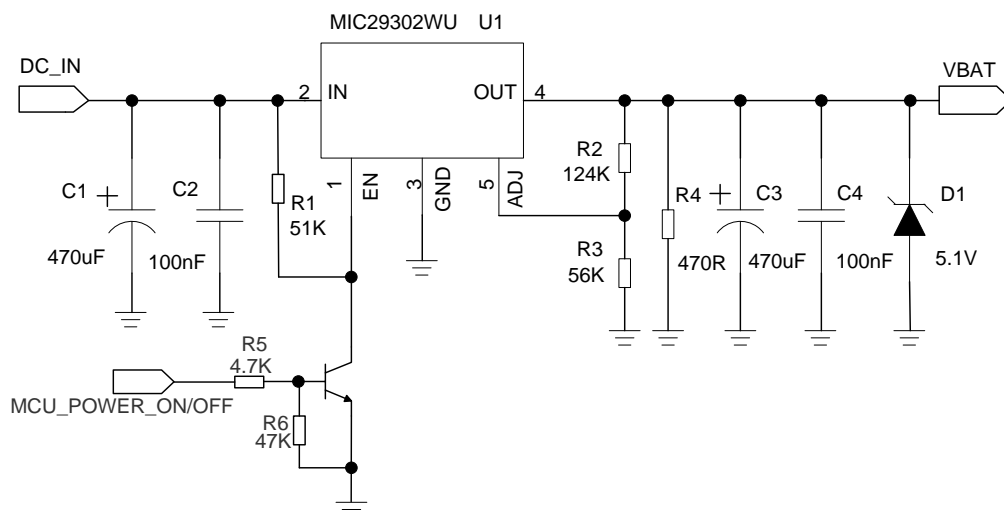


Figure 5: Reference Circuit for Power Supply

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.

3.5.4. 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 **document [1]**.

3.6. Power On/Off Scenarios

3.6.1. 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.

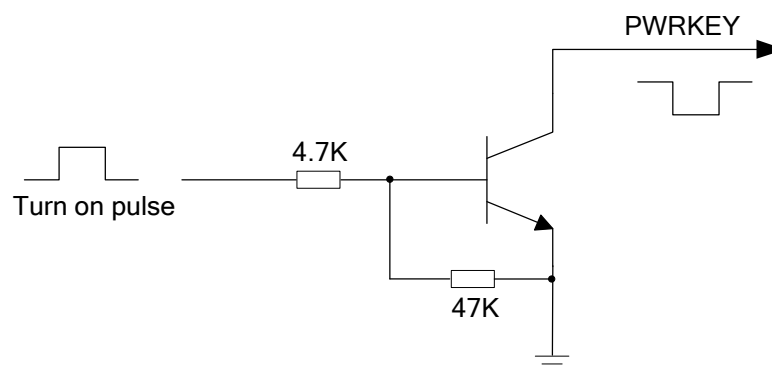


Figure 6: Turn On the Module with an Open-collector Driver

NOTES

1. M95 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" or "at" string in order that the module can detect baud rate of host controller, 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.

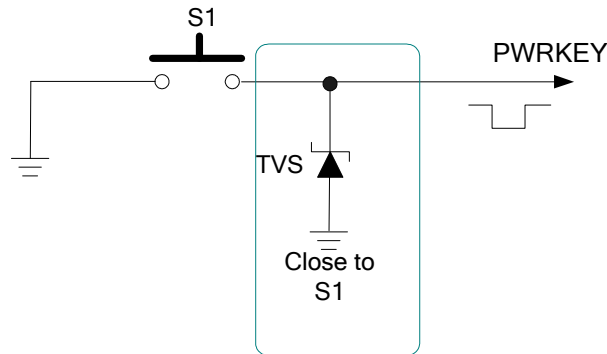


Figure 7: Turn On the Module with a Button

The timing of turning on the module is illustrated as the following figure.

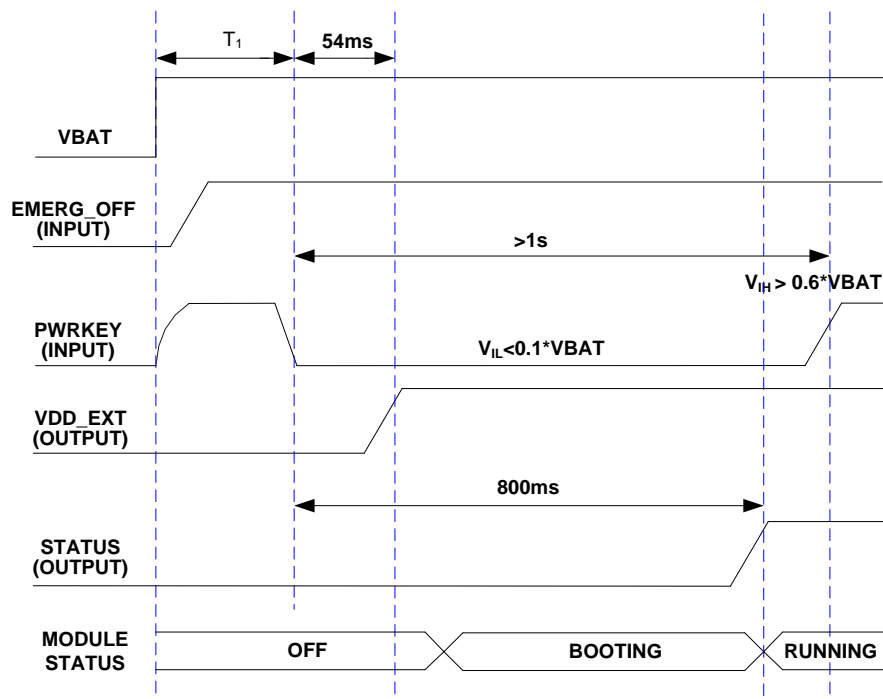


Figure 8: Timing of Turning on the Module

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 **Chapter 3.14**.

3.6.2. Power Off

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=1**.
- 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.

3.6.2.1. 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 timing of turning off the module is illustrated in Figure 9.

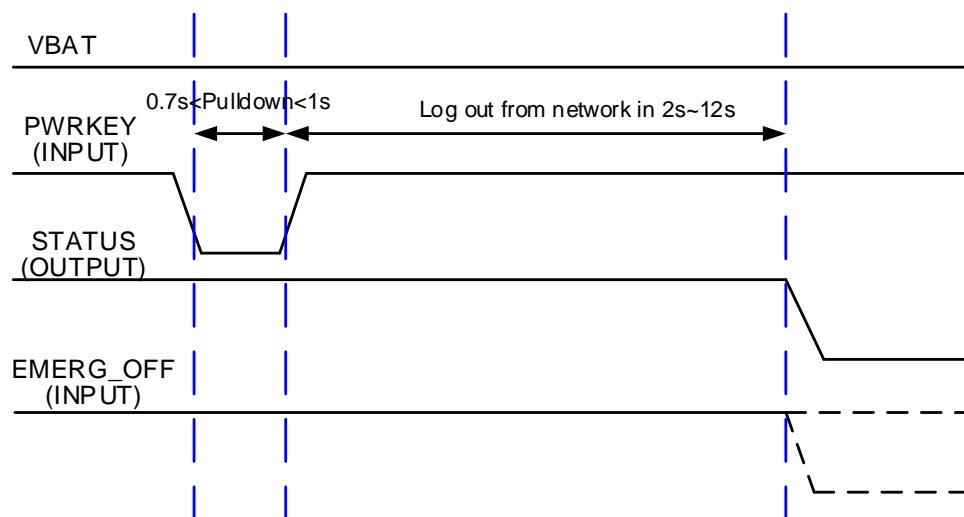


Figure 9: Timing of Turning off the Module

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

NOTES

1. 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.
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 **Chapter 3.14**.

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

3.6.2.2. 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 the result code as 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 **document [1]** for details about the AT command **AT+QPOWD**.

3.6.2.3. Over-voltage or Under-voltage Automatic Shutdown

The module will constantly monitor the voltage applied on the VBAT, if the voltage is $\leq 3.5V$, the following URC will be presented:

UNDER_VOLTAGE WARNING

If the voltage is $\geq 4.5V$, 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 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.

3.6.2.4. 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.

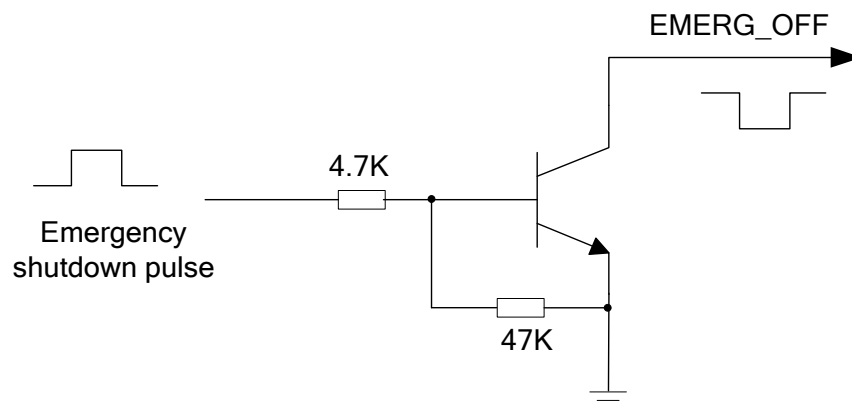


Figure 10: An Open-collector Driver for EMERG_OFF

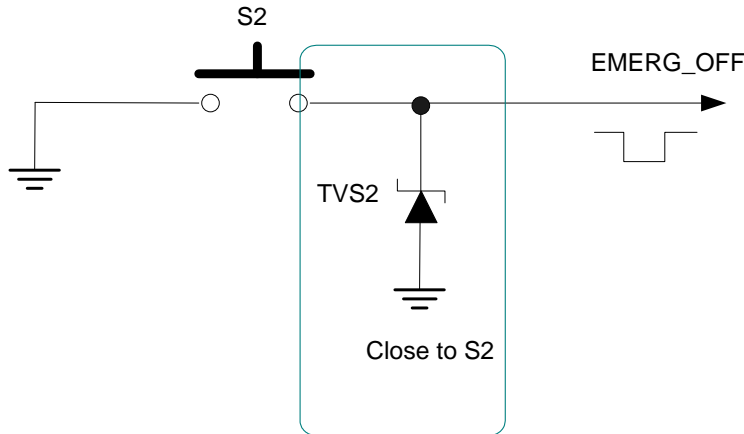


Figure 11: Reference Circuit for EMERG_OFF by Using Button

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.

3.6.3. 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.

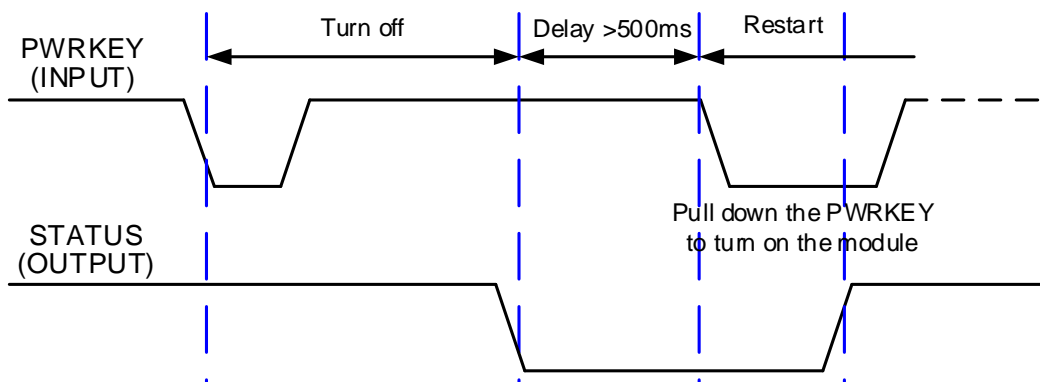


Figure 12: Timing of Restarting System

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

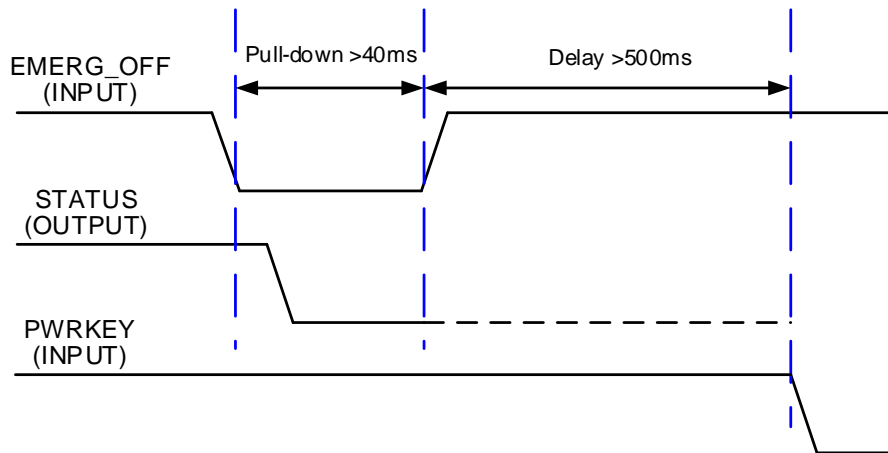


Figure 13: Timing of Restarting System after Emergency Shutdown

NOTE

For more details about the application of STATUS pin, please refer to **Chapter 3.14**.

3.7. 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.

3.7.1. 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 (U)SIM card function would be disabled. In this case, the UART port is still accessible, but all AT commands related with RF function or (U)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 *document [1]*.

3.7.2. 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.

3.7.3. 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 data call 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.

3.7.4. Summary of State Transition

Table 7: Summary of State Transition

| Current Mode | Next Mode | | |
|--------------|------------|-------------|------------|
| | Power Down | Normal Mode | Sleep Mode |
| Power Down | | Use PWRKEY | |

| | | |
|-------------|--|--|
| Normal Mode | AT+QPOWD , use PWRKEY pin, or use EMERG_OFF pin | Use AT command AT+QSCLK=1 and pull DTR up |
| SLEEP Mode | Use PWRKEY pin, or use EMERG_OFF pin | Pull DTR down or incoming voice call or SMS or data call |

3.8. 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.

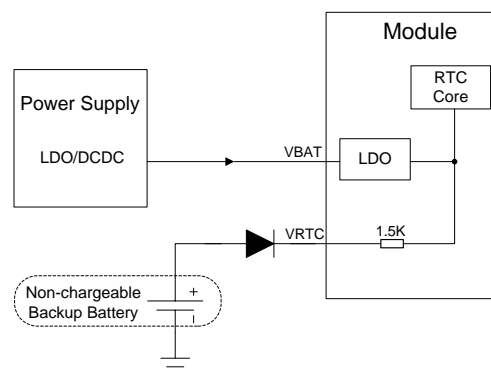


Figure 14: VRTC Is Supplied by a Non-chargeable Battery

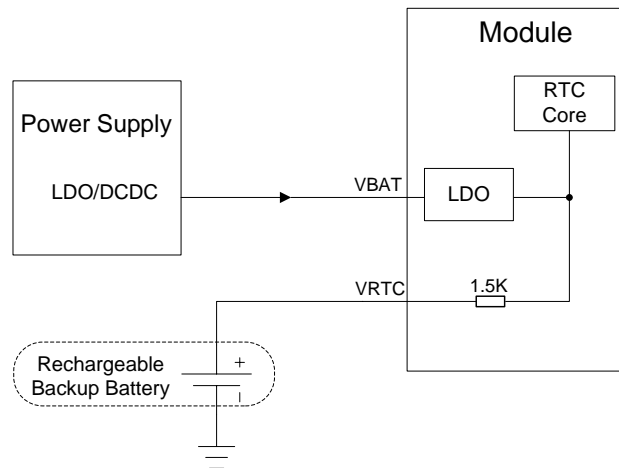


Figure 15: VRTC Is Supplied by a Rechargeable Battery

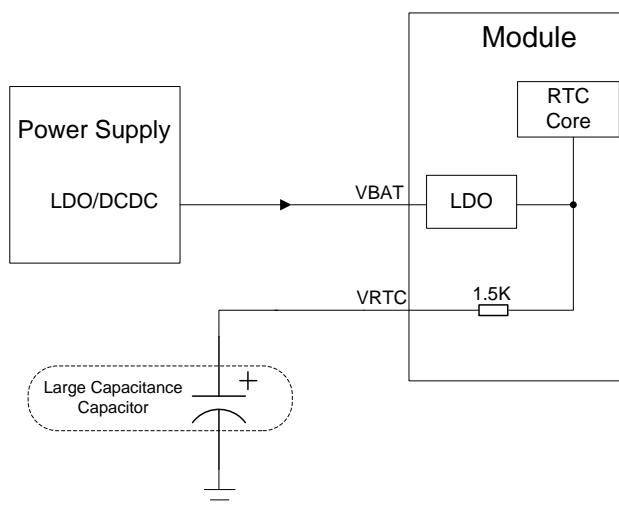


Figure 16: VRTC Is Supplied by a Capacitor

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

NOTE

If the module is only powered by VRTC , the real time will have an error about 5 minutes a day. If you want to keep an accurate real time, please use VBAT to supply the RTC core.

3.9. UART Interfaces

The module provides two UART ports: main UART port and debug UART 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 up the module).
- RI: Ring indicator (when the call, SMS, data of the module are coming, the module will output signal to inform DTE).
- DCD: Data carrier detection (the validity of this pin demonstrates the communication link is set up).

NOTE

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 **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 logic levels are described in the following table.

Table 8: Logic Levels of 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 9: Pin Definition of UART Interfaces

| Interfaces | Pin Name | Pin No. | Description | Multiplexing Function |
|------------|-------------------|---------|------------------------|-----------------------|
| Debug Port | DBG_RXD | 14 | Receive data | |
| | DBG_TXD | 15 | Transmit data | |
| UART Port | DTR ¹⁾ | 20 | Data terminal ready | SIM1_PRESENCE |
| | RXD | 21 | Receive data | |
| | TXD | 22 | Transmit data | |
| | CTS | 23 | Clear to send | |
| | RTS | 24 | Request to send | |
| | DCD ²⁾ | 25 | Data carrier detection | SIM2_RST |
| | RI ³⁾ | 26 | Ring indication | PCM_CLK |

NOTES

- ¹⁾ DTR pin can be used as SIM1_PRESENCE pin via **AT+QSIMDET** command.
- ²⁾ When using the (U)SIM2 interface, DCD pin can be used as SIM2_RST pin. For more details, please refer to **document [6]**.
- ³⁾ When using the PCM interface, RI pin can be used as PCM_CLK.

3.9.1. Main UART Port

3.9.1.1. 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:
300bps, 600bps, 1200bps, 2400bps, 4800bps, 9600bps, 14400bps, 19200bps, 28800bps, 38400bps, 57600bps and 115200bps.
- The default setting is autobauding mode. Support the following baud rates for Autobauding function:
4800bps, 9600bps, 19200bps, 38400bps, 57600bps and 115200bps.

- 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” 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:

1. Synchronization between DTE and DCE:

When DCE (the module) powers on with the autobauding enabled, it is recommended to wait 4 to 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” 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 the Section “AT+IPR” in **document [1]**.

3.9.1.2. The Connection of UART

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.

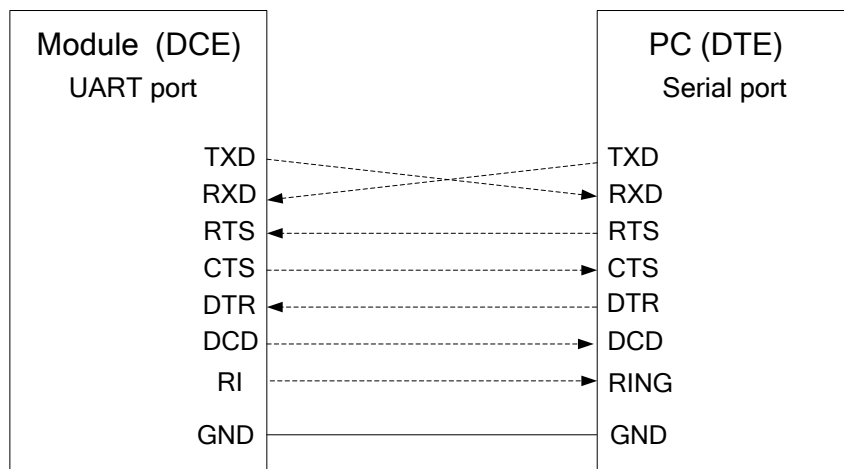


Figure 17: Reference Design for Full-Function UART

Three-line connection is shown as below.

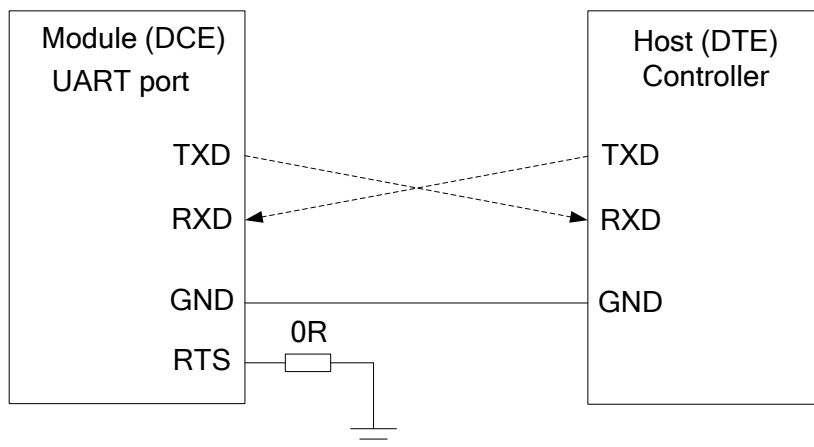


Figure 18: Reference Design for UART Port

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

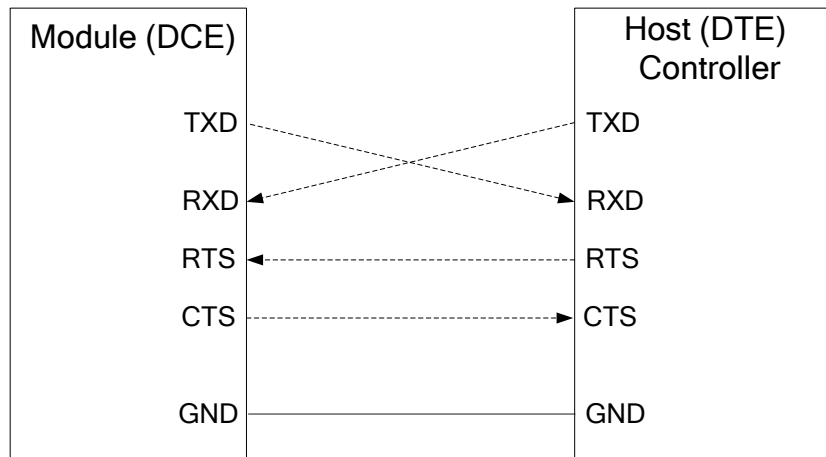


Figure 19: Reference Design for UART Port with Hardware Flow Control

3.9.1.3. 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:

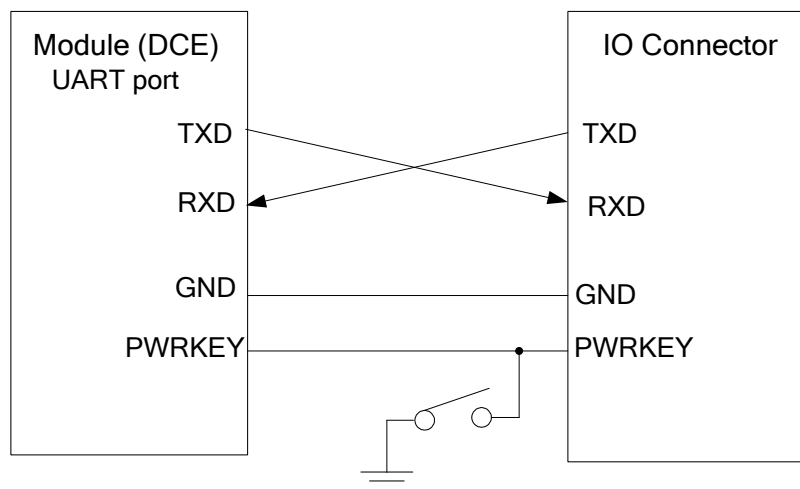


Figure 20: Reference Design for Firmware Upgrade

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.

3.9.2. Debug UART Port

As to Debug Port, there are two working modes, Standard Mode and Advanced Mode, which can be switched through using AT command "AT+QEAUART". For more details, please refer to **document [7]**.

In Standard Mode, it can be used to execute software debug and it can also connect to a peripheral device. Furthermore, its default baud rate is 115200bps.

In Advanced Mode, it can only be used to execute software debug, capture the system's log with Cather Log tool and output the log. In this mode, its baud rate is 460800bps.

The reference design for Debug Port is shown as below.

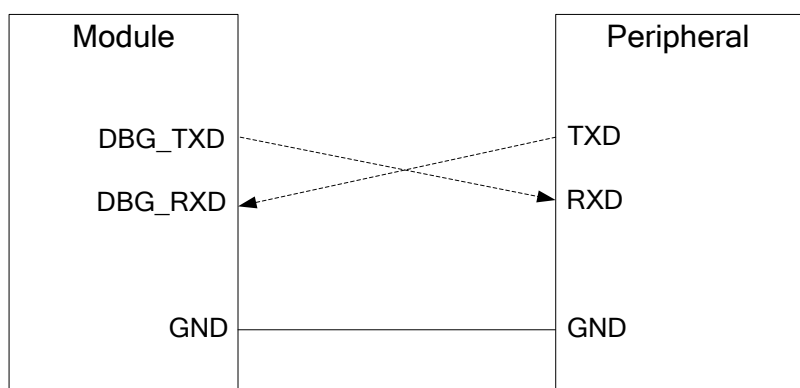


Figure 21: Reference Design for Debug Port

3.9.3. 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 10kΩ.

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

3.10. Audio Interfaces

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

Table 10: Pin Definition of Audio Interface

| Interfaces | Pin Name | Pin No. | Description |
|------------|----------|---------|--|
| AIN1/AOUT1 | MIC1P | 4 | Channel 1 Microphone positive input |
| | MIC1N | 5 | Channel 1 Microphone negative input |
| | SPK1P | 7 | Channel 1 Audio positive output |
| | SPK1N | 6 | Channel 1 Audio negative output |
| AIN2/AOUT2 | AGND | 1 | Form a pseudo-differential pair with SPK2P |
| | MIC2P | 2 | Channel 2 Microphone positive input |
| | MIC2N | 3 | Channel 2 Microphone negative input |
| | 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 loudspeaker output as it embedded an amplifier of class AB whose maximum drive power is 870mW. 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.

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 **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 loudspeaker.

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 **document [1]**.

Table 11: AOUT2 Output Characteristics

| Item | Condition | Min. | Type | Max. | Unit |
|-----------|-----------|------|------|------|------|
| RMS Power | 8ohm load | | | | |
| | VBAT=4.2v | | 870 | | mW |
| | THD+N=1% | | | | |
| | 8ohm load | | | | |
| | VBAT=3.3v | | 530 | | mW |
| | THD+N=1% | | | | |

3.10.1. Audio Interfaces Design Considerations

It is recommended to use the electret microphone with dual built-in capacitors (e.g. 10pF and 33pF) for filtering out RF interference, thus reducing TDD noise. The 33pF capacitor is applied for filtering out RF interference when the module is transmitting at EGSM900. Without placing this capacitor, TDD noise could be heard. The 10pF capacitor here is used for filtering out RF interference at DCS1800. Please note that the resonant frequency point of a capacitor largely depends on the material and production technique. Therefore, customers would have to discuss with their capacitor vendors to choose the most suitable capacitor for filtering out high-frequency noises.

The severity degree of the RF interference in the voice channel during GSM transmitting largely depends on the application design. In some cases, EGSM900 TDD noise is more severe; while in other cases, DCS1800 TDD noise is more obvious. Therefore, a suitable capacitor can be selected based on the test results. Sometimes, even no RF filtering capacitor is required.

In order to decrease radio or other signal interference, RF antennas should be placed away from audio interfaces and audio traces. Power traces cannot be parallel with and also should be far away from the audio traces.

The differential audio traces must be routed according to the differential signal layout rule.

3.10.2. 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.

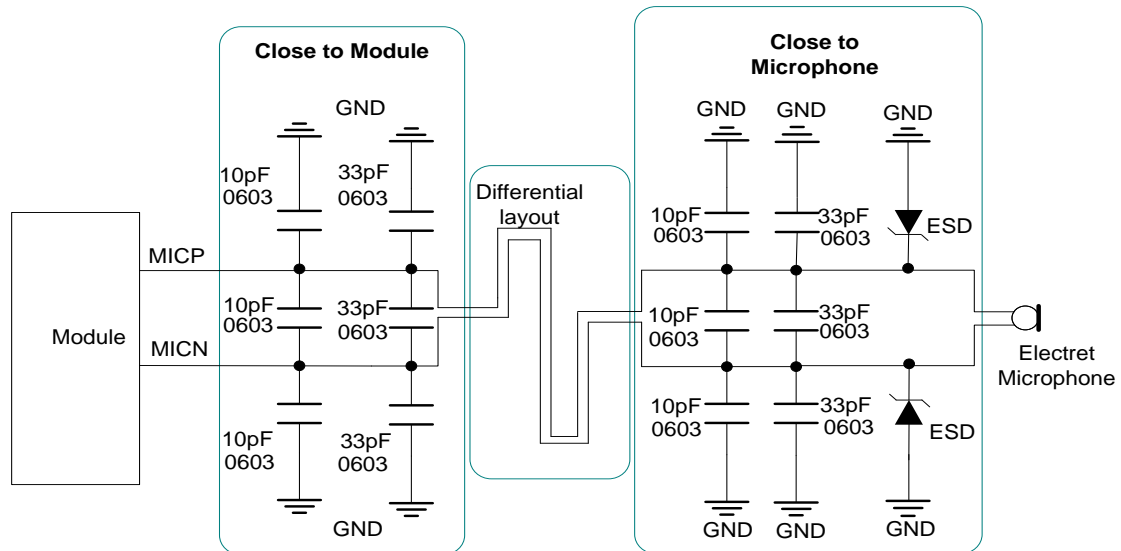


Figure 24: Reference Design for AIN1&AIN2

3.10.3. Receiver Interface Design

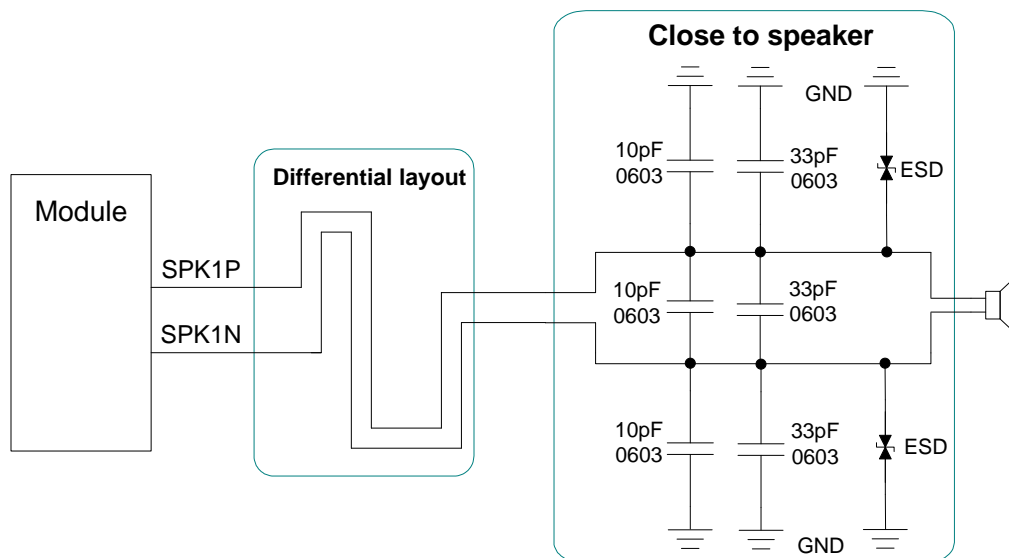


Figure 25: Reference Interface Design of AOUT1

3.10.4. Earphone Interface Design

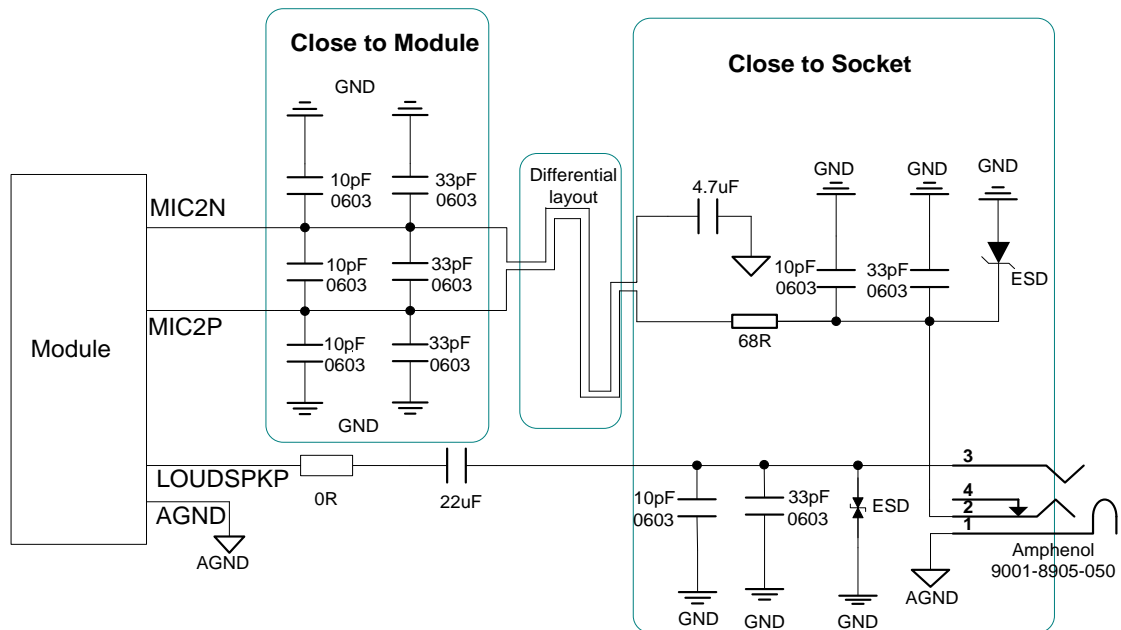


Figure 26: Earphone Interface Design

3.10.5. Loud Speaker Interface Design

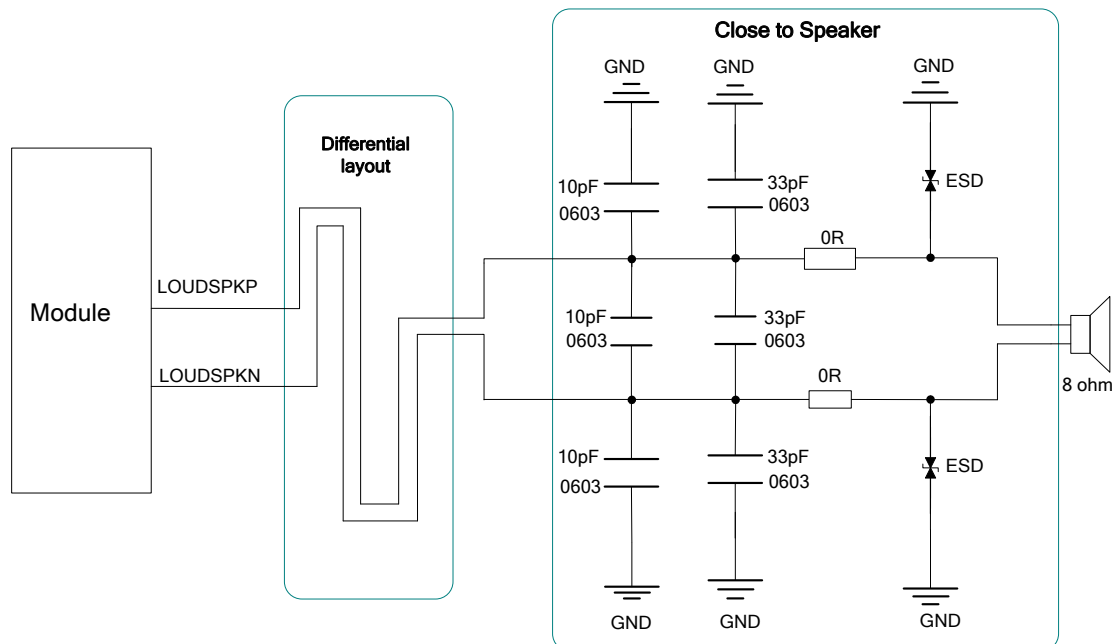


Figure 27: Loud Speaker Interface Design

3.10.6. Audio Characteristics

Table 12: 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 13: 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 | Differential | Load resistance | | 8 | Load Resistance |
| | | Reference level | | 0 | 2×VBAT Vpp |
| | Single-ended | Load resistance | | 8 | Load Resistance |
| | | Reference level | | 0 | VBAT Vpp |

3.11. PCM Interface

Pulse-code modulation (PCM) is a converter that changes the consecutive analog audio signal to discrete digital signal. The whole procedure of Pulse-code modulation contains sampling, quantizing and encoding.

M95 supports PCM interface. It is used for digital audio transmission between the module and the device. This interface is composed of PCM_CLK, PCM_SYNC, PCM_IN and PCM_OUT signal lines.

The module disables PCM interface by default. AT command “AT+QPCMON” is used to configure PCM interface.

Table 14: Pin Definition of PCM Interface

| Pin Name | Pin No. | Description | Multiplexing Function ¹⁾ |
|----------|---------|----------------------------------|-------------------------------------|
| PCM_SYNC | 12 | PCM frame synchronization output | STATUS |
| PCM_CLK | 26 | PCM clock output | RI |
| PCM_OUT | 41 | PCM data output | |
| PCM_IN | 42 | PCM data input | |

NOTE

¹⁾ When using the PCM interface, STATUS pin can be used as PCM_SYNC pin, RI pin can be used as PCM_CLK pin.

3.11.1. Configuration

M95 module supports 13-bit line code PCM format. The sample rate is 8 KHz, and the clock source is 256 KHz, and the module can only act as master mode. The PCM interface supports both long and short synchronization simultaneously. Furthermore, it only supports MSB first. For detailed information, please refer to the table below.

Table 15: Configuration

| PCM | |
|----------------------------------|---|
| Line Interface Format | Linear |
| Data Length | Linear: 13 bits |
| Sample Rate | 8KHz |
| PCM Clock/Synchronization Source | PCM master mode: clock and synchronization is generated by module |
| PCM Synchronization Rate | 8KHz |
| PCM Clock Rate | PCM master mode: 256KHz (line) |
| PCM Synchronization Format | Long/short synchronization |
| PCM Data Ordering | MSB first |

| | |
|----------------|-----|
| Zero Padding | Yes |
| Sign Extension | Yes |

3.11.2. Timing

The sample rate of the PCM interface is 8 KHz and the clock source is 256 KHz, so every frame contains 32 bits data, since M95 supports 16 bits line code PCM format, the left 16 bits are invalid. The following diagram shows the timing of different combinations. The synchronization length in long synchronization format can be programmed by firmware from one bit to eight bits. In the Sign extension mode, the high three bits of 16 bits are sign extension, and in the Zero padding mode, the low three bits of 16 bits are zero padding.

Under zero padding mode, you can configure the PCM input and output volume by executing **AT+QPCMVOL** command. For more details, please refer to **Chapter 3.11.4**.

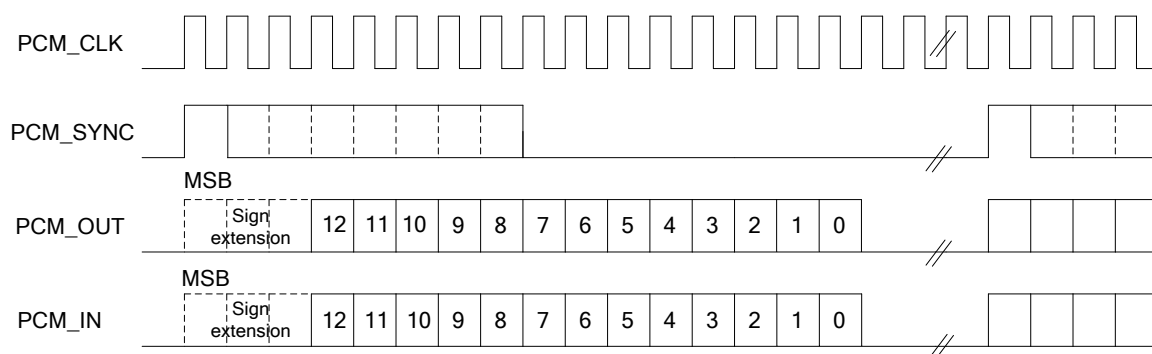


Figure 28: Long Synchronization & Sign Extension Diagram

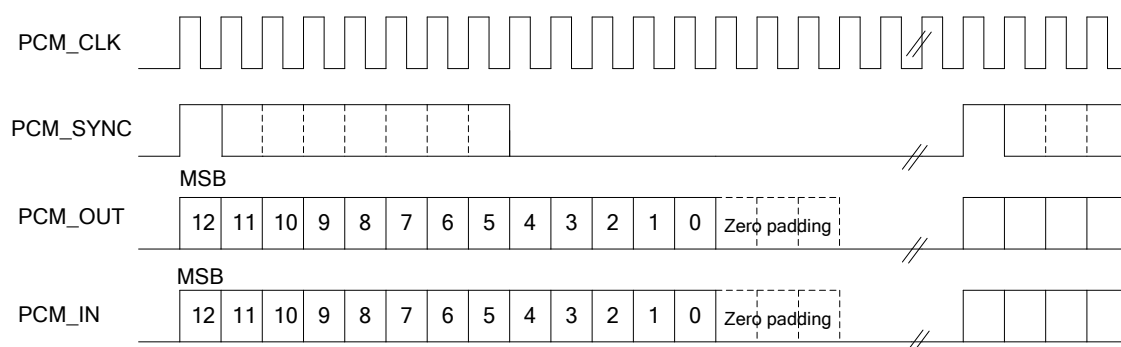


Figure 29: Long Synchronization & Zero Padding Diagram

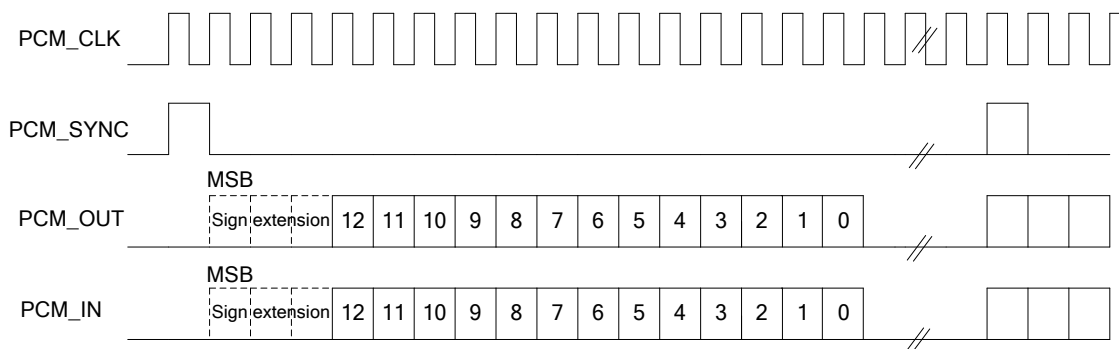


Figure 30: Short Synchronization & Sign Extension Diagram

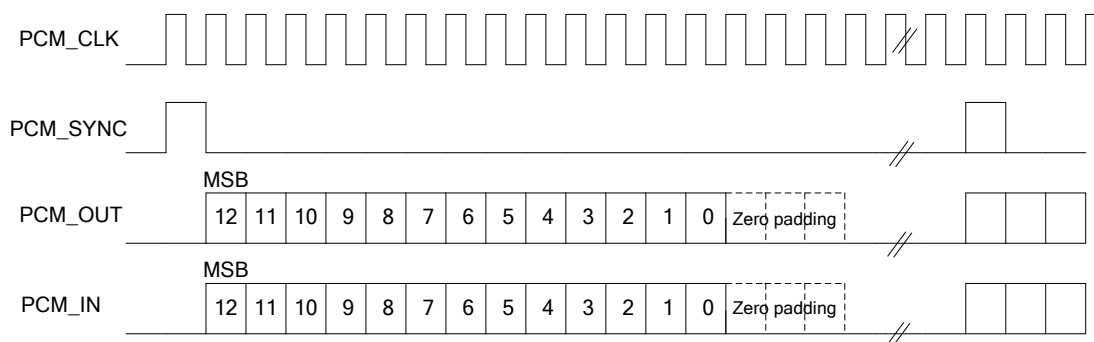


Figure 31: Short Synchronization & Zero Padding Diagram

3.11.3. Reference Design

M95 can only work as a master, providing synchronization and clock source. The reference design is shown as below.

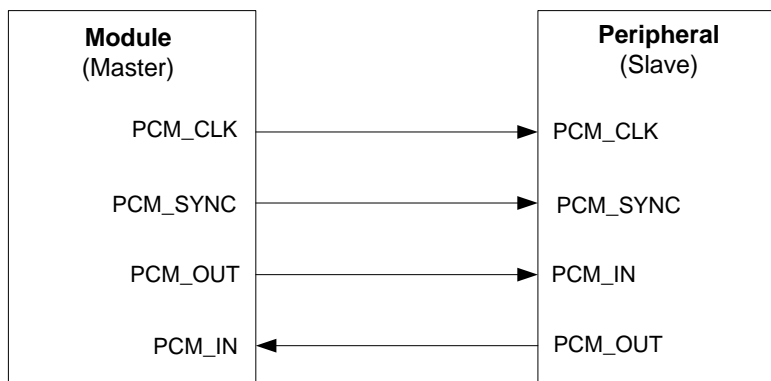


Figure 32: Reference Design for PCM

3.11.4. AT Command

There are two AT commands about the configuration of PCM, listed as below.

AT+QPCMON can configure operating mode of PCM.

AT+QPCMON=<mode>,<Sync_Type>,<Sync_Length>,<SignExtension>,<MSBFirst>

Table 16: QPCMON Command Description

| Parameter | Scope | Description |
|-----------------|-------|--|
| <Mode> | 0~2 | 0: Close PCM 1: Open PCM 2: Open PCM when audio talk is set up |
| <Sync_Type> | 0~1 | 0: Short synchronization 1: Long synchronization |
| <Sync_Length> | 1~8 | Programmed from one bit to eight bit |
| <SignExtension> | 0~1 | 0: Zero padding 1: Sign extension |
| <MSBFirst> | 0~1 | 0: MSB first 1: Not support |

AT+QPCMVOL can configure the volume of input and output.

AT+QPCMVOL=<vol_pcm_in>,<vol_pcm_out>

Table 17: QPCMVOL Command Description

| Parameter | Scope | Description |
|---------------|---------|--|
| <vol_pcm_in> | 0~32767 | Set the input volume |
| <vol_pcm_out> | 0~32767 | Set the output volume The voice may be distorted when this value exceeds 16384. |

3.12. (U)SIM Interfaces

The module contains two smart interfaces to allow module access to the two (U)SIM cards. These two (U)SIM interfaces share the same ground and only (U)SIM1 interface has card insertion detection. Only one (U)SIM card can work at a time. For more details, please refer to **document [6]**.

3.12.1. (U)SIM Card Application

The (U)SIM interfaces 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 (U)SIM card, which is intended for use with a (U)SIM application Tool-kit.

The (U)SIM interfaces are powered by an internal regulator in the module. Both 1.8V and 3.0V (U)SIM Cards are supported.

Table 18: Pin Definition of (U)SIM Interfaces

| Pin Name | Pin No. | Description | Multiplexing Function ¹⁾ |
|---------------|---------|---|-------------------------------------|
| SIM1_VDD | 27 | Supply power for (U)SIM1 card. Automatic detection of (U)SIM1 card voltage. 3.0V±5% and 1.8V±5%. Maximum supply current is around 10mA. | |
| SIM1_CLK | 30 | (U)SIM1 card clock. | |
| SIM1_DATA | 29 | (U)SIM1 card data I/O. | |
| SIM1_RST | 28 | (U)SIM1 card reset. | |
| SIM1_PRESENCE | 20 | (U)SIM1 card detection. | DTR |
| SIM_GND | 31 | (U)SIM card ground. | |
| SIM2_VDD | 18 | Supply power for (U)SIM2 card. Automatic detection of (U)SIM2 card voltage. 3.0V±5% and 1.8V±5%. Maximum supply current is around 10mA. | |
| SIM2_CLK | 17 | (U)SIM2 card clock. | |
| SIM2_DATA | 16 | (U)SIM2 card data I/O. | |
| SIM2_RST | 25 | (U)SIM2 card reset. | DCD |

NOTE

¹⁾ If several interfaces share the same I/O pin, to avoid conflict between these Multiplexing functions, only one peripheral should be enabled at a time.

The following figure is the reference design for (U)SIM1 interface.

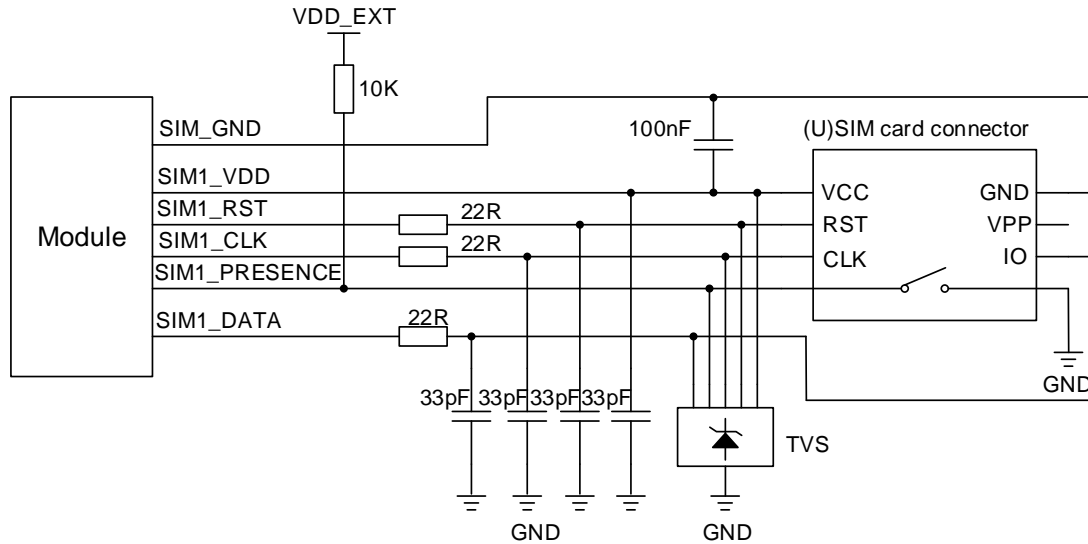


Figure 33: Reference Circuit for (U)SIM1 Interface with 8-pin (U)SIM Card Connector

If SIM1 card detection function is not used, keep SIM1_PRESENCE pin open. The reference circuit for a 6-pin (U)SIM card socket is illustrated as the following figure.

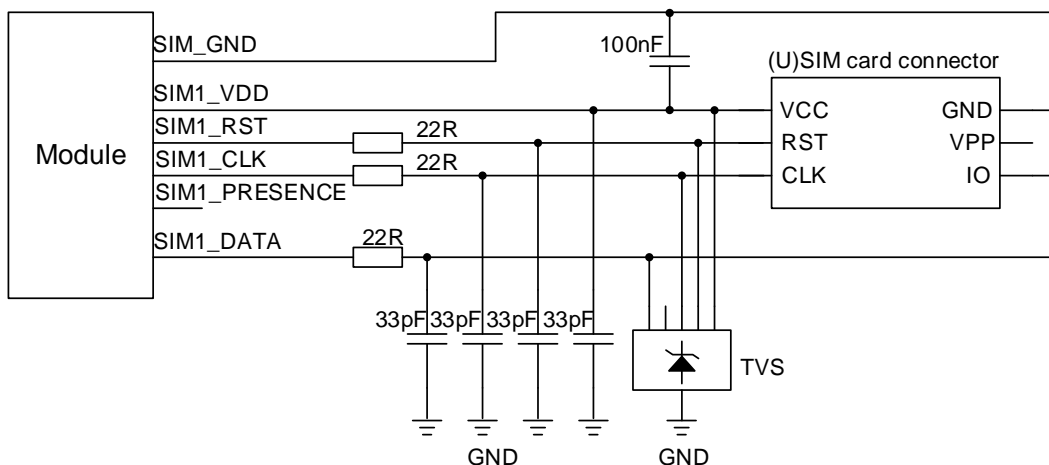


Figure 34: Reference Circuit for (U)SIM1 Interface with 6-pin (U)SIM Card Connector

The following figure is the reference design for (U)SIM2 interface with the 6-pin (U)SIM card connector.

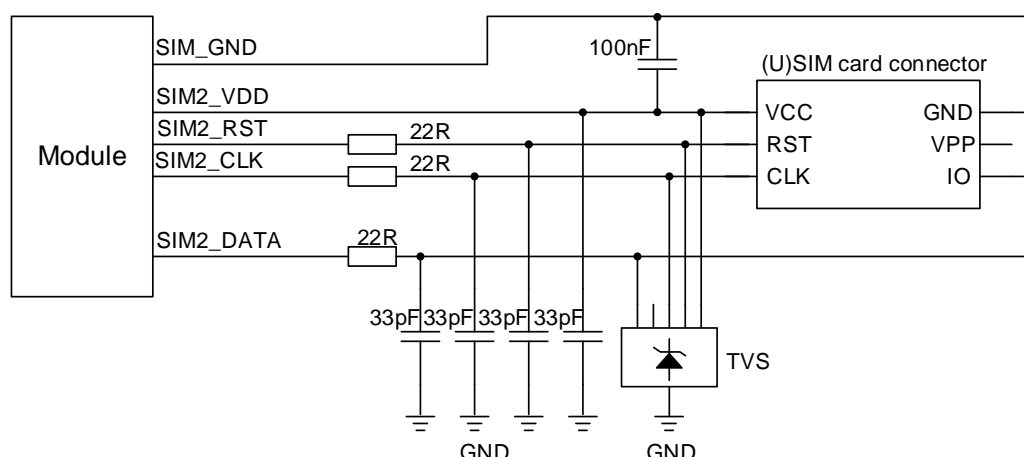


Figure 35: Reference Circuit for (U)SIM2 Interface with 6-pin (U)SIM Card Connector

For more information of (U)SIM card holder, you can visit <http://www.amphenol.com> and <http://www.molex.com>.

In order to enhance the reliability and availability of the (U)SIM card in application. Please follow the below criteria in the (U)SIM circuit design.

- Keep layout of (U)SIM card as close as possible to the module. Assure the possibility of the length of the trace is less than 200mm.
- Keep (U)SIM card signal away from RF and VBAT alignment.
- Assure the ground between module and (U)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 1μF and must be near to (U)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, you can visit <http://www.onsemi.com>. The most important rule is to place your ESD protection device close to the (U)SIM card socket and make sure the net 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 (U)SIM card so as to suppress the EMI spurious transmission and enhance the ESD protection. Please to be noted that the (U)SIM peripheral circuit should be close to the (U)SIM card socket.
- Place the RF bypass capacitors (33pF) close to the (U)SIM card on all signals line for improving EMI.

3.13. Behaviors of The RI

When using PCM interface, RI pin can be used as PCM_CLK.

Table 19: 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. For more details, please refer to document [1] . |

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 as below.

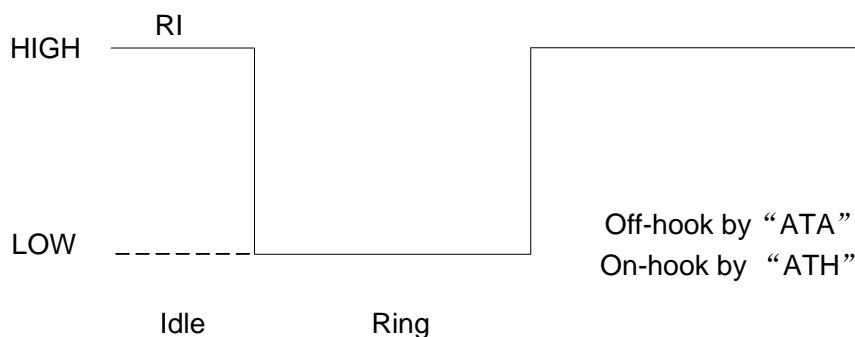


Figure 36: RI Behavior of Voice Calling as a Receiver

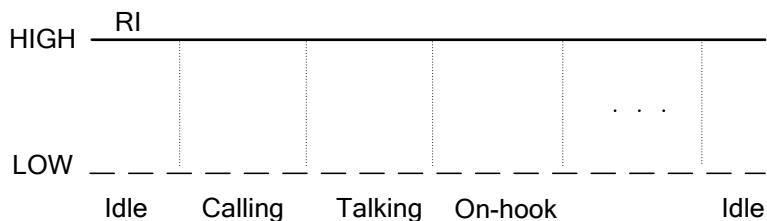


Figure 37: RI Behavior as a Caller

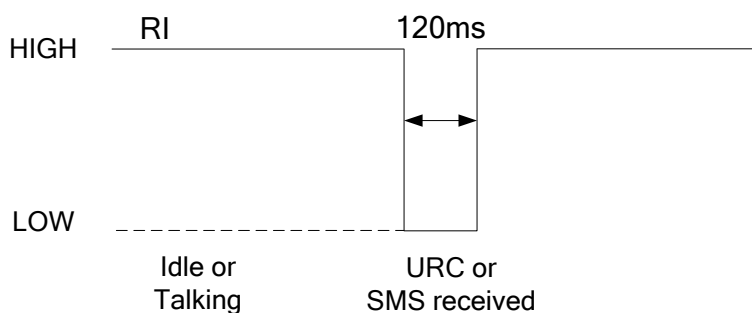


Figure 38: RI Behavior of URC or SMS Received

3.14. 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 20: 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.

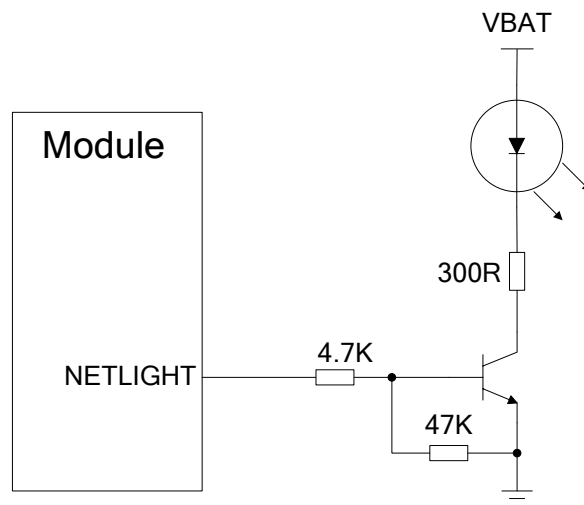


Figure 39: Reference Design for NETLIGHT

3.15. 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 21: Pin Definition of the STATUS

| Pin Name | Pin No. | Description | Multiplexing Function ¹⁾ |
|----------|---------|----------------------------------|-------------------------------------|
| STATUS | 12 | Indicate module operating status | PCM_SYNC |

NOTE

¹⁾ When using PCM interface, STATUS pin can be used as PCM_SYNC.

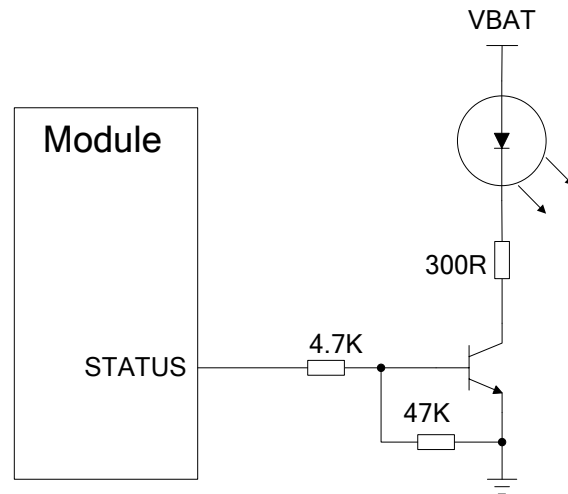


Figure 40: Reference Design for STATUS

4 Antenna Interface

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

Table 22: Pin Definition of the RF_ANT

| Pin Name | Pin No. | Description |
|----------|---------|----------------|
| GND | 37 | Ground |
| GND | 38 | Ground |
| RF_ANT | 39 | RF antenna pad |
| GND | 40 | Ground |

4.1. RF Reference Design

The reference design for RF is shown as below.

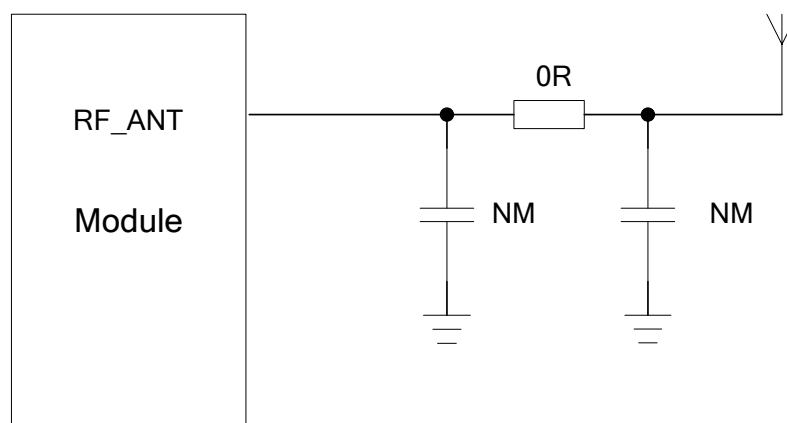


Figure 41: Reference Design for RF

M95 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. M95 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 23: The Module Conducted RF Output Power

| Frequency | Max. | Min. |
|-----------|-----------------|----------------|
| GSM850 | 33dBm \pm 2dB | 5dBm \pm 5dB |
| EGSM900 | 33dBm \pm 2dB | 5dBm \pm 5dB |
| DCS1800 | 30dBm \pm 2dB | 0dBm \pm 5dB |
| PCS1900 | 30dBm \pm 2dB | 0dBm \pm 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 24: The Module Conducted RF Receiving Sensitivity

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

4.4. Operating Frequencies

Table 25: 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 26: Antenna Cable Requirements

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

Table 27: 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.

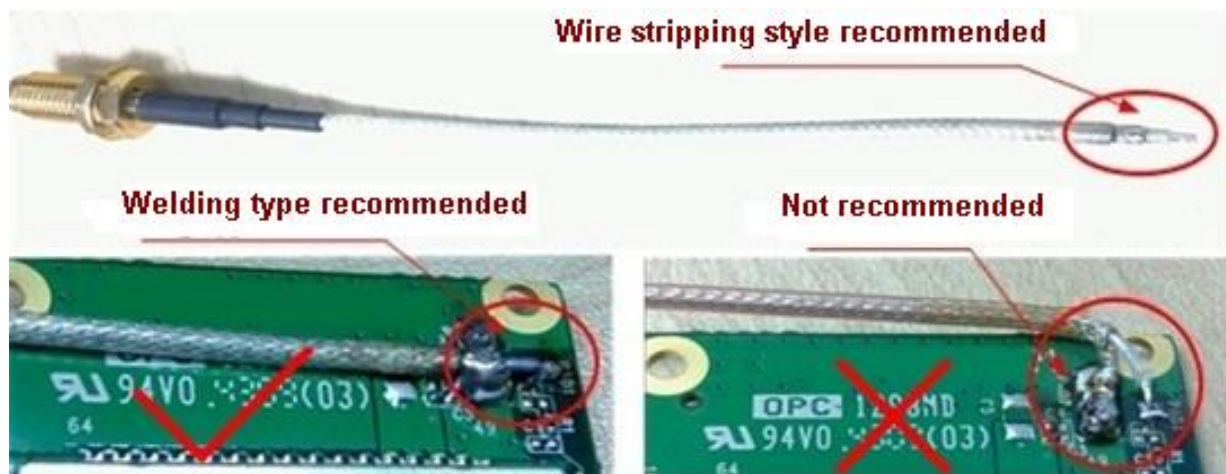


Figure 42: RF Soldering Sample

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 28: 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. Operation and Storage Temperatures

The operation and storage temperatures are listed in the following table.

Table 29: Operation and Storage Temperatures

| Parameter | Min. | Typ. | Max. | Unit |
|---|------|------|------|------|
| Operation Temperature Range ¹⁾ | -35 | +25 | +75 | °C |
| Extended Temperature Range ²⁾ | -40 | | +85 | °C |
| Storage Temperature Range | -40 | | +90 | °C |

NOTES

- ¹⁾ Within operation temperature range, the module is 3GPP compliant.
- ²⁾ Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operation temperature levels, the module will meet 3GPP specifications again.

5.3. Power Supply Ratings

Table 30: The Module Power Supply Ratings

| Parameter | Description | Conditions | Min. | Typ. | Max. | Unit |
|-------------------|--|--|------|------|------|------|
| VBAT | Supply voltage | The actual input voltages must be kept between the minimum and maximum values. | 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(2 Rx,3Tx) | | | |
| | GSM850/EGSM900 ¹⁾ | 506/546 | | mA |
| | DCS1800/PCS1900 ²⁾ | 366/349 | | mA |
| | DATA mode, GPRS (4Rx,1Tx) | | | |
| | GSM850/EGSM900 ¹⁾ | 217/234 | | mA |
| | DCS1800/PCS1900 ²⁾ | 172/170 | | mA |
| | DATA mode, GPRS (1Rx,4Tx) | | | |
| | GSM850/EGSM900 ¹⁾ | 458/485 | | mA |
| | DCS1800/PCS1900 ²⁾ | 462/439 | | mA |
| Peak supply current (during transmission slot) | Maximum power control level on GSM850 and EGSM900. | 1.6 | 2 | A |

NOTES

- ¹⁾ Power control level PCL 5.
- ²⁾ Power control level PCL 0.
- 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 31: 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 (3 Rx, 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 (2 Rx, 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 (4 Rx, 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 (1 Rx, 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. Electrostatic Discharge

The module is not protected against electrostatics discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the module's electrostatics discharge characteristics.

Table 32: Electrostatics Discharge Characteristics (25°C, 45% Relative Humidity)

| Tested Interfaces | Contact Discharge | Air Discharge | Unit |
|-------------------|-------------------|---------------|------|
| VBAT, GND | ±5 | ±10 | kV |
| RF_ANT | ±5 | ±10 | kV |
| TXD, RXD | ±2 | ±4 | kV |
| Others | ±0.5 | ±1 | kV |

6 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module. All dimensions are measured in mm, and the dimensional tolerances are $\pm 0.05\text{mm}$ unless otherwise specified.

6.1. Mechanical Dimensions of Module

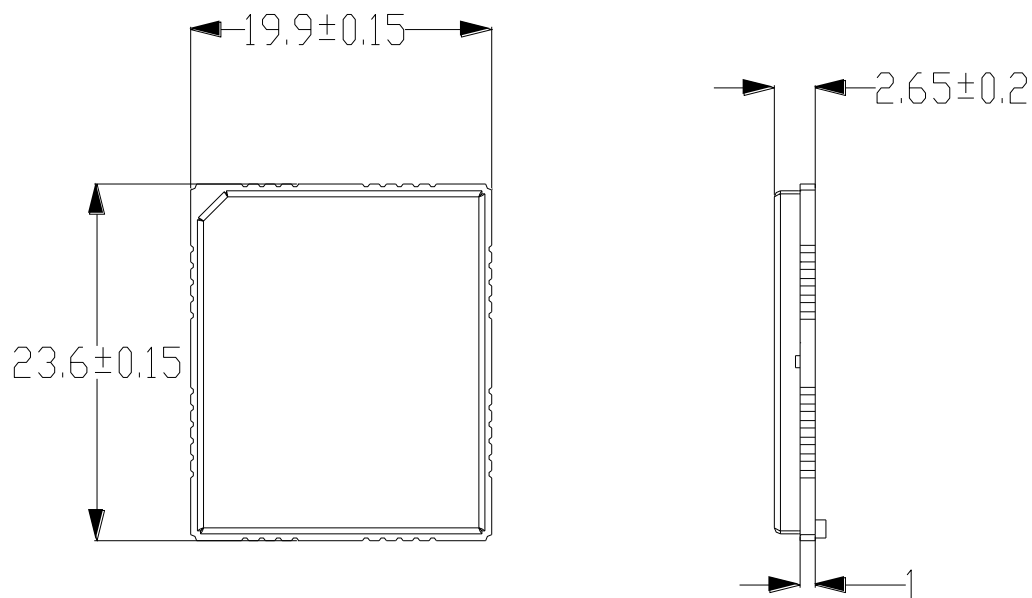


Figure 43: Module Top and Side Dimensions

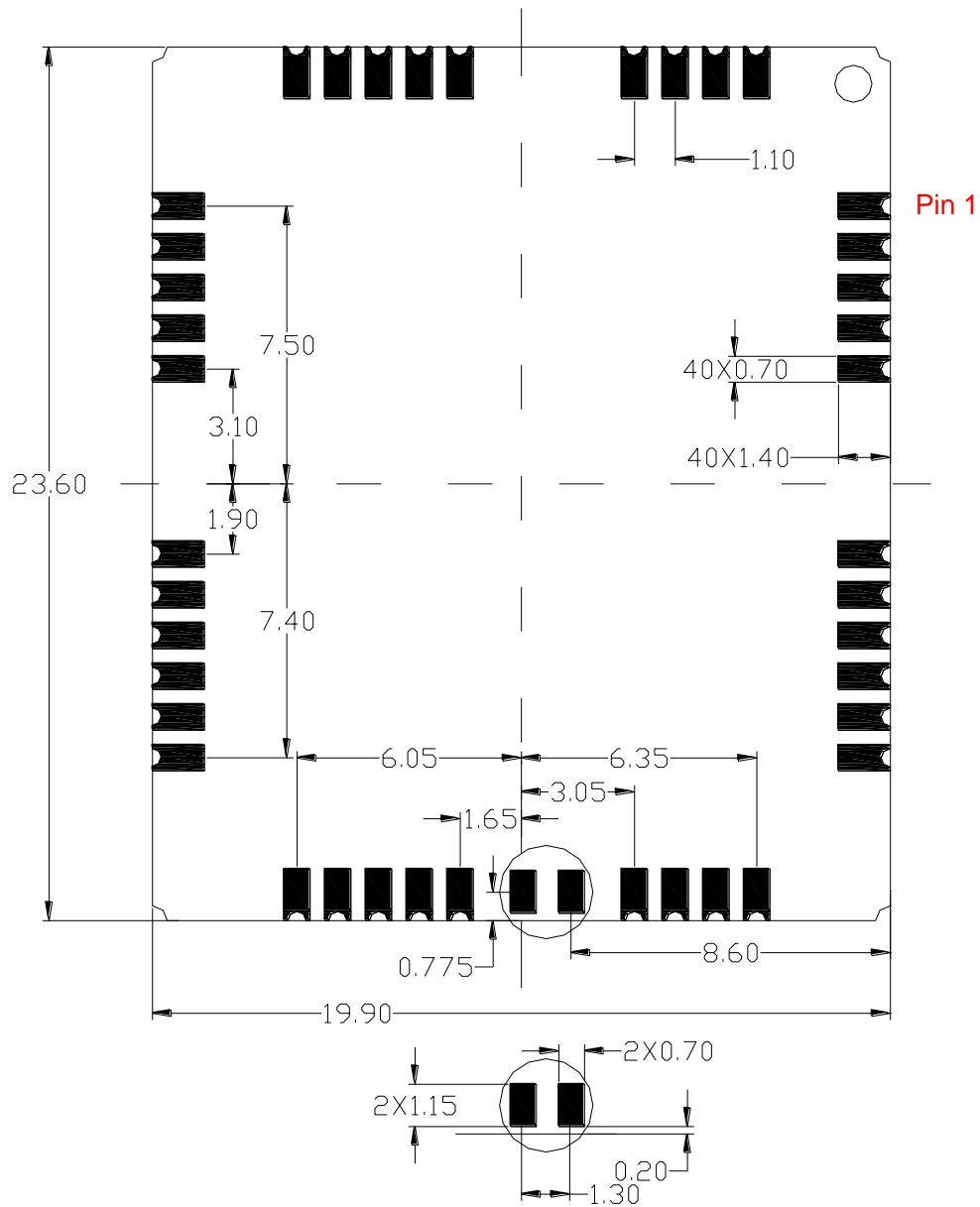


Figure 44: Module Bottom Dimensions (Bottom View)

6.2. Recommended Footprint

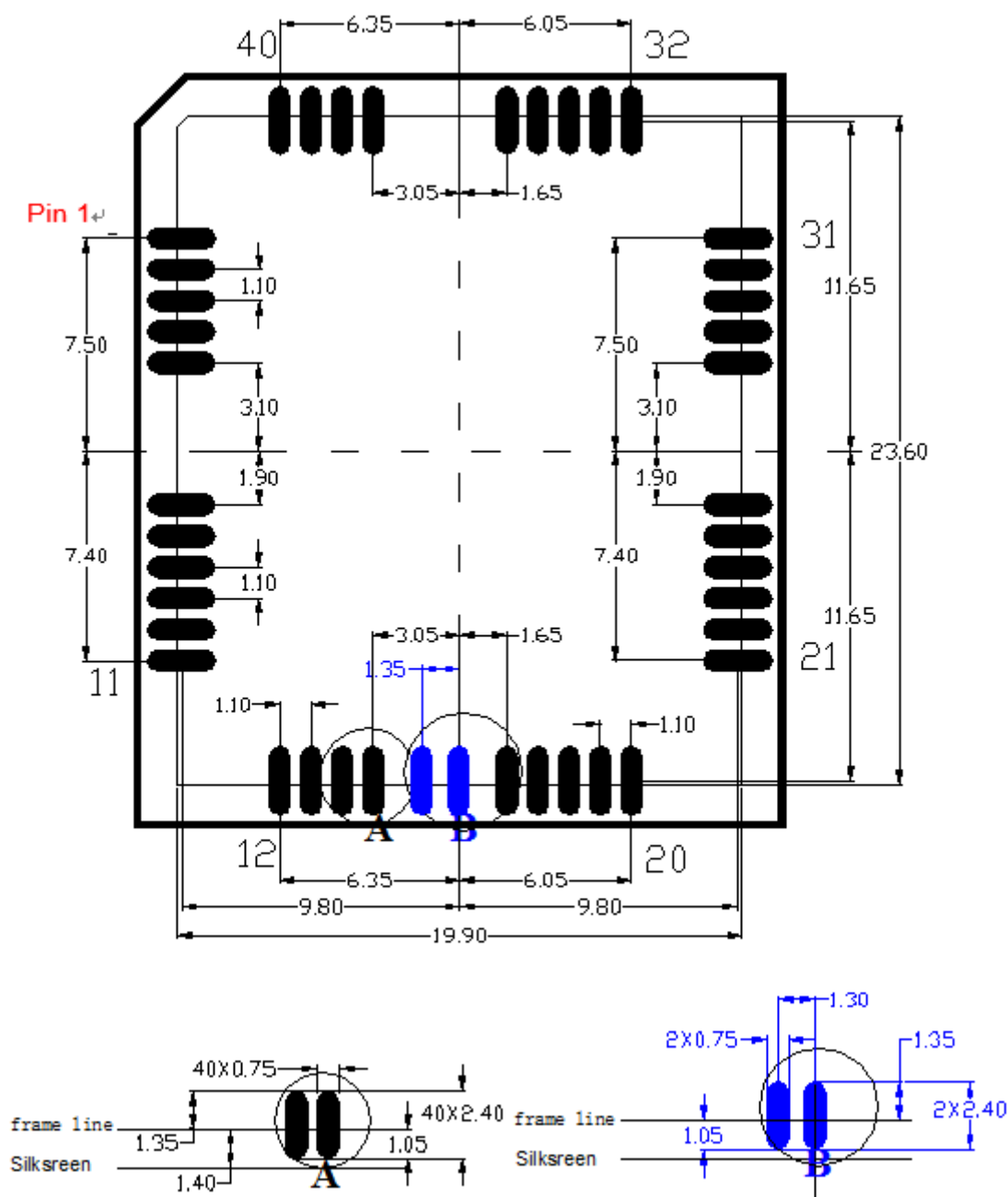


Figure 45: Recommended Footprint (Top View)

NOTE

The module should keep about 3mm away from other components in the host PCB.

6.3. Design Effect Drawings of the Module

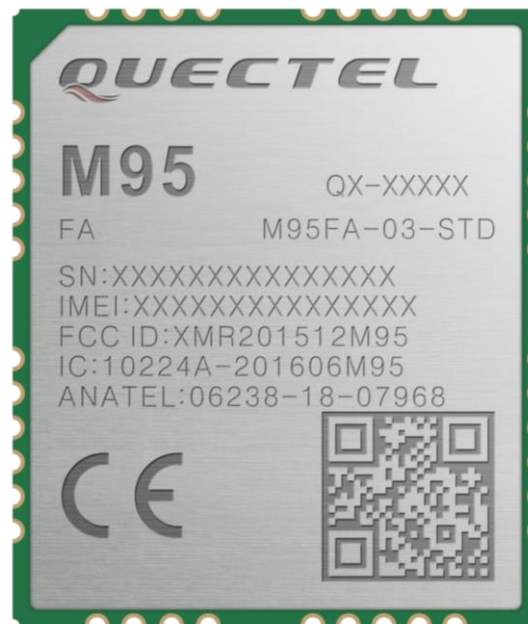


Figure 46: Top View of the Module

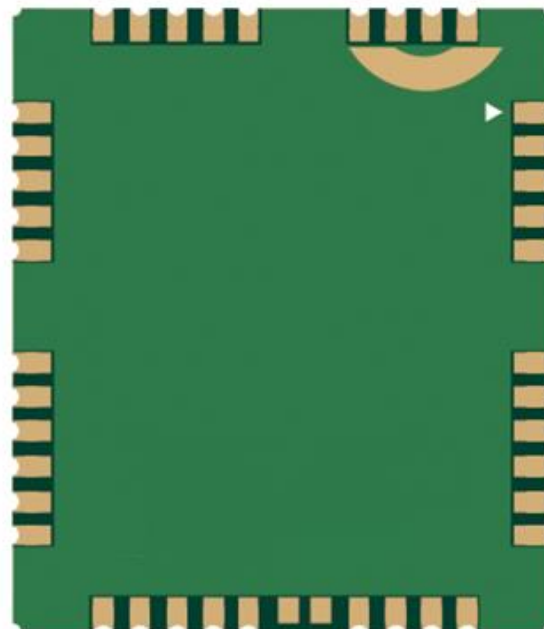


Figure 47: Bottom View of the Module

7 Storage and Manufacturing

7.1. Storage

M95 is stored in a vacuum-sealed bag. It is rated at MSL 3, and storage restrictions are shown as below.

1. Shelf life in the vacuum-sealed bag: 12 months at <40°C/90%RH.
2. After the vacuum-sealed bag is opened, devices that will be subjected to reflow soldering or other high temperature processes must be:
 - Mounted within 168 hours at the factory environment of ≤30°C/60%RH.
 - Stored at <10%RH.
3. Devices require baking before mounting, if any circumstance below occurs.
 - When the ambient temperature is 23°C±5°C and the humidity indication card shows the humidity is >10% before opening the vacuum-sealed bag.
 - Device mounting cannot be finished within 168 hours at factory conditions of ≤30°C/60%RH.
4. If baking is required, devices may be baked for 8 hours at 120°C±5°C.

NOTE

As the plastic package cannot be subjected to high temperature, it should be removed from devices before high temperature (120°C) baking. If shorter baking time is desired, please refer to *IPC/JEDECJ-STD-033* for baking procedure.

7.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. The force on the squeegee should be adjusted properly so as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, the thickness of stencil for the module is recommended to be 0.20mm. For more details, please refer to **document [5]**.

It is suggested that the peak reflow temperature is 238°C~245°C, and the absolute maximum reflow temperature is 245°C. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

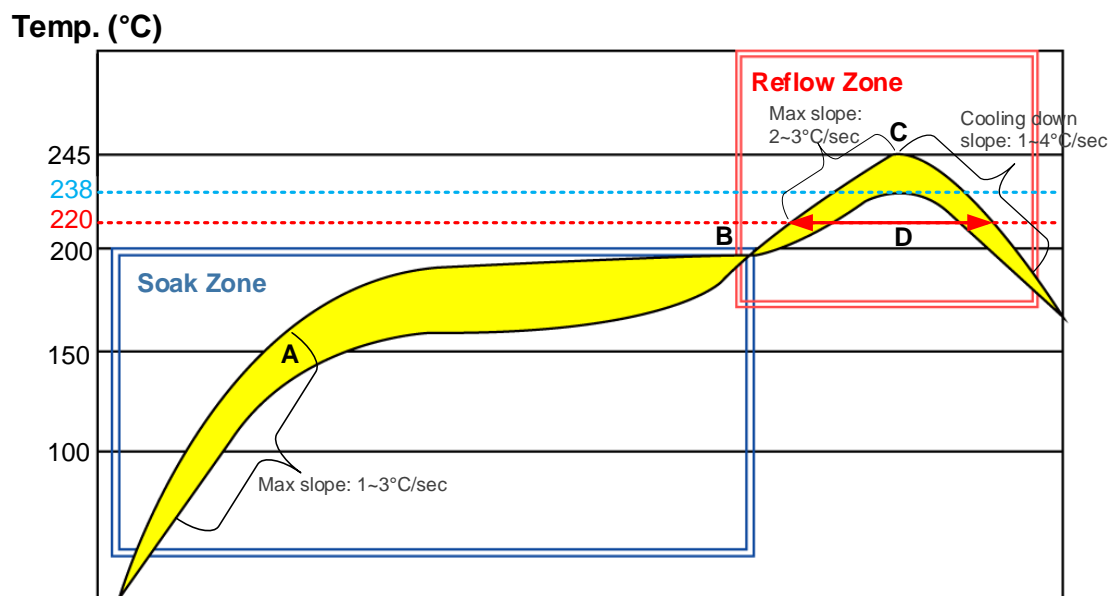


Figure 48: Reflow Soldering Thermal Profile

Table 33: Recommended Thermal Profile Parameters

| Factor | Recommendation |
|--|----------------|
| Soak Zone | |
| Max slope | 1~3°C/sec |
| Soak time (between A and B: 150°C and 200°C) | 60~120sec |
| Reflow Zone | |

| | |
|-----------------------------|-----------|
| Max slope | 2~3°C/sec |
| Reflow time (D: over 220°C) | 40~60sec |
| Max temperature | 238~245°C |
| Cooling down slope | 1~4°C/sec |
| Reflow Cycle | |
| Max reflow cycle | 1 |

7.3. Packaging

M95 is packaged in tap and reel carriers. Each reel is 11.88m long and contains 250 modules. The figure below shows the package details, measured in mm.

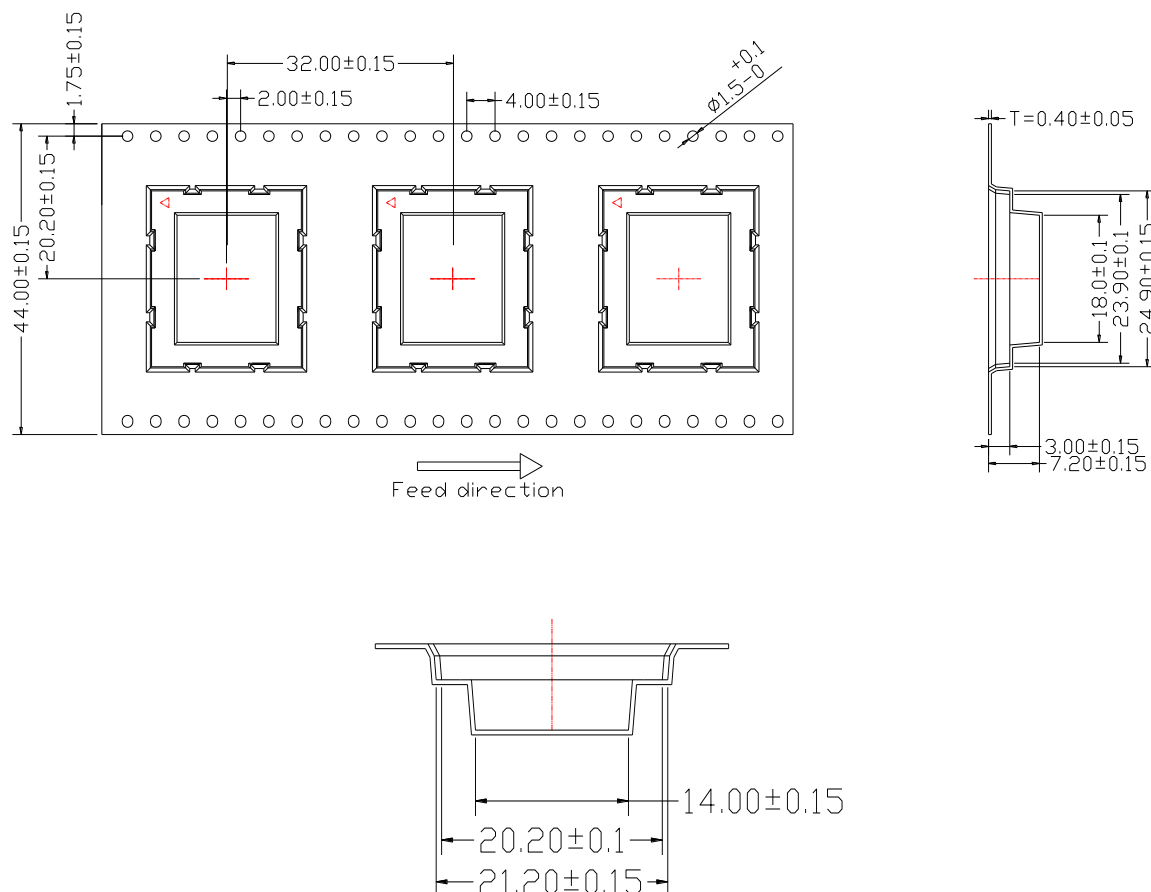


Figure 49: Tape Specifications

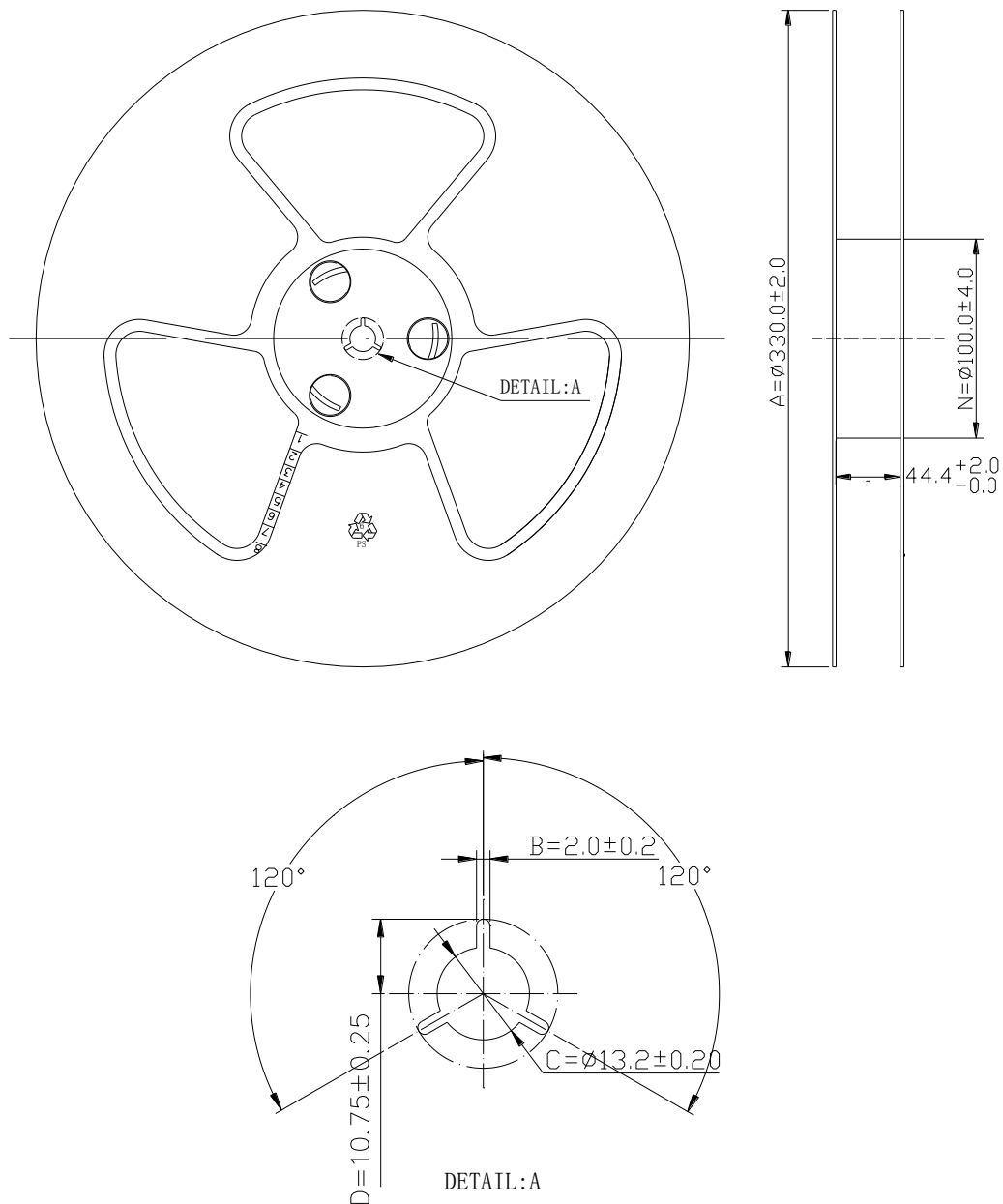


Figure 50: Reel Specifications

Table 34: Reel Packing

| Model Name | MOQ for MP | Minimum Package: 250pcs | Minimum Package×4=1000pcs |
|------------|------------|---|--|
| M95 | 250pcs | Size: 370 × 350 × 56mm ³ N.W: 0.63kg G.W: 1.47kg | Size: 380 × 250 × 365mm ³ N.W: 2.5kg G.W: 6.4kg |

8 Appendix A Reference

Table 35: Related Documents

| SN | Document Name | Remark |
|------|--|--|
| [1] | Quectel_M95_AT_Commands_Manual | AT commands manual |
| [2] | ITU-T Draft new recommendation V.25ter | Serial asynchronous automatic dialing and control |
| [3] | Quectel_GSM_UART_Application_Note | UART port application note |
| [4] | Quectel_GSM_EVB_User_Guide | GSM EVB user guide |
| [5] | Quectel_Module_Secondary_SMT_User_Guide | Module secondary SMT user guide |
| [6] | Quectel_M95_Dual_SIM_Application_Notes | M95 Dual SIM Application Notes |
| [7] | Quectel_GSM_Multi_UART_Application_Note | M95 Multi UART Application Notes |
| [8] | Quectel_GSM_Module_Digital_IO_Application_Note | GSM module digital IO application note |
| [9] | GSM 07.07 | Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME) |
| [10] | GSM 07.10 | Support GSM 07.10 multiplexing protocol |
| [11] | 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) |
| [12] | GSM 11.14 | Digital cellular telecommunications (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment (SIM – ME) interface |
| [13] | GSM 11.11 | Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment (SIM – ME) interface |

| | | |
|------|-----------|---|
| [14] | GSM 03.38 | Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information |
| [15] | GSM 11.10 | Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification |

Table 36: 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 |
| I _{max} | Maximum Load Current |
| I _{norm} | 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) |

| | |
|-------|---|
| MSL | Moisture Sensitivity Level |
| 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 |
| USIM | Universal Subscriber Identification Module |
| USSD | Unstructured Supplementary Service Data |
| VSWR | Voltage Standing Wave Ratio |
| Vmax | Maximum Voltage Value |
| Vnorm | Normal Voltage Value |
| Vmin | Minimum Voltage Value |

| | |
|-------------|---|
| V_{IHmax} | Maximum Input High Level Voltage Value |
| V_{IHmin} | Minimum Input High Level Voltage Value |
| V_{ILmax} | Maximum Input Low Level Voltage Value |
| V_{ILmin} | Minimum Input Low Level Voltage Value |
| V_{Imax} | Absolute Maximum Input Voltage Value |
| V_{Imin} | Absolute Minimum Input Voltage Value |
| V_{OHmax} | Maximum Output High Level Voltage Value |
| V_{OHmin} | Minimum Output High Level Voltage Value |
| V_{OLmax} | Maximum Output Low Level Voltage Value |
| V_{OLmin} | 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 37: 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.

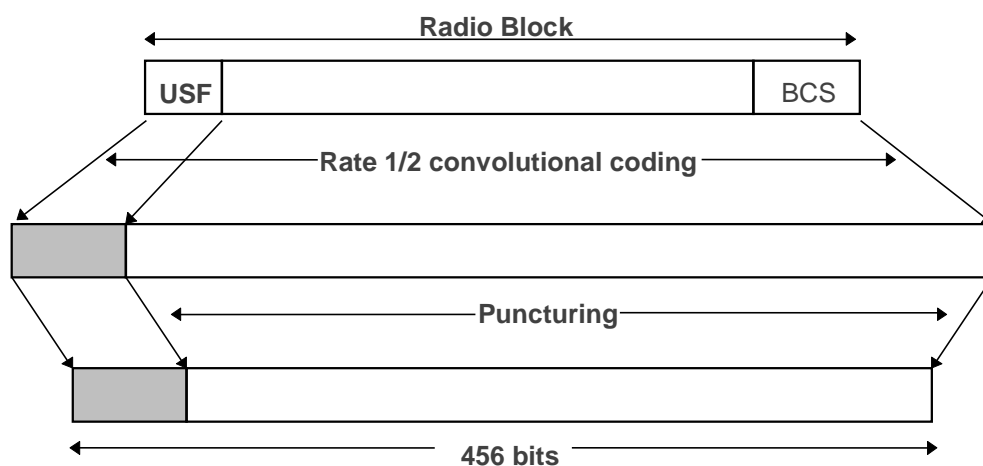


Figure 51: Radio Block Structure of CS-1, CS-2 and CS-3

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

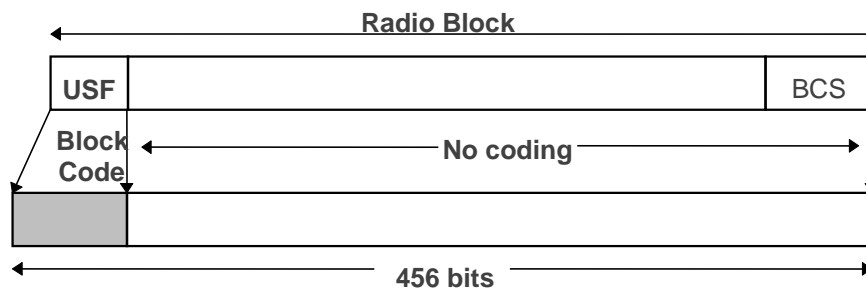


Figure 52: Radio Block Structure of CS-4

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 dependent, 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 38: GPRS Multi-slot Classes

| Multi-slot 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 |