# MC65-OpenCPU

# Hardware Design

**GSM/GPRS/GNSS Module Series**

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## GENERAL NOTES



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# About the Document

## History

| Revision | Date | Author | Description |
|---|---|---|---|
| 1.0 | 2019-11-01 | Andy ZHAO/<br>Rim HUANG | Initial |

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# 1 Introduction

This document defines the MC65-OpenCPU module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers quickly understand MC65-OpenCPU module interface specifications, electrical and mechanical details, as well as other related information of the module. Associated with application notes and user guides, customers can use MC65-OpenCPU 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 MC65-OpenCPU 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. |
|   | Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength. |
|  | 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

OpenCPU is an embedded development solution for M2M field in which the module acts as the main processor. With the development of communication technology and the ever-changing market demands, more and more customers have realized the advantages of OpenCPU solution. Especially, its advantage in reducing the product cost is greatly valued by customers. With OpenCPU solution, development flow for wireless application and hardware design will be simplified. Main features of the solution are as below:

1. Reduce product development time.
2. Simplify circuit design and reduce cost & power consumption.
3. Decrease product size.
4. Upgrade firmware remotely via OpenCPU DFOTA.
5. Decrease the total cost and enhance the competitive advantages.

MC65-OpenCPU is a multi-purpose module which integrates a high performance GNSS engine and a quad-band GSM/GPRS engine. It can work as **All-in-one** solution or **Stand-alone** solution according to customers' application demands. For more details about **All-in-one** solution and **Stand-alone** solution, please refer to ***Chapter 3.4***.

The quad-band GSM/GPRS engine can work at frequencies of GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. MC65-OpenCPU 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***.

The GNSS engine is a single receiver integrating GLONASS and GPS systems. It supports multiple positioning and navigation systems including autonomous GPS, GLONASS, SBAS (including WAAS, EGNOS, MSAS and GAGAN), and QZSS. It is able to achieve the industry's highest level of sensitivity, accuracy and TTFF with the lowest power consumption. The embedded flash memory provides capacity for storing user-specific configurations and allows for future updates.

MC65-OpenCPU is an SMD type module which can be easily embedded into applications through its 54 LCC pads and 14 LGA pads. With a compact profile of 18.7mm × 16.0mm × 2.1mm, the module can meet almost all the requirements for M2M applications, including vehicle and personal tracking, wearable devices, security systems, wireless POS, industrial PDA, smart metering, remote maintenance & control, etc.

Designed with power saving technique, the current consumption of MC65-OpenCPU's GSM part is as low as 1.1mA in Sleep mode when DRX is 5 and the GNSS part is powered off. The GNSS engine also supports Backup power saving mode which can fit the requirement of low-power consumption in different scenarios.

GSM part of MC65-OpenCPU is integrated with Internet service protocols, such as TCP/UDP, PPP*, HTTP and FTP. Extended AT commands have been developed for customers to use these Internet service protocols easily.

GNSS part of MC65-OpenCPU is embedded with AGPS technology, allowing GNSS part to achieve fast TTFF in either hot or warm start.

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

**NOTE**

"*" means under development.

## 2.2. Key Features

The following table describes the detailed features of MC65-OpenCPU.

**Table 1: Key Features (GSM/GPRS Part of MC65-OpenCPU)**

| Features | Details |
|---|---|
| Power Supply | Single supply voltage: 3.45V~4.25V<br>Typical supply voltage: 4.0V |
| Power Saving | Typical power consumption in Sleep mode (GNSS is powered off):<br>1.1mA @DRX=5<br>1.0mA @DRX=9 |
| Frequency Bands | ● Quad-band: GSM850, EGSM900, DCS1800, PCS1900<br>● The module can search these frequency bands automatically.<br>● The frequency bands can be set by AT commands.<br>● Compliant to GSM Phase 2/2+ |
| GSM Power Class | ● Class 4 (2W) at GSM850 and EGSM900<br>● Class 1 (1W) at DCS1800 and PCS1900 |
| GPRS Connectivity | ● GPRS multi-slot class 12 (default)<br>● GPRS multi-slot class 1~12 (configurable)<br>● GPRS mobile station class B |
| DATA GPRS | ● GPRS data downlink transfer: max 85.6kbps<br>● GPRS data uplink transfer: max 85.6kbps<br>● Coding scheme: CS-1, CS-2, CS-3 and CS-4<br>● Support PAP (Password Authentication Protocol) usually used for PPP connection<br>● Internet service protocols: TCP/UDP/NTP/PING/FTP/HTTP/PPP*, etc.<br>● Support Packet Broadcast Control Channel (PBCCH)<br>● Support Unstructured Supplementary Service Data (USSD) |
| Temperature Range | ● Operation temperature range: -35°C ~ +75°C 1)<br>● Extended temperature range: -40°C ~ +85°C 2)<br>● Storage temperature range: -40°C ~ +90°C |
| (U)SIM Interface | ● Support (U)SIM: 1.8V/3.0V<br>● Support Single SIM Single Standby |
| SMS | ● Text and PDU mode<br>● SMS storage: (U)SIM card |
| Audio Features | Speech codec modes:<br>● Half Rate (ETS 06.20)<br>● Full Rate (ETS 06.10)<br>● Enhanced Full Rate (ETS 06.50/06.60/06.80)<br>● Adaptive Multi-Rate (AMR) |

| | |
|---|---|
| | ● Echo Suppression<br>● Noise Reduction<br>● Embedded one amplifier of class AB with maximum driving power up to 800mW |
| UART Interfaces | Main UART port:<br>● Seven lines on main UART port interface<br>● Used for AT command communication and GPRS data transmission<br>● Used for GNSS related AT command input and NMEA message reading in the **All-in-one** solution<br>● Multiplexing function<br>● Autobauding supports baud rates from 4800bps to 115200bps<br>Debug UART port:<br>● Two-wire debug UART port: DBG_TXD and DBG_RXD<br>● Used for firmware download, upgrade, debugging and log output<br>● Fixed baud rate 921600bps<br>Auxiliary UART port:<br>● Two lines on auxiliary port interface: TXD_AUX and RXD_AUX<br>● Used for communication with the GNSS part in **All-in-one** solution |
| Phonebook Management | Support phonebook types: SM, ME, ON, MC, RC, DC, LD, LA |
| SIM Application Toolkit | Support SAT class 3, GSM 11.14 Release 99 |
| Physical Characteristics | Size: (18.7±0.15)mm × (16±0.15)mm × (2.1±0.2)mm<br>Package: LCC+LGA<br>Weight: Approx. 1.3g |
| Firmware Upgrade | ● Debug UART port<br>● DFOTA |
| Antenna Interfaces | ● GSM antenna interface and GNSS antenna interface<br>● Antenna impedance: 50Ω |

**NOTES**

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, 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.
3. "*" means under development.

**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 |

**Table 3: Key Features (GNSS Part of MC65-OpenCPU)**

| Features | Description |
|---|---|
| GNSS | ● GPS+GLONASS (by default) |
| Power Consumption | ● Acquisition: 23.8mA @-130dBm (GPS)<br>● Tracking: 22.6mA @-130dBm (GPS)<br>● Acquisition: 25.3m A @-130dBm (GPS+GLONASS)<br>● Tracking: 24.7mA @-130dBm (GPS+GLONASS)<br>● Backup: 25uA @VRTC=2.8V |
| Receiver Type | ● GPS L1 1575.42±1.023MHz C/A Code<br>● GLONASS G1 1602±3.9375MHz C/A Code |
| Sensitivity (GPS+GLONASS) | ● Acquisition: -144dBm<br>● Reacquisition: -157dBm<br>● Tracking: -156dBm |
| Time-to-First-Fix | ● Cold Start (Autonomous): <35s average @-130dBm<br>● Warm Start (Autonomous): <30s average @-130dBm<br>● Hot Start (Autonomous): 1s @-130dBm |
| Horizontal Position Accuracy (Autonomous) | ● <2.5m CEP @-130dBm |
| Update Rate | ● Up to 10Hz, 1Hz by default |
| Accuracy of 1PPS Signal | ● Typical accuracy <10ns<br>● Time pulse width: 100ms |
| Velocity Accuracy | ● Without aid: 0.1m/s |
| Acceleration Accuracy | ● Without aid: 0.1m/s² |
| Dynamic Performance | ● Maximum Altitude: 18000m<br>● Maximum Velocity: 515m/s<br>● Acceleration: 4G |

| | |
|---|---|
| GNSS UART Port | ● GNSS UART ports: GNSS_TXD and GNSS_ RXD<br>● Baud rate: 9600bps by default<br>● Used for communication with the GSM Part in **All-in-one** solution<br>● Used for communication with peripherals in **Stand-alone** solution |

**Table 4: Protocols Supported by the Module**

| Protocol | Type |
|---|---|
| NMEA | Output, ASCII, 0183, 3.01 |

**NOTE**

For details of the NMEA standard protocol, please refer to ***document [14]***.

## 2.3. Functional Diagram

The following figure shows a block diagram of MC65-OpenCPU and illustrates the major functional parts.

- Radio frequency part
- Power management
- Memory
- Peripheral interfaces
  - Power supply
  - PWRKEY
  - UART interfaces
  - Audio interfaces
  - PCM interface*
  - I2C interface
  - (U)SIM interface
  - SD card interface*
  - ADC interface
  - RF interfaces

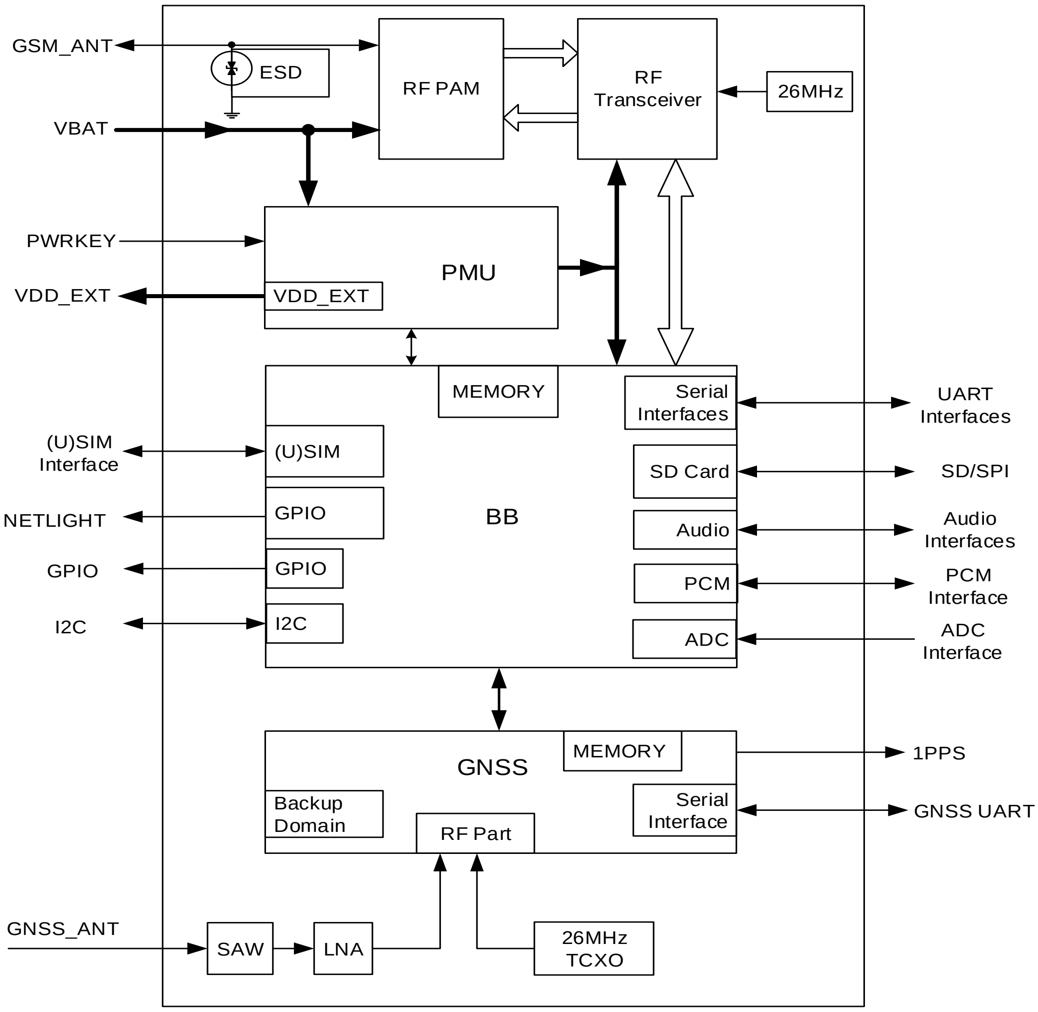



**Figure 1: Module Functional Diagram**

**NOTE**

SD Card interface and PCM interface are under development.

## 2.4. Evaluation Board

Quectel provides a complete set of development tools to facilitate the use and test of MC65-OpenCPU module. The development tool kit includes GSM-EVB Kit and MC65-OpenCPU-TE-A Kit. For more details, please refer to ***document [11]*** and ***document [15]***.

# 3 Application Interfaces

## 3.1. General Description

MC65-OpenCPU is an SMD type module with 54 LCC pads and 14 LGA pads. The subsequent chapters will provide detailed descriptions of the following functions/pins/interfaces:

- Module pin
- Power supply
- Backup domain of GNSS
- Operating modes
- Power-on/off
- Power saving
- UART interfaces
- Audio interfaces
- PCM interface*
- I2C interface
- (U)SIM interface
- SD card interface*
- ADC interface
- Behaviors of the RI
- Network status indication
- PPS VS. NMEA

**NOTE**

"*" means under development.

## 3.2. Pin Assignment

The following figure shows the pin assignment of MC65-OpenCPU.

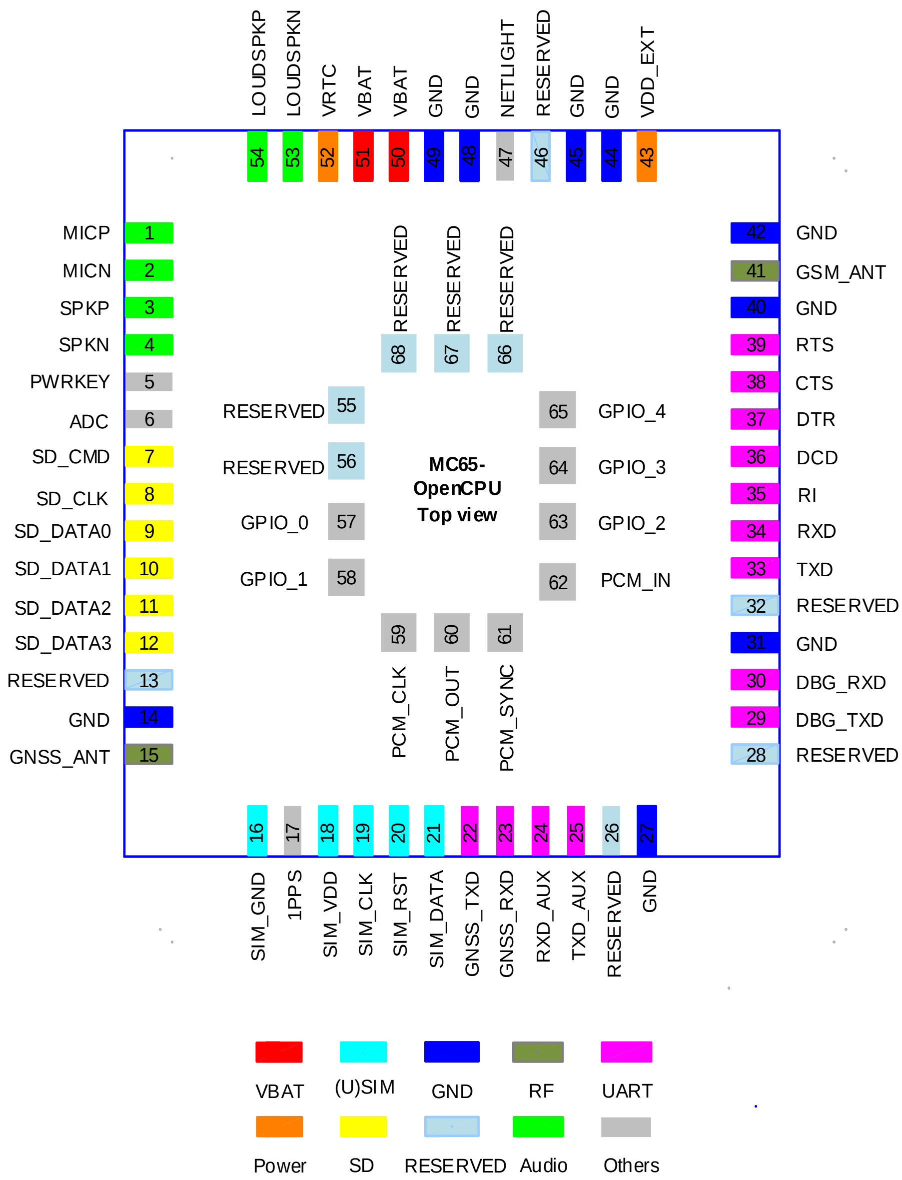



**Figure 2: Pin Assignment**

**NOTE**

Please keep all reserved pins open.

## 3.3. Pin Description

**Table 5: I/O 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 6: Pin Description**

| **Power Supply** | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| VBAT | 50, 51 | PI | Power supply of GSM/GPRS part: VBAT=3.45V~4.25V | $V_I$max=4.25V<br>$V_I$min=3.45V<br>$V_I$norm=4.0V | It must be able to be provided with sufficient current up to 1.6A in a transmitting burst. |
| VRTC | 52 | IO | Input: Power supply for GSM's RTC.<br>Output: Charging for backup battery or capacitor when the VBAT is applied. | $V_I$max=3.3V<br>$V_I$min=2.0V<br>$V_I$norm=2.8V<br>$V_O$max=3.2V<br>$V_O$min=3.0V<br>$V_O$norm=3.1V<br>Iout(max)=1.35mA<br>Iin≈25uA | Refer to ***Chapter 3.6.5*** |
| VDD_EXT | 43 | PO | Supply 2.8V voltage for external circuit. | $V_O$max=2.9V<br>$V_O$min=2.7V<br>$V_O$norm=2.8V<br>$I_O$max=20mA | If unused, keep this pin open.<br>It is recommended to add a 2.2uF~4.7uF |

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|---|---|---|---|---|---|
| | | | | | bypass capacitor, when using this pin for power supply. |
| GND | 14, 27, 31, 40, 42, 44, 45, 48, 49 | | Ground | | |

**PWRKEY**

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|---|---|---|---|---|---|
| PWRKEY | 5 | DI | Turn-on/off key. PWRKEY should be pulled down for a moment to turn on or turn off the system. | $V_{IL}$max= 0.1 × VBAT<br>$V_{IH}$min= 0.6 × VBAT<br>$V_{IH}$max=3.1V | An open collector driver circuit is recommended to control this pin. |

**Audio Interfaces**

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|---|---|---|---|---|---|
| MICP, MICN | 1, 2 | AI | Positive and negative voice input | Refer to ***Chapter 3.10*** | If unused, keep these pins open. |
| SPKP, SPKN | 3, 4 | AO | Channel 1 positive and negative voice output | | If unused, keep these pins open. Support both voice and ringtone output. |
| LOUDSPKP, LOUDSPKN | 54, 53 | AO | Channel 2 positive and negative voice output | | If unused, keep these pins open. Internally integrate an amplifier of class AB. Support both voice and ringtone output. |

**Network Status Indicator**

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|---|---|---|---|---|---|
| NETLIGHT | 47 | DO | Network status indication | $V_{OH}$min= 0.85 × VDD_EXT<br>$V_{OL}$max= 0.15 × VDD_EXT | If unused, keep this pin open. |

| Main UART Port | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| TXD | 33 | DO | Transmit data | $V_{IL}$min=0V<br>$V_{IL}$max= 0.25 × VDD_EXT<br>$V_{IH}$min= 0.75 × VDD_EXT<br>$V_{IH}$max= VDD_EXT+0.2<br>$V_{OH}$min= 0.85 × VDD_EXT<br>$V_{OL}$max= 0.15 × VDD_EXT | If only TXD, RXD and GND are used for communication, it is recommended to keep all other pins open. |
| RXD | 34 | DI | Receive data | | |
| DTR | 37 | DI | Data terminal ready | | |
| RI | 35 | DO | Ring indication | | |
| DCD | 36 | DO | Data carrier detection | | |
| CTS | 38 | DO | Clear to send | | |
| RTS | 39 | DI | Request to send | | |
| **Debug UART Port** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| DBG_TXD | 29 | DO | Transmit data | $V_{IL}$min=0V<br>$V_{IL}$max= 0.25 × VDD_EXT<br>$V_{IH}$min= 0.75 × VDD_EXT<br>$V_{IH}$max= VDD_EXT+0.2<br>$V_{OH}$min= 0.85 × VDD_EXT<br>$V_{OL}$max= 0.15 × VDD_EXT | If unused, keep these pins open. |
| DBG_RXD | 30 | DI | Receive data | | |
| **Auxiliary UART Port** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| TXD_AUX | 25 | DO | Transmit data | $V_{IL}$min=0V<br>$V_{IL}$max= 0.25 × VDD_EXT<br>$V_{IH}$min= 0.75 × VDD_EXT<br>$V_{IH}$max= VDD_EXT+0.2<br>$V_{OH}$min= 0.85 × VDD_EXT<br>$V_{OL}$max= | It is recommended to keep these pins open in **Stand-alone** solution. Refer to ***Chapter 3.9.3*** |
| RXD_AUX | 24 | DI | Receive data | | |

| | | | | | |
|---|---|---|---|---|---|
| | | | | 0.15 × VDD_EXT | |
| **GNSS UART Port** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| GNSS_TXD | 22 | DO | Transmit data | $V_{OL}$max=0.42V<br>$V_{OH}$min=2.4V<br>$V_{OH}$nom=2.8V<br>$V_{IL}$min=-0.3V<br>$V_{IL}$max=0.7V<br>$V_{IH}$min=2.1V<br>$V_{IH}$max=3.1V | Refer to ***Chapter 3.9.3*** |
| GNSS_RXD | 23 | DI | Receive data | | |
| **(U)SIM Interface** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| SIM_VDD | 18 | PO | Power supply for (U)SIM card | The voltage can be selected by software automatically. Either 1.8V or 3.0V. | All signals of (U)SIM interface should be protected against ESD with a TVS diode array.<br>Maximum trace length is 200mm from the module pad to (U)SIM card connector. |
| SIM_CLK | 19 | DO | Clock signal of (U)SIM card | $V_{OL}$max= 0.15 × SIM_VDD<br>$V_{OH}$min= 0.85 × SIM_VDD | |
| SIM_DATA | 21 | IO | Data signal of (U)SIM card | $V_{IL}$max= 0.25 × SIM_VDD<br>$V_{IH}$min= 0.75 × SIM_VDD<br>$V_{OL}$max= 0.15 × SIM_VDD<br>$V_{OH}$min= 0.85 × SIM_VDD | |
| SIM_RST | 20 | DO | Reset signal of (U)SIM card | $V_{OL}$max= 0.15 × SIM_VDD<br>$V_{OH}$min= 0.85 × SIM_VDD | |
| SIM_GND | 16 | | Specified ground for (U)SIM card | | |
| **ADC** | | | | | |
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| ADC | 6 | AI | General purpose analog to digital converter | Voltage range: 0V to 1.8V | If unused, keep this pin open. |

| Digital Audio Interface (PCM)* | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| PCM_CLK | 59 | DO | PCM clock | $V_{IL}$min= 0V<br>$V_{IL}$max= 0.25 × VDD_EXT<br>$V_{IH}$min= 0.75 × VDD_EXT<br>$V_{IH}$max= VDD_EXT+0.2<br>$V_{OH}$min= 0.85 × VDD_EXT<br>$V_{OL}$max= 0.15 × VDD_EXT | If unused, keep these pins open. |
| PCM_OUT | 60 | DO | PCM data output | | |
| PCM_SYNC | 61 | DO | PCM frame synchronization | | |
| PCM_IN | 62 | DI | PCM data input | | |

| SD Card Interface* | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| SD_CMD | 7 | DO | Command signal of SD card | $V_{IL}$min=0V<br>$V_{IL}$max= 0.25 × VDD_EXT<br>$V_{IH}$min= 0.75 × VDD_EXT<br>$V_{IH}$max= VDD_EXT+0.2<br>$V_{OH}$min= 0.85 × VDD_EXT<br>$V_{OL}$max= 0.15 × VDD_EXT | If unused, keep these pins open. |
| SD_CLK | 8 | DO | Clock signal of SD card | | |
| SD_DATA0,<br>SD_DATA1,<br>SD_DATA2,<br>SD_DATA3 | 9,<br>10,<br>11,<br>12 | IO | Data signal of SD card | | |

| Antenna Interfaces | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| GSM_ANT | 41 | IO | GSM antenna pad | | If unused, keep these pins open.<br>50Ω Impedance. |
| GNSS_ANT | 15 | AI | GNSS signal input | | |

| Other Interfaces | | | | | |
|---|---|---|---|---|---|
| **Pin Name** | **Pin No.** | **I/O** | **Description** | **DC Characteristics** | **Comment** |
| 1PPS | 17 | DO | One pulse per second | $V_{OL}$max=0.42V<br>$V_{OH}$min=2.4V<br>$V_{OH}$nom=2.8V | Synchronized at rising edge, and the pulse width is |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | 100ms.<br>If unused, keep this pin open. |
| GPIO | 57,58<br>63,64,<br>65 | IO | | $V_{OL}$max=VDD_EXT<br>$V_{OH}$min=2.0V<br>$V_{IL}$max=0.67V<br>$V_{IH}$min=1.7V<br>$V_{IH}$max=<br>VDD_EXT+0.3V | If unused, keep these pins open. |
| RESERVED | 13, 26,<br>28, 32,<br>46, 55,<br>56, 66<br>67, 68 | | | | Keep these pins open. |

**Table 7: Multiplexing Functions**

| Pin Name | Pin No. | Mode 1 (Default) | Mode 2 | Mode 3 | Mode 4 |
|---|---|---|---|---|---|
| SD_CMD | 7 | SD_CMD | GPIO | EINT | SPI_CS |
| SD_CLK | 8 | SD_CLK | GPIO | EINT | SPI_CLK |
| SD_DATA0 | 9 | SD_DATA0 | GPIO | EINT | |
| SD_DATA1 | 10 | SD_DATA1 | GPIO | EINT | SPI_MOSI |
| SD_DATA2 | 11 | SD_DATA2 | GPIO | EINT | SPI_MISO |
| SD_DATA3 | 12 | SD_DATA3 | GPIO | EINT | |
| RI | 35 | RI | GPIO | I2SCL | EINT |
| DCD | 36 | DCD | GPIO | I2SDA | EINT |
| DTR | 37 | DTR | GPIO | EINT | SIM_PRESENCE |
| CTS | 38 | CTS | GPIO | EINT | |
| RTS | 39 | RTS | GPIO | EINT | |
| NETLIGHT | 47 | NETLIGHT | GPIO | EINT | |
| PCM_CLK | 59 | PCM_CLK | GPIO | EINT | |
| PCM_OUT | 60 | PCM_OUT | GPIO | EINT | |

| | | | | |
|---|---|---|---|---|
| PCM_SYNC | 61 | PCM_SYNC | GPIO | EINT |
| PCM_IN | 62 | PCM_IN | GPIO | EINT |

## 3.4. Application Mode Introduction

MC65-OpenCPU integrates GSM and GNSS engines, both of which can work as a whole unit (**All-in-one** solution) or work independently (**Stand-alone** solution) according to customers' demands.

In **All-in-one** solution, GSM and GNSS communicate with MCU through main UART port for AT command (including AT command of GNSS function) sending, NMEA statement reading, etc.

In **Stand-alone** solution, GSM part communicates with MCU through main UART port for AT command sending, GSM data transmission, etc., while GNSS communicates with MCU through GNSS UART port, for GNSS command sending and NMEA statement output.

**All-in-one** solution and **Stand-alone** solution schematic diagrams are shown below.

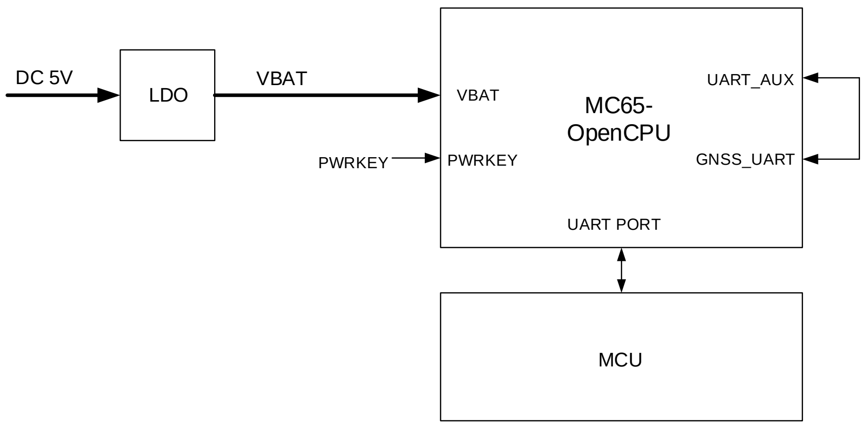



**Figure 3: Schematic Diagram of All-in-one Solution**

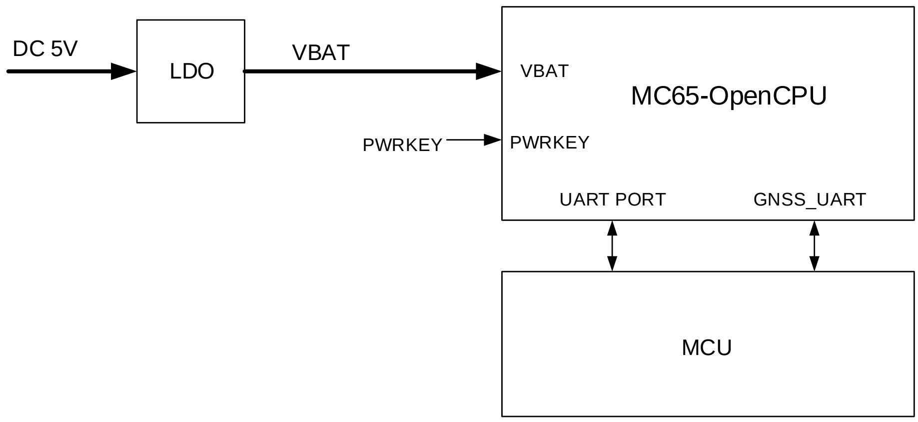



**Figure 4: Schematic Diagram of Stand-alone Solution**

**NOTE**

In **Stand-alone** solution, in order to make GNSS work normally, GSM should be kept at ON state.

**Table 8: Comparison between All-in-one and Stand-alone Solutions**

| Operations | All-in-one | Stand-alone | Remarks |
|---|---|---|---|
| Firmware upgrade | Firmware upgrade via debug UART port | Firmware upgrade via debug UART port | Refer to ***Chapter 3.9.2*** for details |
| Data transmission | Both GSM and GNSS data are transmitted through the main UART Port | GSM data is transmitted through the main UART port. GNSS data is transmitted through the GNSS UART port. | |
| GNSS's AGPS data download | AGPS data can be downloaded directly through GSM part. | MCU receives the AGPS data which is downloaded through the GSM part, and then transmit it to the GNSS part. | |

## 3.5. Flash Memory Allocation

A 32M-bit flash memory is used in the module. The flash memory allocation is shown as below.

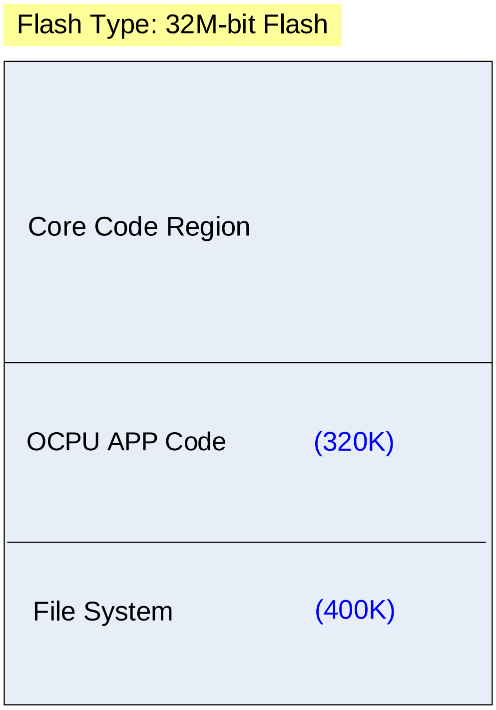



**Figure 5：Flash Memory Allocation**

320KB space is allocated for customer’s code and 400KB file system space is used to store the data (e.g. system configuration file, temporary data, image, multimedia file, etc.) related to file operation.

In addition, 100KB RAM space is reserved for the embedded application and the module provides about 500KB dynamic memory at most.

For details, please refer to ***document [16]***.

## 3.6. Power Supply

### 3.6.1. Power Features

Power supply design is very important in MC65-OpenCPU application design. Due to the 577us radio burst in GSM part every 4.615ms, the power supply must be able to deliver high current peaks in a burst period. During these peaks, drops on the supply voltage should not exceed the minimum working voltage of the GSM part.

The maximum current consumption of GSM part could reach 1.6A during a burst transmission. It will cause a large voltage drop on the VBAT. In order to ensure stable operation of the part, it is recommended that the maximum voltage drop during the burst transmission does not exceed 400mV.

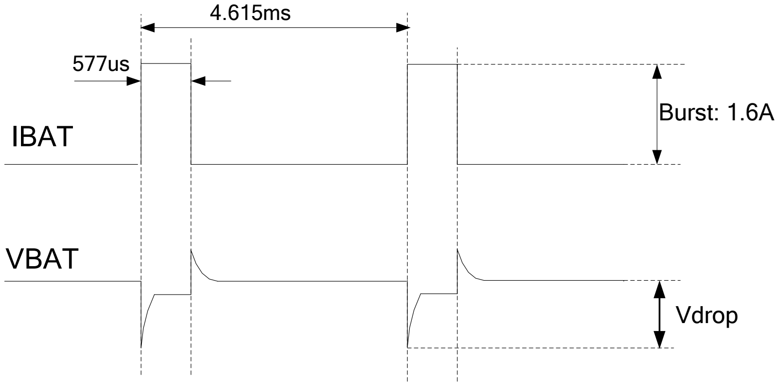



**Figure 6: Voltage Ripple during Transmitting (GSM Part)**

### 3.6.2. Decrease Supply Voltage Drop

Power supply range of MC65-OpenCPU VBAT is from 3.45V to 4.25V. Make sure that the input voltage will never drop below 3.45V even in a burst transmission. If the power voltage drops below 3.45V, the module will be turned 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 10pF near the VBAT pin. A reference circuit is illustrated in the following figure.

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

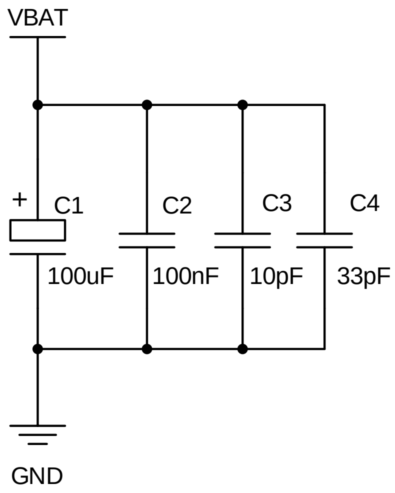



**Figure 7: Reference Circuit for VBAT Input**

### 3.6.3. Reference Design for Power Supply

The power supply of MC65-OpenCPU is capable of providing sufficient current up to 2.0A at least. If the voltage drop between the input and output is not too high, it is suggested to use an LDO as the 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 the power supply.

The following figure is the reference design for the +5V supply circuit. In this reference design, the power supply output voltage is 4.0V and the load current peak is 3.0A. In order to ensure the stability of the output voltage and prevent the surge voltage from damaging the module, it is recommended to reserve a TVS tube at the output port of the LDO and near the VBAT pin of the module.

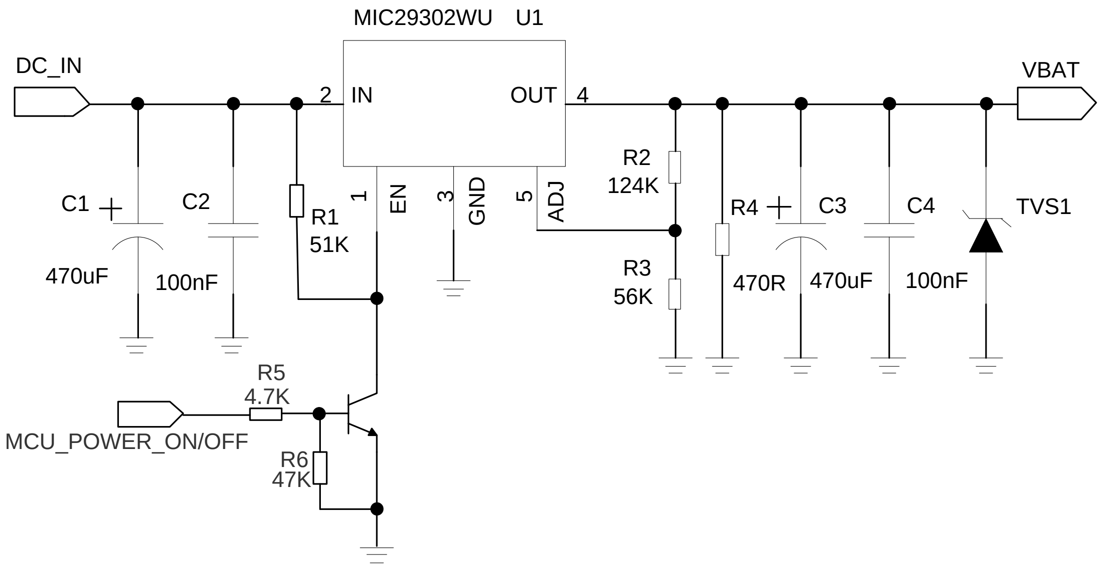



**Figure 8: Reference Circuit for Power Supply**

**NOTE**

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

### 3.6.4. Monitor Power Supply

The **AT+CBC** command can be used to monitor the supply voltage of the GSM part. The unit of the displayed voltage is mV. For details, please refer to ***document [1]***.

### 3.6.5. RTC of GSM Part

The GSM part of MC65-OpenCPU module supports the RTC function. The following are the power supply design methods of RTC.

- **Use VBAT as the RTC power supply.**

The RTC is still active when the module is turned off and VBAT is not powered down, because VBAT is still supplying power to the RTC domain of the module. In this mode, the VRTC pin can be kept open.

- **Use VRTC as the RTC power supply.**

If the power supply of VBAT is removed after the module is turned off, backup power supply such as button battery, ultra-capacitor, etc. needs to be connected to the VRTC pin to maintain the RTC.

- **Use both VBAT and VRTC as the RTC power supply.**

As only powering the VRTC pin to keep the RTC will lead an error of 1.5 minutes a day, it is recommended to power VBAT and VRTC pin at the same time when RTC function is needed.

The recommended RTC power supply design circuits are shown below:

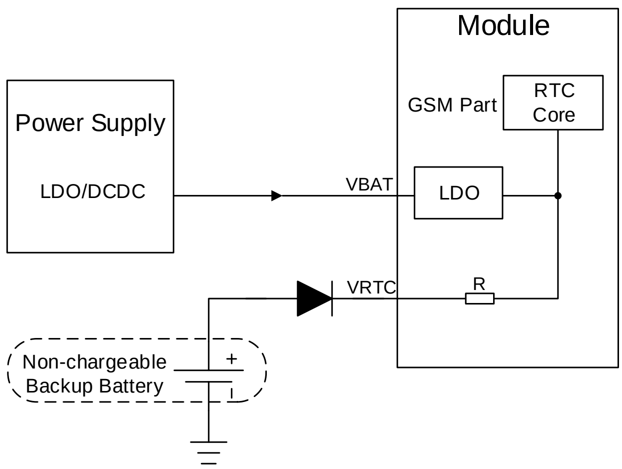



**Figure 9: VRTC Pin Powered by Non-rechargeable Battery**

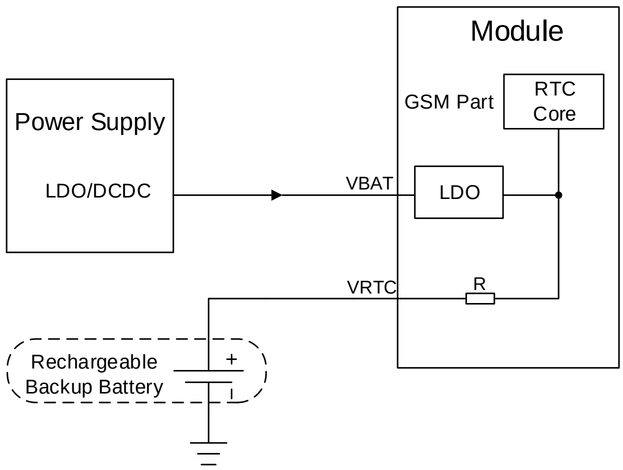



**Figure 10: VRTC Pin Powered by Rechargeable Battery**

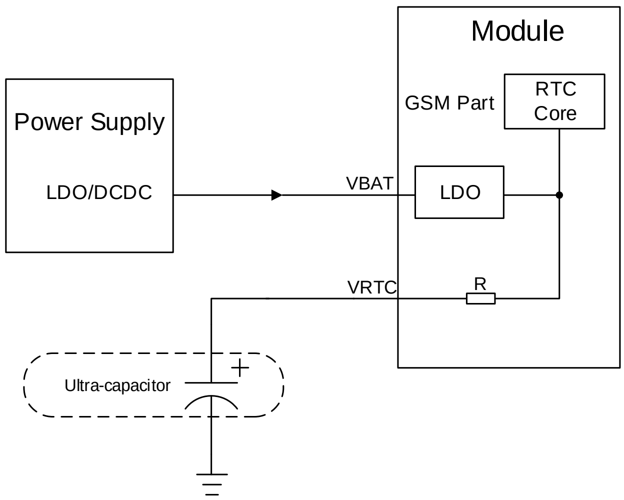



**Figure 11: VRTC Pin Powered by Ultra-capacitor**

### 3.6.6. Backup Domain of GNSS

The GNSS part of MC65-OpenCPU features a backup domain which contains all the necessary information for quick start-up and a small amount of user configuration parameters.

The backup domain of the GNSS part is powered by VBAT. Therefore, when VBAT remains powered and the GSM part is powered on, sending **AT+QGNSSC=0** command through the main UART port will make the GNSS part to enter backup mode. So in order to improve the TTFF of the module relocation, please keep the VBAT powered and the GSM part is powered on (GSM can enter the sleep state to reduce power consumption). The reference circuit block diagram is as follows:

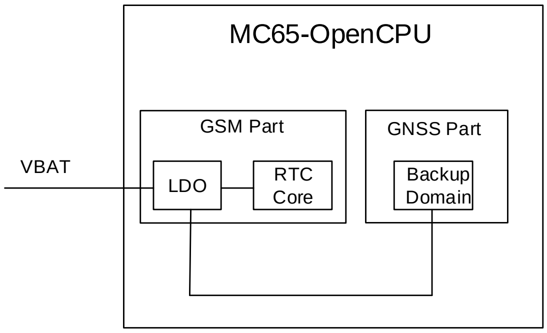



**Figure 12: Power Construction of GNSS Backup Domain**

# 3.7. Operating Modes

## 3.7.1. Operating Modes of GSM Part

The table below briefly summarizes various operating modes of GSM part mentioned in the following chapters.

**Table 9: Operating Modes of GSM Part**

| Modes | Function | |
|---|---|---|
| GSM Normal Operation | GSM/GPRS Sleep | After calling **Ql_SleepEnable()**, the GSM part of the module will automatically go into sleep mode.The CPU will be in idle mode. In this case, the current consumption of the GSM part will reduce to the minimal level. During Sleep mode, the GSM part can still receive paging message and SMS from the system normally. |
| | GSM IDLE | Software is active. The GSM part has registered on GSM network, and it 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 GSM part is not registered on GPRS network. It is not reachable through GPRS channel. |
| | GPRS READY | The PDP context is active, but no data transfer is ongoing. The GSM part is ready to receive or send GPRS data. |
| | 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 calling **Ql_PowerDown()** or using the PWRKEY pin. In shutdown mode, The UART interfaces are not accessible and software is not active |
| Minimum Functionality Mode (without removing power supply) | **AT+CFUN** command can set the GSM part to a minimum functionality mode without removing the power supply. In this case, the RF part of the GSM part 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 main UART port is still accessible. The power consumption in this case is very low. |

#### 3.7.1.1. Minimum Functionality Mode

Minimum functionality mode reduces the functionality of the GSM part 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 via 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 from both transmitting and receiving RF signals

If the GSM part is set to minimum functionality by **AT+CFUN=0**, the RF function and (U)SIM card function would be disabled. In this case, the main UART port is still accessible, but all AT commands related with RF function or (U)SIM card function will be unavailable.

If the GSM part is set by the command **AT+CFUN=4**, the RF function will be disabled, but the main UART port is still active. In this case, all AT commands related with RF function will be unavailable.

After the GSM part is set by **AT+CFUN=0** or **AT+CFUN=4**, it can return to full functionality mode by **AT+CFUN=1**.

For detailed information about **AT+CFUN**, please refer to ***document [1]***.

#### 3.7.1.2. Sleep Mode

After entering Sleep mode, the GSM part can still receive calls, SMS and GPRS data, but the serial interfaces do not work. The Sleep mode is disabled by default. The GSM part can enter and exit Sleep mode through calling the API function **Ql_SleepEnable()** and **Ql_SleepDisable()** respectively.

When the GSM part is in Sleep mode, the following methods can wake it up.

- SMS or MMS
- Incoming call or GPRS data
- External interrupts

- System timer timeout

For detailed information about API functions, please refer to the ***document [16]***.

### 3.7.2. Operating Modes of GNSS Part

#### 3.7.2.1. Full on Mode

Full on mode includes tracking mode and acquisition mode. Acquisition mode is defined as that the GNSS part starts to search satellites, and to determine the visible satellites, coarse carrier frequency & code phase of satellite signals. When the acquisition is completed, it switches to tracking mode automatically. Tracking mode is defined as that the GNSS part tracks satellites and demodulates the navigation data from specific satellites.

#### 3.7.2.2. Backup Mode

In backup mode, only the backup domain of the GNSS keeps working, other parts of the power supply are turned off, and the GNSS part will stop acquiring and tracking satellites, but the backup domain contains the necessary GNSS information (such as information for quick start and a small number of user configuration parameters). The module can quickly enter warm start or hot start mode when GNSS is started again.

The following method can make GNSS part enter backup mode:

- When VBAT is powered and GSM part is kept on, sending **AT+QGNSSC=0** command can make GNSS part enter into backup mode from full on mode.

The following method can make GNSS part exit from backup mode:

- Sending **AT+QGNSSC=1** command through the main UART port can make GNSS part immediately exit from the backup mode and enter full on mode.

**NOTE**

In order to ensure the GNSS part can work normally in backup mode, make sure the GSM part remains powered on.

## 3.8. Power-on/off Scenarios

### 3.8.1. 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.

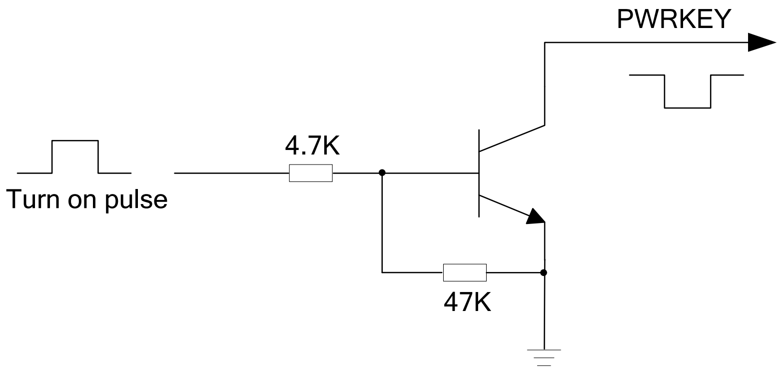



**Figure 13: Turn on the Module through an Open-collector Driver**

**NOTES**

1. MC65-OpenCPU is set to autobauding mode (**AT+IPR=0**) by default. In autobauding mode, URC **RDY** is not reported to the host controller after the module is powered on. When the module is powered on after a delay of 4s~5s, it can receive AT commands. Host controller should first send an **AT** string in order that the module can detect baud rate of host controller, and it should continue to send the next **AT** string until receiving **OK** string from the module. Then enter **AT+IPR=x;&W** to set a fixed baud rate for the module and save the configuration to flash memory of the module. After these configurations, the URC **RDY** would be received from the main 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. When AT command is responded, it indicates the 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. While pressing the key, electrostatic strike may generate from the finger, and thus, 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. A reference circuit is shown in the following figure.

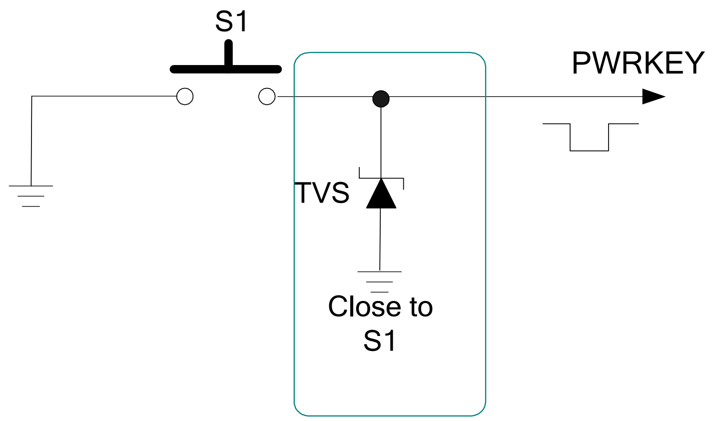



**Figure 14: Turn on the Module through a Button**

**AT+QGNSSC=1** Command should be sent to enable the GNSS power supply after the GSM part is running, and GNSS part will automatically start positioning. The power-on scenario is shown below.

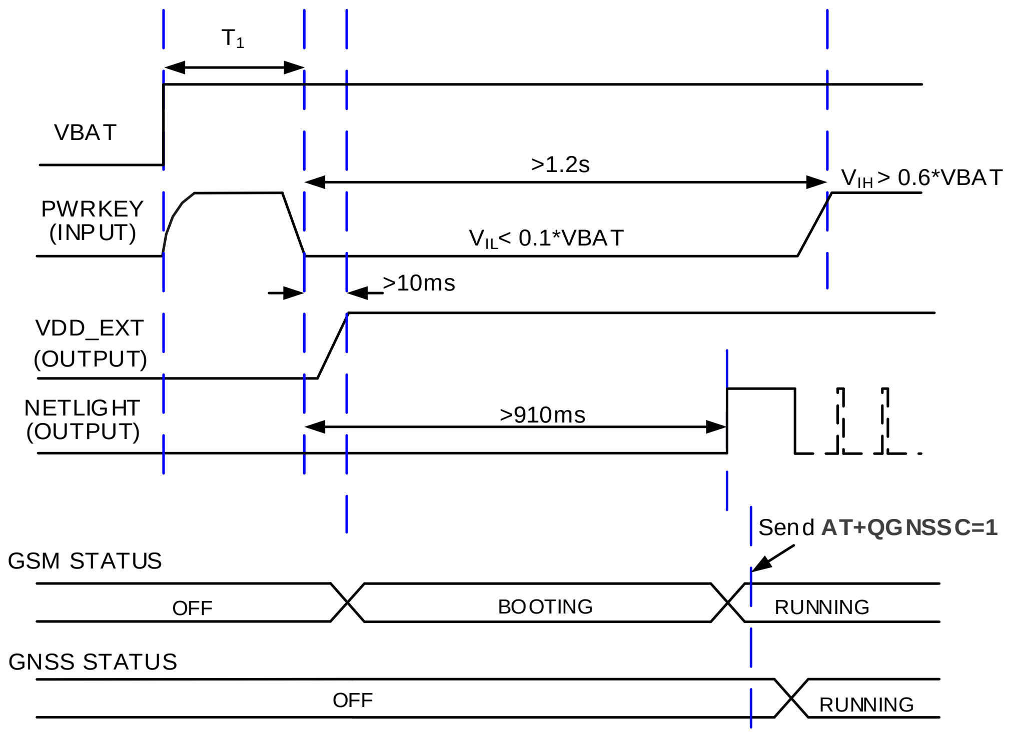



**Figure 15: Timing of Turning On the Module**

**NOTE**

Make sure the VBAT voltage is stable before pulling down the PWRKEY pin. T1 (the time between powering on VBAT and pulling off PWRKEY) is recommended to be 100ms.

### 3.8.2. Power-off

The following procedures can be used to turn off the module:

- Normal power-off procedure: Turn off module using the PWRKEY pin.
- Normal power-off procedure: Turn off module using **AT+QPOWD** command or calling API **Ql_PowerDown()**.
- Under-voltage automatic shutdown: Take effect when under-voltage is detected.

#### 3.8.2.1. Turn off the Module Using PWRKEY Pin

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

The power-off 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-off procedure, the module sends out the result code shown below:

***NORMAL POWER DOWN***

NOTES

1. When autobauding is active, this unsolicited result codes do not appear, and the DTE and DCE devices do not synchronize properly with each other when the module is boot up, so it is recommended to set the module to a fixed baud rate.
2. As network logout 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.

Then no further AT commands can be executed, and the module enters the power down mode.

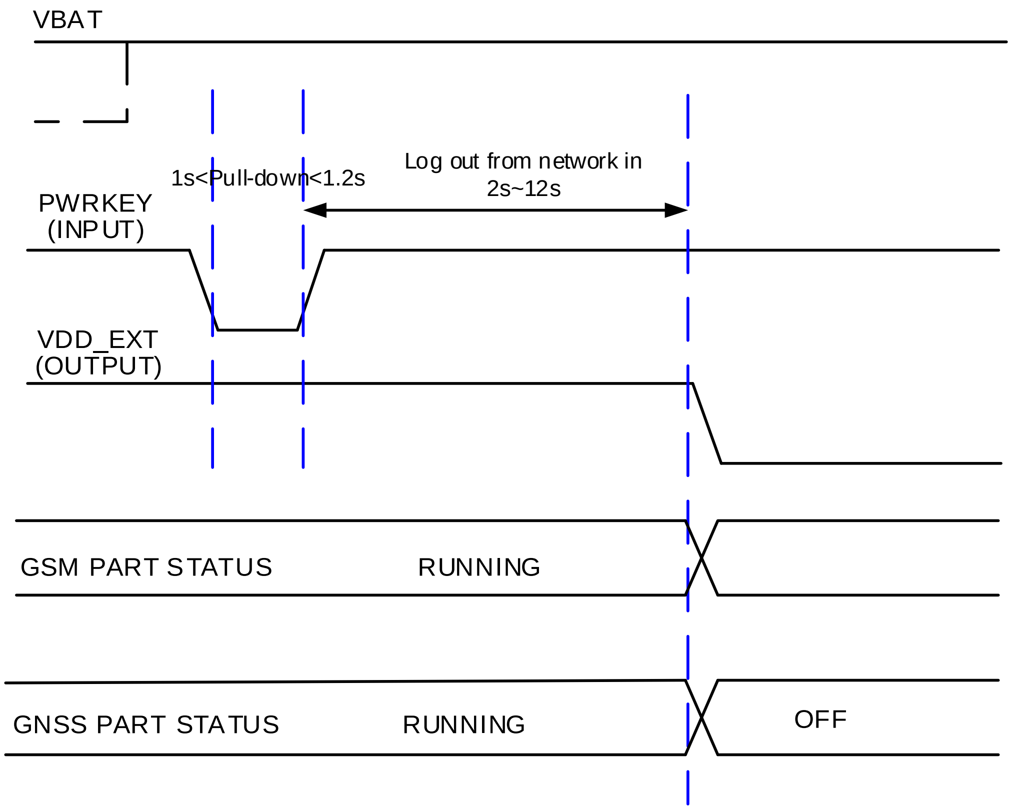



**Figure 16: Power-off Scenario by Using PWRKEY Pin**

#### 3.8.2.2. Turn off the Module Using AT Command

It is also a safe way to turn off the module via command **AT+QPOWD=1**. This command will let the module 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-off procedure, the module sends out the result code shown below:

***NORMAL POWER DOWN***

After that moment, no further AT commands can be executed. And then the module enters into power-off mode.

Please refer to ***document [1]*** for details about **AT+QPOWD** command.

#### 3.8.2.3. Turn off GNSS Part Alone Using AT Command

It is a safe way to turn off the GNSS part alone via **AT+QGNSSC=0** command. The power-off scenario of GNSS part is illustrated in the following figure.

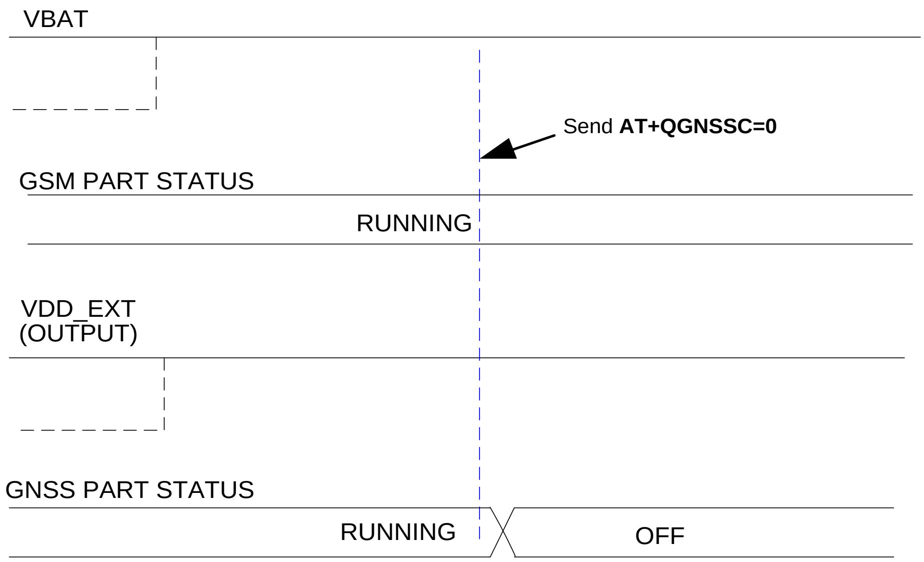



**Figure 17: Power-off Scenario of GNSS Part by Using AT Command**

#### 3.8.2.4. Under-voltage Automatic Shutdown

The module will constantly monitor the voltage applied on the VBAT. If the voltage is ≤3.55V, the following URC will be presented:

***UNDER_VOLTAGE WARNING***

The normal input voltage range is from 3.45V to 4.25V. If the voltage is <3.45V, the module will automatically shut down.

**NOTE**

When unsolicited result codes do not appear when autobauding is active and DTE & DCE are not correctly synchronized after start-up, the module is recommended to be set to a fixed baud rate.

### 3.8.3. Recommended Turn-on Structure for OpenCPU System

In order to ensure the stability of OpenCPU system, it is suggested to use a low-power MCU to monitor the status of the module. The MCU should possess several GPIOs and one ADC interface. The system structure is shown in the figure below. This structure possesses two advantages:

- When the VBAT voltage detected by ADC is too low, the MCU will turn off the module by controlling PWRKEY pin and switch off power supply by controlling the PMOS transistor.

- Normally, the module outputs periodic pulse to the MCU. If the MCU does not detect the pulse within the stipulated time, the MCU will switch off VBAT and then turn on the module again.

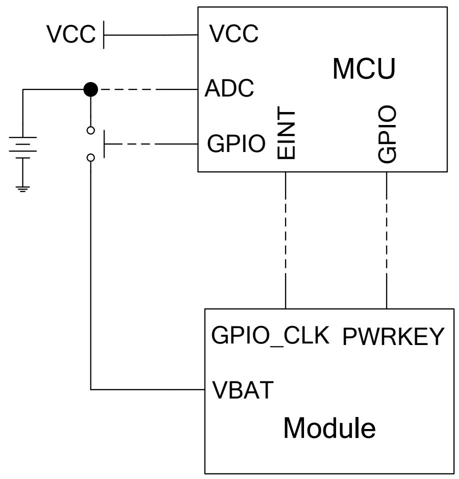



**Figure 18: Recommended Turn-on Structure for OpenCPU System**

Furthermore, a watchdog component can also be used to control the power of module. A watchdog component with timeout of 1.6s at least should be used, for instance, TI's TPS3823-33DBVR. One GPIO of the module should be connected to the WDI pin of the watchdog and change the voltage level of the WDI pin timely. If timeout occurs, the watchdog will switch off the power of module. For detailed information about watchdog, please refer to ***document [17]***.

The sketch map for watchdog is shown as below:

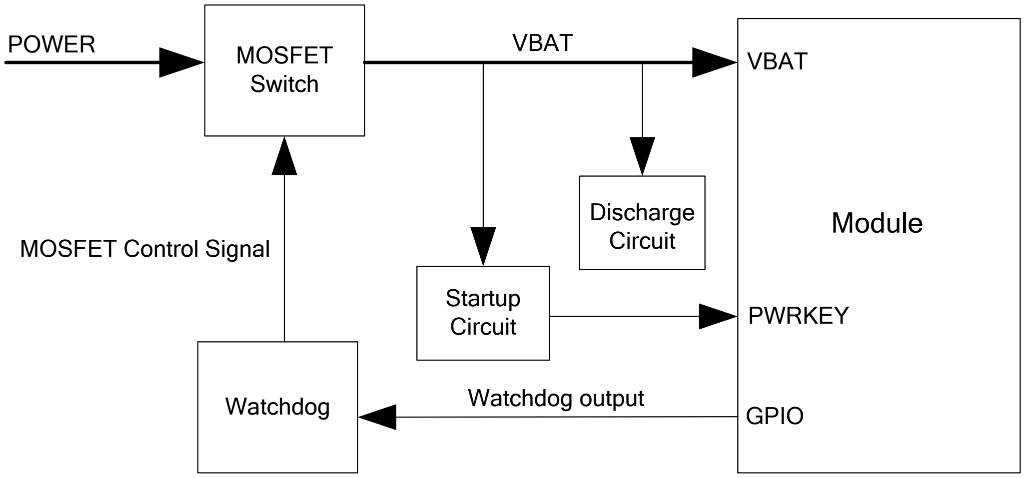



**Figure 19: Sketch Map for Watchdog**

## 3.9. UART Interfaces

The module provides four UART interfaces: main UART port, debug UART port, auxiliary UART port and GNSS UART port. The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. Autobauding function supports baud rates from 4800bps to 115200bps.

The Main UART Port:

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

The Debug UART Port:

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

The Auxiliary UART Port:

- In **All-in-one** solution:

TXD_AUX: Send data to the GNSS part.
RXD_AUX: Receive data from the GNSS part.

- In **Stand-alone** solution:

TXD_AUX: Be kept open.
RXD_AUX: Be kept open.

The GNSS UART Port:

- In **All-in-one** solution:

GNSS_TXD: Send data to the GSM part.
GNSS_RXD: Receive data from the GSM part.

- In **Stand-alone** solution:

GNSS_TXD: Send GNSS data to the COM port of peripheral.
GNSS_RXD: Receive GNSS data from the COM port of peripheral.

The logic levels are described in the following table.

**Table 10: 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 11: Pin Definition of UART Interfaces**

| Interface | Pin Name | Pin No. | I/O | Description |
|---|---|---|---|---|
| Main UART Port | TXD | 33 | DO | Transmit data |
| | RXD | 34 | DI | Receive data |

| | | | | |
|---|---|---|---|---|
| | DTR [2)] | 37 | DI | Data terminal ready |
| | RI [2)] | 35 | DO | Ring indication |
| | DCD [2)] | 36 | DO | Data carrier detection |
| | CTS [2)] | 38 | DO | Clear to send |
| | RTS [2)] | 39 | DI | Request to send |
| Debug UART Port | DBG_RXD | 30 | DI | Receive data |
| | DBG_TXD | 29 | DO | Transmit data |
| Auxiliary UART Port [1)] | RXD_AUX [1)] | 24 | DI | Receive data |
| | TXD_AUX [1)] | 25 | DO | Transmit data |
| GNSS UART Port | GNSS_RXD | 23 | DI | Receive data |
| | GNSS_TXD | 22 | DO | Transmit data |

**NOTES**

1. [1)] It is recommended to keep these pins open in **Stand-alone** solution.
2. [2)] These pins can be multiplexed as GPIOs. As to GPIO, please refer to ***Chapter 3.17***.

The main UART port related functions are listed as follows:

- **Ql_UART_Register**: register a callback for the specified serial port
- **Ql_UART_Open**: open the specified serial port
- **Ql_UART_Write**: send data to the specified serial port
- **Ql_UART_Read**: read data from the specified serial port
- **Ql_UART_SetDCBConfig**: set DCB of serial port
- **EVENT_UART_READY_TO_READ**: read indication when data comes

For more details about the software design, please refer to the ***document [16]***.

### 3.9.1. Main UART Port

#### 3.9.1.1. Features of Main UART Port

- Seven-wire UART interface
- Contain data lines TXD and RXD, hardware flow control lines RTS and CTS, as well as other control

lines DTR, DCD and RI.

- Used for AT command sending, GPRS data transmission, etc. Multiplexing function is supported on the main UART port. And NMEA output can be supported in **All-in-one** solution.
- Support the following communication baud rates: 300bps, 600bps, 1200bps, 2400bps, 4800bps, 9600bps, 14400bps, 19200bps, 28800bps, 38400bps, 57600bps, 115200bps.
- The default setting is autobauding mode. The default baud rate is 115200.
- Hardware flow control is disabled by default. When hardware flow control is required, RTS and CTS should be connected to the host. Calling Ql_UART_Open to enable or disable hardware flow control. For more details, please refer to ***document [16]***.

#### 3.9.1.2. The Connection of UART

The connection between the module and the host using main UART port is very flexible. The following are three common connection methods.

A reference design for full-function UART connection is shown as below when it is applied in modulation-demodulation.

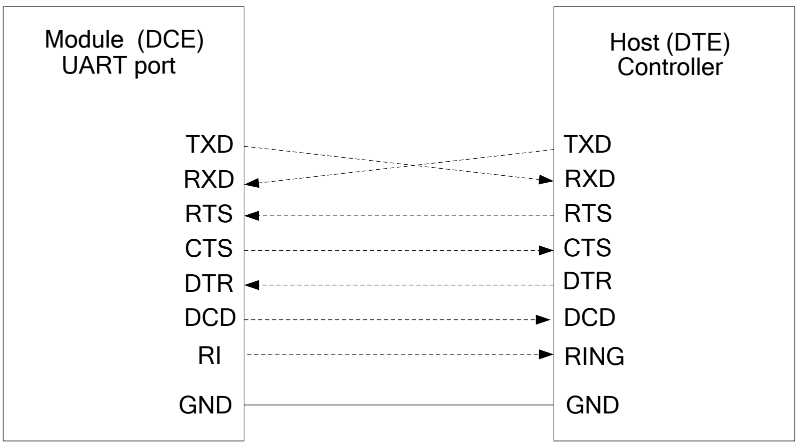



**Figure 18: Reference Design for Full-Function UART**

Three-wire connection is shown as below.

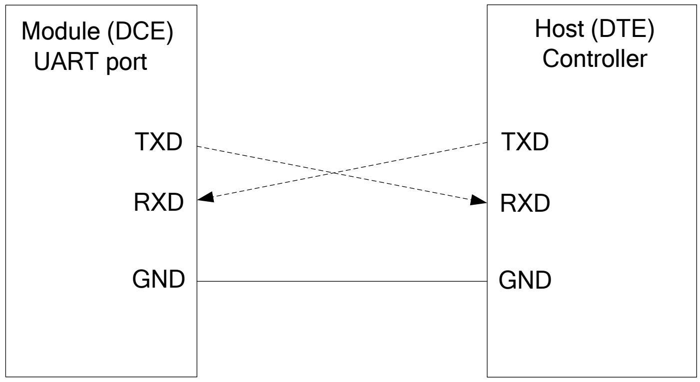



**Figure 19: Reference Design for Main UART Port (Three-wire Connection)**

A reference design for main UART port with hardware flow control is shown as below. The connection will enhance the reliability of the mass data communication.

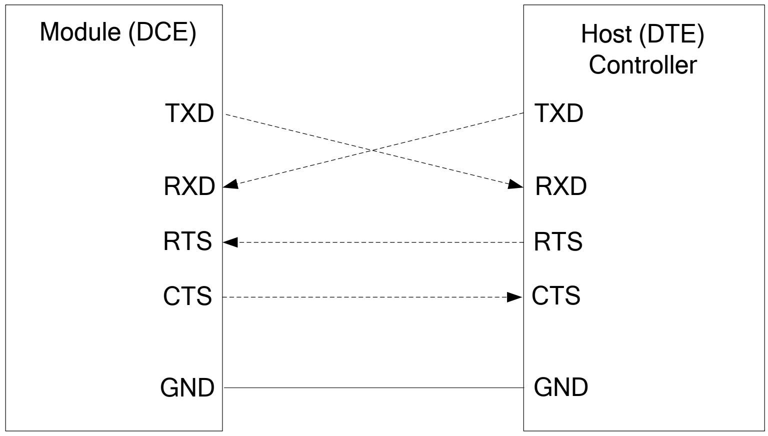



**Figure 20: Reference Design for UART Port with Hardware Flow Control**

### 3.9.2. Debug UART Port

- Two lines: DBG_TXD and DBG_RXD.
- Debug UART port outputs log information automatically.
- Debug UART port can be used for firmware debugging, and its baud rate must be configured as 921600bps.
- Debug UART port can be used for firmware download and upgrade.

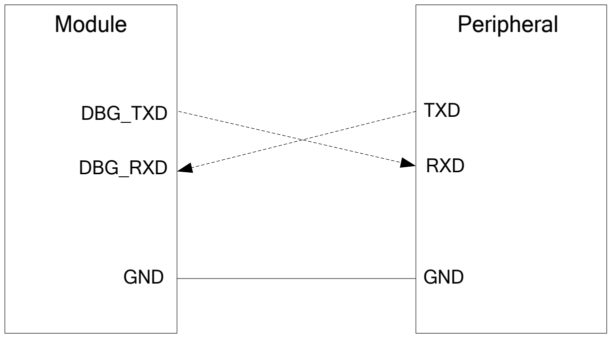



**Figure 21: Reference Design for Debug UART Port**

#### 3.9.2.1. Firmware Upgrade

MC65-OpenCPU module upgrades firmware through debug UART port. During the upgrade, the PWRKEY pin must be pulled down. The reference circuit is shown as the following figure:

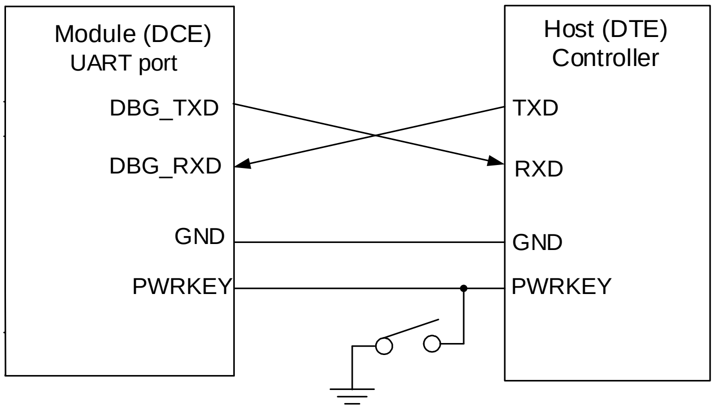



**Figure 22: Reference Design for Firmware Upgrade**

**NOTES**

It is recommended to keep these pins on the host because module firmware may need to be upgraded for some reasons.

### 3.9.3. Auxiliary UART Port and GNSS UART Port

#### 3.9.3.1. Connection in All-in-one Solution

In **All-in-one** solution, the auxiliary UART port and GNSS UART port should be connected together, thus allowing for communication between GSM and GNSS parts. A reference design is shown below.

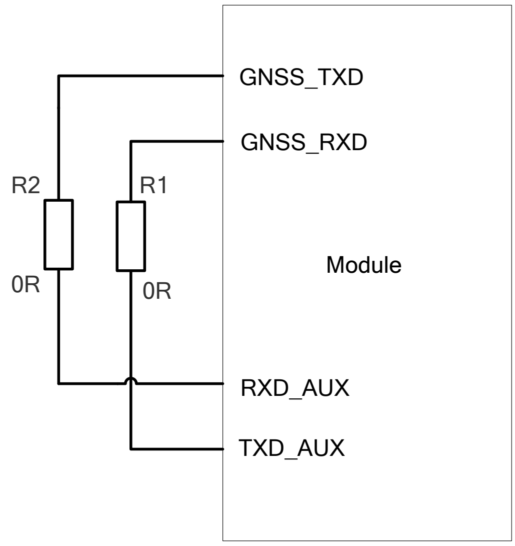



**Figure 23: Auxiliary and GNSS UART Port Connection in All-in-one Solution**

#### 3.9.3.2. Connection in Stand-alone Solution

In **Stand-alone** solution, the GNSS UART port is connected to the COM port of peripheral. The auxiliary UART port should be kept open. The reference design is shown below.

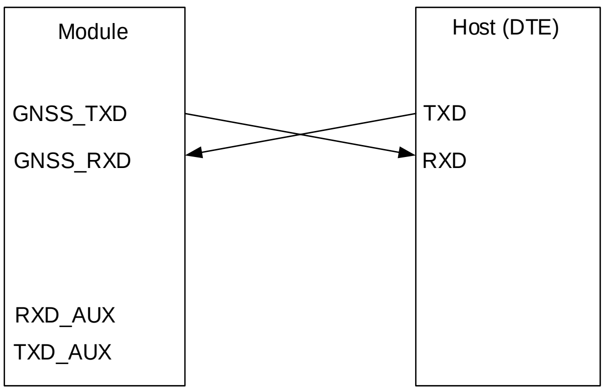



**Figure 24: Auxiliary and GNSS UART Ports Connection in Stand-alone Solution**

### 3.9.4. UART Application

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

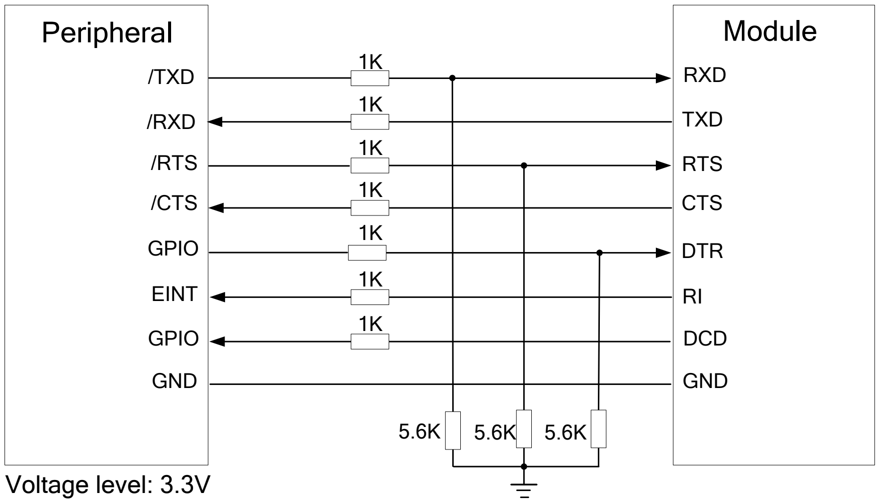



**Figure 25: Level Match Design for 3.3V System**

**NOTE**

It is highly recommended to add the resistor divider circuit on the UART signal lines when the host's level is 3V or 3.3V. For a higher voltage level system, a level shifter IC could be used between the host and the module. For more details about UART circuit design, please refer to ***document [10]***.

The following figure shows a sketch map between the module and the standard RS-232 interface. As the electrical level of the module is 2.8V, a RS-232 level shifter should be used. Please ensure the I/O voltage of level shifter which connects to the module is 2.8V.

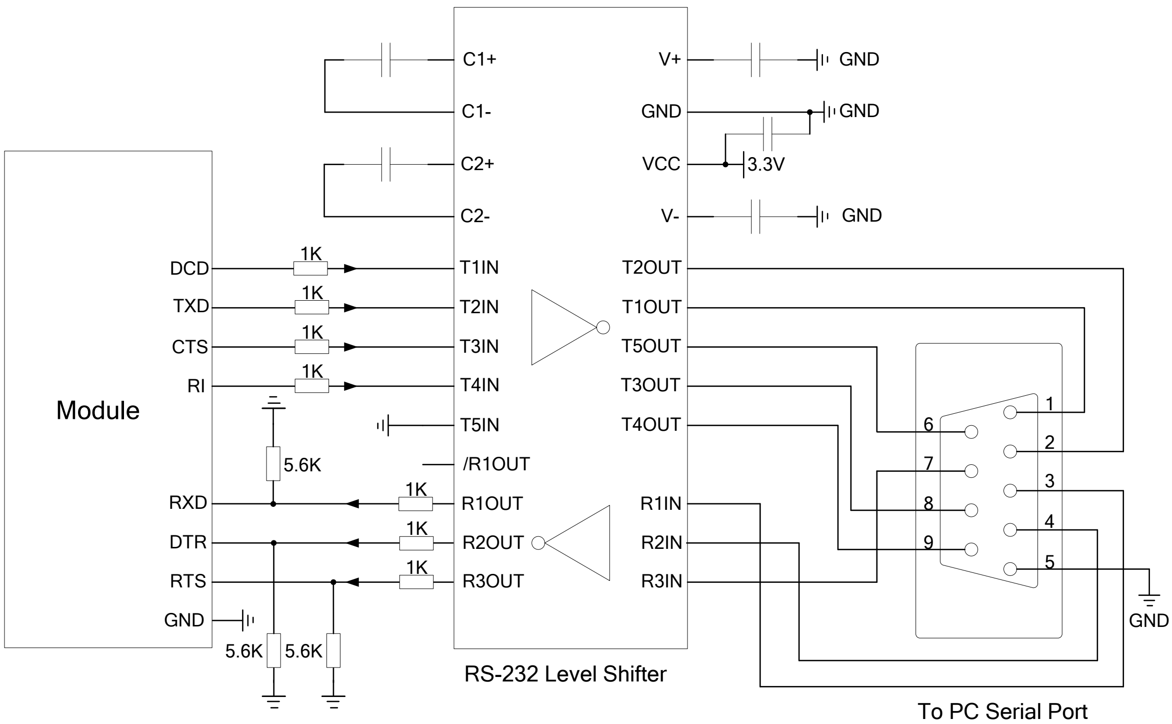



**Figure 26: Reference Circuit for RS-232 Level Shifter**

Please visit vendors' websites to select a suitable IC, such as: http://www.maximintegrated.com and http://www.exar.com.

## 3.10. Audio Interfaces

The module provides one analog input channel and two analog output channels.

**Table 12: Pin Definition of Audio Interfaces**

| Interface | Pin Name | Pin No. | I/O | Description |
|---|---|---|---|---|
| AIN/AOUT1 | MICP | 1 | AI | Microphone positive input |
| | MICN | 2 | | Microphone negative input |
| | SPKP | 3 | AO | Channel 1 Audio positive output |
| | SPKN | 4 | | Channel 1 Audio negative output |
| AIN/AOUT2 | MICP | 1 | AI | Microphone positive input |

| | | | | |
|---|---|---|---|---|
| | MICN | 2 | | Microphone negative input |
| | LOUDSPKP | 54 | AO | Channel 2 Audio positive output |
| | LOUDSPKN | 53 | | Channel 2 Audio negative output |

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

AOUT1 is used for output of receiver. The channel is typically used for handset. AOUT1 channel is a differential channel.

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

All these 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+QAUDCH** command to select audio channel:

- **AT+QAUDCH=0**: AIN/AOUT1, the default value is 0.
- **AT+QAUDCH=2**: AIN/AOUT2, this channel is always used for loudspeaker.

For each channel, customers can use **AT+QMIC** to adjust the input gain level of microphone. Customers 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 13: AOUT2 Output Characteristics**

| Item | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| RMS Power | 8Ω load<br>VBAT=3.7V<br>THD+N=1% | | 800 | | mW |

### 3.10.1. Decrease TDD Noise and Other Noises

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 900MHz RF interference when the module is transmitting at EGSM900MHz. Without placing this capacitor, TDD noise could be heard. The 10pF capacitor is used for filtering out 1800MHz RF interference. 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 capacitors for filtering out GSM850MHz, EGSM900MHz, DCS1800MHz and

PCS1900MHz interference 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, EGSM900 TDD noise is more severe; while in other cases, DCS1800 TDD noise is more obvious. Therefore, customers can choose a suitable capacitor based on the 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 interface, and the audio trace 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 trace. The power trace could not be parallel with the audio trace, and should be far away from it.

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

### 3.10.2. Microphone Interface Design

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

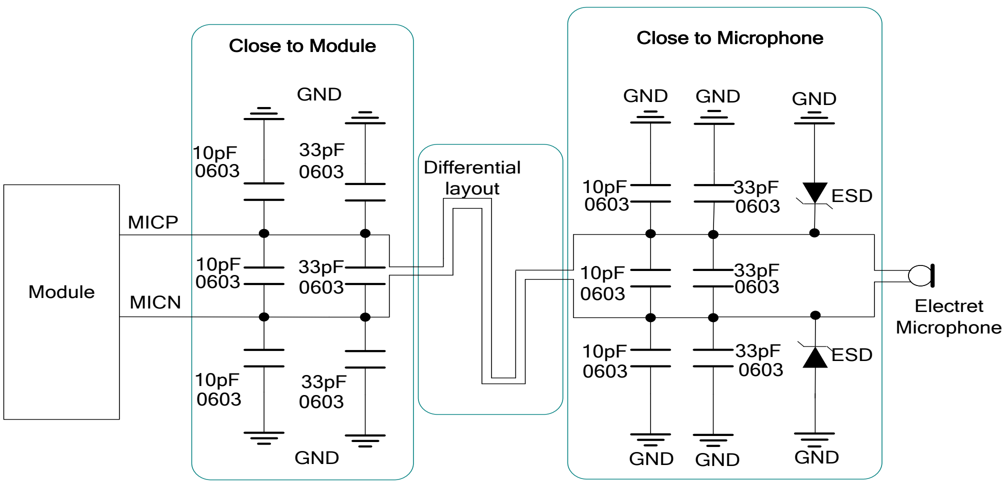



**Figure 27: Reference Design for Microphone**

### 3.10.3. Speaker Interface Design

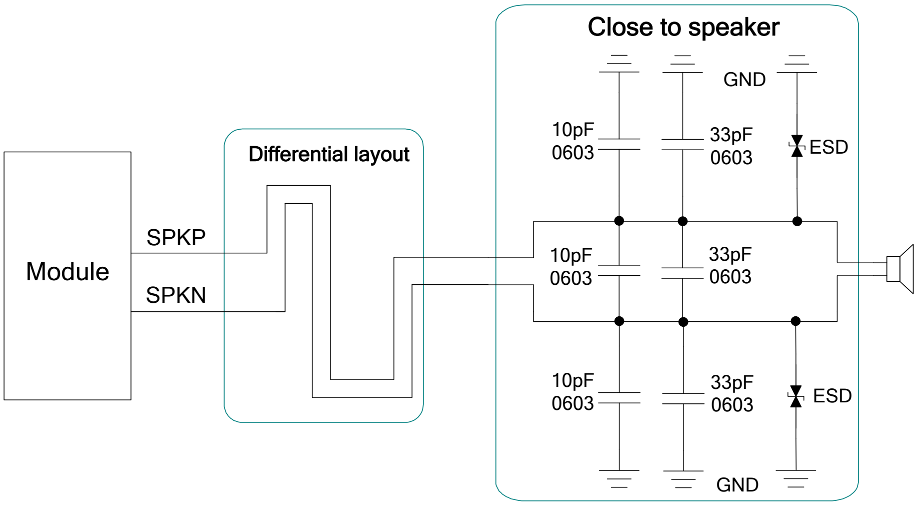



**Figure 28: Reference Design for Speaker**

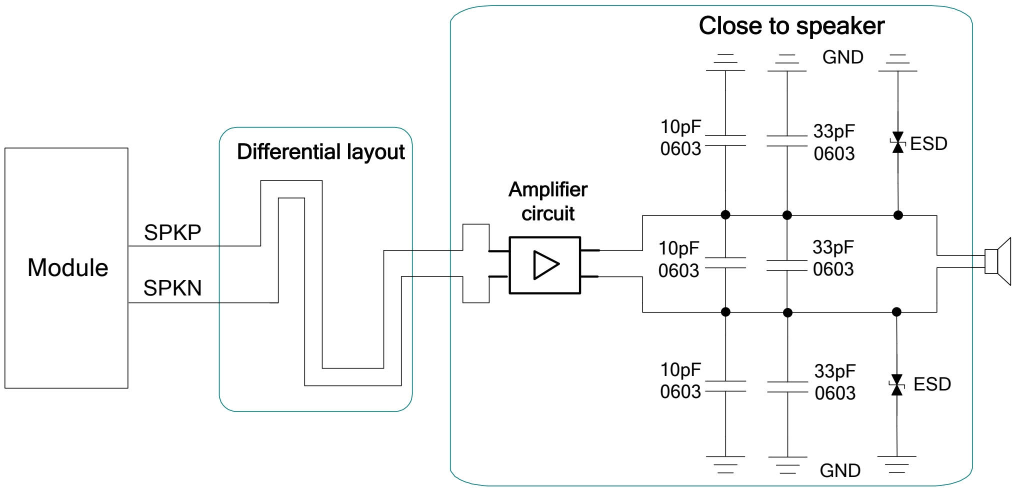



**Figure 29: Reference Design for Speaker with an Amplifier**

A suitable differential audio amplifier can be chosen from the Texas Instrument's website (http://www.ti.com).

### 3.10.4. Loudspeaker Interface Design

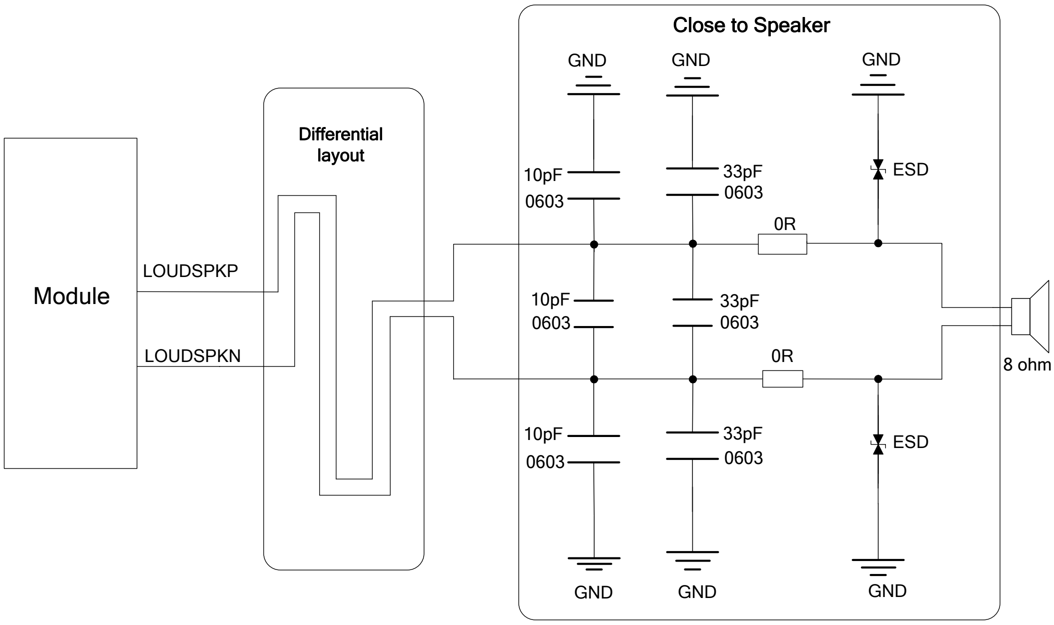



**Figure 30: Reference Design for Loudspeaker**

### 3.10.5. Audio Characteristics

**Table 14: Typical Electret Microphone Characteristics**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Working Voltage | 1.8 | 2 | 2.4 | V |
| Working Current | | | 1000 | uA |
| External Microphone Load Resistance | | 2 | | kΩ |

**Table 15: Typical Speaker Characteristics**

| Parameter | | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| AOUT1 Output | Differential | Load resistance | | 32 | | Ω |
| | | Reference level | 0 | | 3.7 | Vpp |
| AOUT2 | Differential | Load resistance | | 8 | | Ω |

| | | | | |
|---|---|---|---|---|
| Output | Reference level | 0 | 5.6 | Vpp |

## 3.11. PCM Interface*

TBD。

**NOTE**

"*" means under development.

## 3.12. SPI and I2C Interfaces

### 3.12.1. SPI Interface

The SPI interface is multiplexed from SD card interface. SPI interface of MC65-OpenCPU module acts as the master only. It provides a duplex, synchronous and serial communication link with the peripheral devices. Its operation voltage is 2.8V, with clock rates up to 35MHz. Main features of the SPI interface are listed below.

- Support master mode operation
- Adjustable clock speed
- Serial clock with programmable polarity and phase

The logic levels of SPI interfaces are described in the following table.

**Table 16: Logic Levels of the SPI Interface**

| 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 17: Pin Definition of the SPI Interface**

| Pin No. | Pin Name | I/O | Description | Alternate Function [1)] |
|---|---|---|---|---|
| 10 | SPI_MOSI | DO | Master output, Slave input of SPI interface | SD_DATA1 |
| 8 | SPI_CLK | DI | Clock signal of SPI interface | SD_CLK |
| 11 | SPI_MISO | DO | Master input, Slave output of SPI interface | SD_DATA2 |
| 7 | SPI_CS | DO | Chip select of SPI interface | SD_CMD |

**NOTE**

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

The MC65-OpenCPU SPI must be configured as the master. The API functions of the file system can be used to read/write SPI. For detailed information about the software design, please refer to the ***document [16]***.

### 3.12.2. I2C Interface

I2C is a two-wire serial interface which is multiplexed from RI and DCD pins. The two signals are SCL and SDA. Main features of the I2C interface are listed below.

- Support master mode operation
- Support 7-bit addressing
- Support rates of 100KHz and 400KHz

**Table 18: Logic Levels of the I2C Interface**

| 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 19: Pin Definition of the I2C Interface**

| Pin No. | Pin Name | I/O | Description | Comment | Alternate Function [1)] |
|---|---|---|---|---|---|
| 35 | I2C_SCL | DO | I2C serial clock | Require external pull-up resistor | RI |
| 36 | I2C_SDA | DO | I2C serial data | | DCD |

**NOTE**

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

The API functions of the file system can be used to read/write I2C. For detailed information about the software design, please refer to the ***document [16]***.

## 3.13. (U)SIM Interface

MC65-OpenCPU's (U)SIM interface circuitry meets GSM Phase 1 and GSM Phase 2+ specifications, and supports FAST 64kbps (U)SIM card (intended for use with a (U)SIM application tool-kit).

The (U)SIM card is powered by an internal regulator in the module. Both 1.8V/3.0V (U)SIM cards and Single SIM Single Standby function are supported.

**Table 20: Pin Definition of (U)SIM Interface**

| Pin Name | Pin No. | I/O | Description | Multiplexing Function [1)] |
|---|---|---|---|---|
| SIM_VDD | 18 | PO | Supply power for (U)SIM card.<br>Automatic detection of (U)SIM card voltage.<br>Voltage accuracy: 3.0V±5% and 1.8V±5%.<br>Maximum supply current is around 10mA. | |
| SIM_CLK | 19 | DO | Clock signal of (U)SIM card | |
| SIM_DATA | 21 | IO | Data signal of (U)SIM card | |
| SIM_RST | 20 | DO | Reset signal of (U)SIM card | |
| SIM_PRESENCE | 37 | DI | (U)SIM card insertion detection | DTR |
| SIM_GND | 16 | | Specified ground for (U)SIM card | |

**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 shows a reference design for (U)SIM interface with an 8-pin (U)SIM card connector.

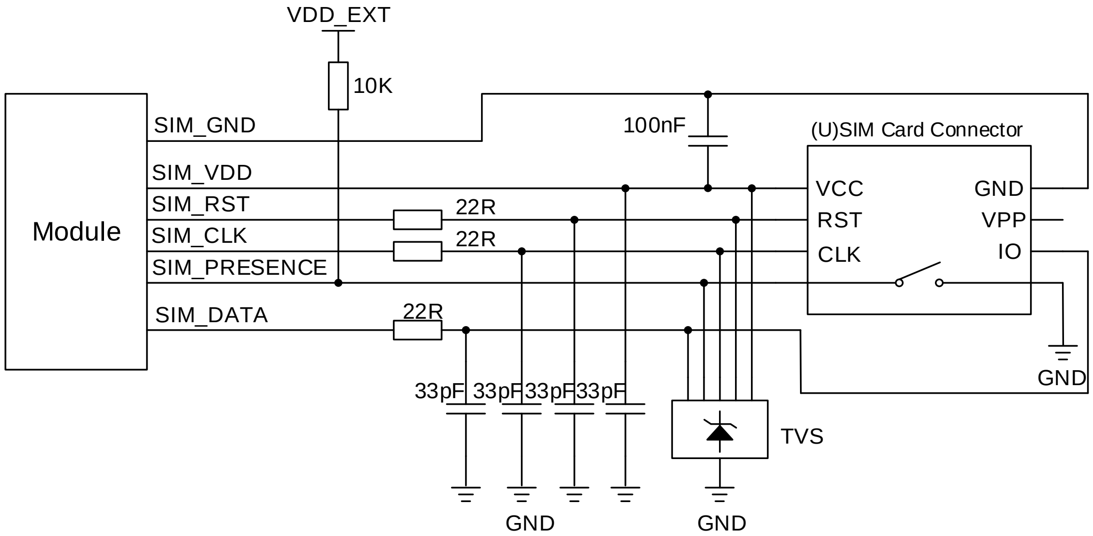



**Figure 31: Reference Circuit for (U)SIM Interface with an 8-Pin (U)SIM Card Connector**

If (U)SIM card insertion detection function is not used, keep pin SIM_PRESENCE unconnected. A reference circuit for (U)SIM interface with a 6-pin (U)SIM card connector is illustrated in the following figure.

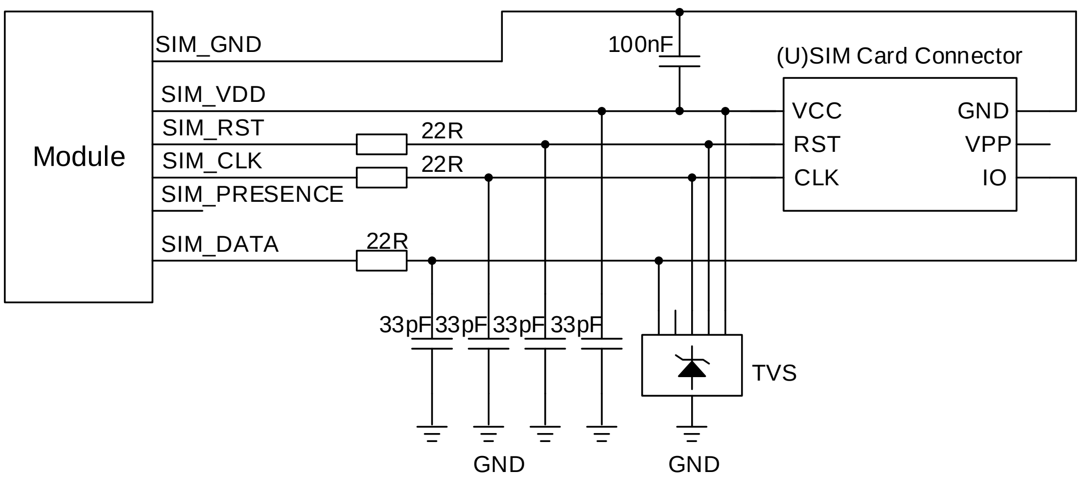



**Figure 32: Reference Circuit for (U)SIM Interface with a 6-Pin (U)SIM Card Connector**

In order to enhance the reliability and availability of the (U)SIM card in applications, please follow the criteria below in (U)SIM circuit design:

- Keep the placement of (U)SIM card connector as close as possible to the module. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and VBAT traces.
- Ensure the trace between the ground of module and (U)SIM card connector short and wide. Keep the trace width of ground no less than 0.5mm to maintain the same electric potential. The decoupling capacitor between SIM_VDD and GND should be no more than 1μF and be placed close to the (U)SIM card connector.
- To avoid cross talk between SIM_DATA and SIM_CLK, keep them away from each other and shield them separately with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array whose parasitic capacitance should be no more than 50pF. The ESD protection device should be placed as close to (U)SIM card connector as possible, and make sure the (U)SIM card signal lines go through the ESD protection device first from (U)SIM card connector and then to the module. The 22Ω resistors should be connected in series between the module and the (U)SIM card connector so as to suppress EMI spurious transmission and enhance ESD protection. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on SIM_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

## 3.14. SD Card Interface*

TBD

**NOTE**

"*" means under development.

## 3.15. ADC

The module provides an ADC input channel to measure the value of voltage. The API function **Ql_ADC_Read** can be used to read the voltage value from ADC input channel. For detailed information about the software design, please refer to the ***document [16]***.

**Table 21: Pin Definition of ADC Interface**

| Pin Name | Pin No. | I/O | Description |
|---|---|---|---|
| ADC | 6 | AI | Analog-to-digital converter |

## 3.16. External Interrupt

All MC65-OpenCPU pins that can be multiplexed as GPIO function have external interrupt function. External interrupts are multiplexing functions. When the default function of the pin is not used, it can be configured as an external interrupt.

## 3.17. GPIO

MC65-OpenCPU provides 21 GPIOs in all. In order to reduce the pin number, GPIO is multiplexed with other functions. When pin's default function is not used, it can be configured as GPIO. API functions, such as **Ql_GPIO_Init**, **Ql_GPIO_SetLevel**, **Ql_GPIO_SetDirection**, **Ql_GPIO_SetPullSelection**, can be used for GPIO configuration. For detailed information about the software design, please refer to the ***document [16]***.

**Table 22：Pin List for GPIO**

| Pin Name | Pin Name | Mode | Reset | | Output Driving |
|---|---|---|---|---|---|
| | | | I/O | PU/PD | |
| 7 | SD_CMD[2)] | Mode 2 | I | PU | 4mA |
| 8 | SD_CLK[1)] | Mode 2 | LO | / | 4mA |
| 9 | SD_DATA0[2)] | Mode 2 | I | PU | 4mA |
| 10 | SD_DATA1[2)] | Mode 2 | I | PU | 4mA |
| 11 | SD_DATA2[2)] | Mode 2 | I | PU | 4mA |
| 12 | SD_DATA3[2)] | Mode 2 | I | PU | 4mA |
| 35 | RI | Mode 2 | I | PD | 4mA |
| 36 | DCD | Mode 2 | I | PD | 4mA |

| | | | | | |
|---|---|---|---|---|---|
| 37 | DTR | Mode 2 | I | PD | 4mA |
| 38 | CTS | Mode 2 | I | PU | 4mA |
| 39 | RTS | Mode 2 | I | PU | 4mA |
| 47 | NETLIGHT | Mode 2 | I | PD | 4mA |
| 57 | GPIO_0 | Mode 1 | I | PD | 4mA |
| 58 | GPIO_1 | Mode 1 | I | PD | 4mA |
| 59 | PCM_CLK[2)] | Mode 2 | HO | / | 4mA |
| 60 | PCM_OUT[2)] | Mode 2 | LO | PD | 4mA |
| 61 | PCM_SYNC[2)] | Mode 2 | HO | / | 4mA |
| 62 | PCM_IN[2)] | Mode 2 | HO | / | 4mA |
| 63 | GPIO_2 | Mode 1 | I | PD | 4mA |
| 64 | GPIO_3 | Mode 1 | I | PD | 4mA |
| 65 | GPIO_4 | Mode 1 | I | PD | 4mA |

**NOTE**

1. [1)] The level of SD_CLK pin is unstable when module is powered up for about 200ms.
2. [2)] There is a 1.9V level transition of these pins from power-up to software running for a duration of about 200ms.

## 3.18. Behaviors of RI

**Table 23: Behaviors of RI**

| State | RI Response |
|---|---|
| Standby | HIGH |
| Voice Call | Change to LOW, and then:<br>● Change to HIGH when call is established.<br>● Change to HIGH when use ATH to hang up the call.<br>● Change to HIGH first when calling party hangs up and then change to LOW for |

| | |
|---|---|
| | 120ms indicating "NO CARRIER" as an URC. After that, RI changes to HIGH again.<br>● Change to HIGH when SMS is received. |
| SMS | When a new SMS comes, the RI changes to LOW and maintains low level for about 120ms, and then changes to HIGH. |
| URC | When a specific URC is reported, the RI is triggered to be pulled down by 120ms. For more details, please refer to ***document [1]***. |

If the module is used as a caller, the RI would maintain high except when the URC or SMS is received. When it is used as a receiver, the timing of RI is shown below.

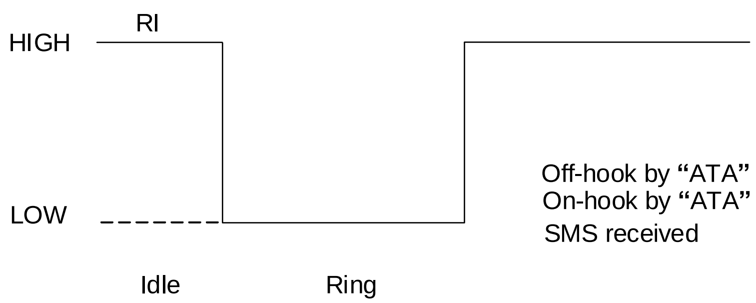



**Figure 33: RI Behavior when the Module is Receiving a Voice Call**

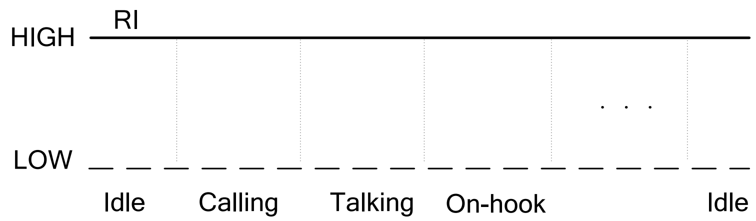



**Figure 34: RI Behavior When the Module is a Caller**

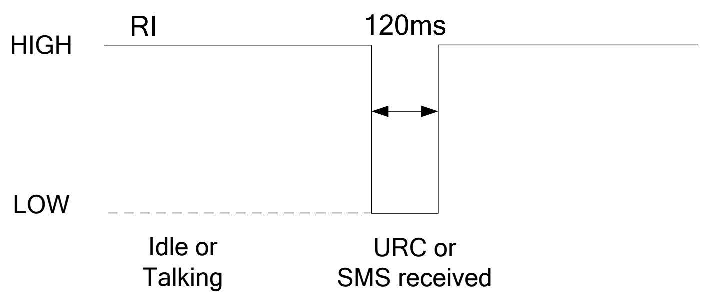



**Figure 35: RI Behavior When URC or SMS is Received**

## 3.19. 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 24: Working State of NETLIGHT**

| State | Module Function |
|---|---|
| OFF | The module is not working. |
| 64ms ON/800ms OFF | The module is not synchronized with network. |
| 64ms ON/2000ms OFF | The module is synchronized with network. |
| 64ms ON/600ms OFF | GPRS data transmission after dialing the PPP connection. |

A reference circuit is shown as below.

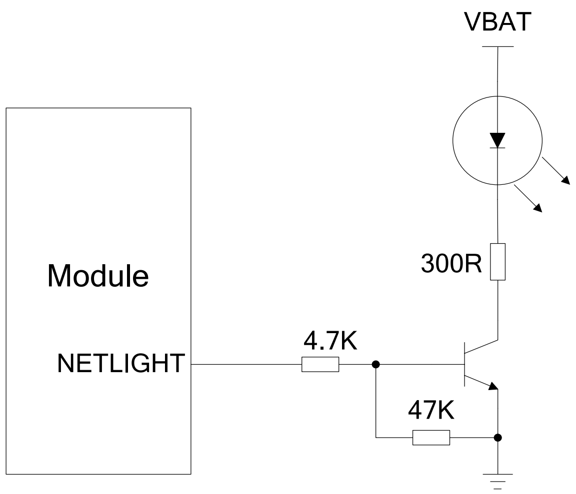



**Figure 36: Reference Design for NETLIGHT**

## 3.20. PPS VS. NMEA (1PPS Function)

Pulse per Second (PPS) VS. NMEA can be used for timing service. The latency range of the beginning of GNSS_TXD is 35ms~45ms and is after the rising edge of PPS.

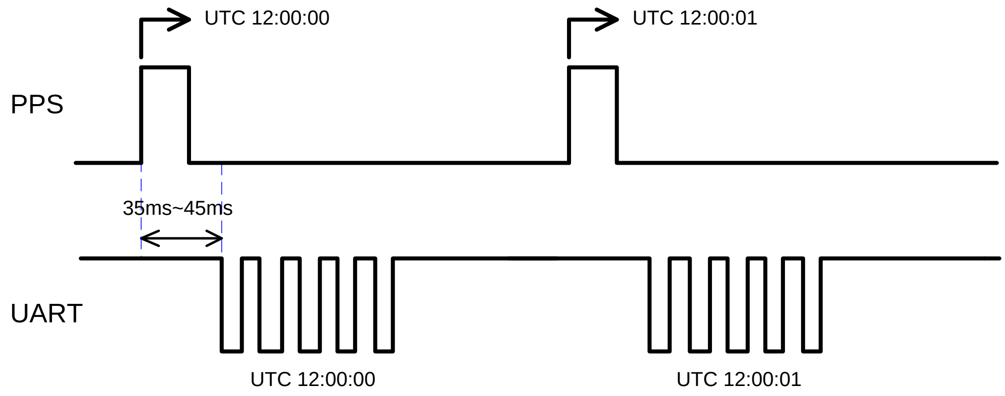



**Figure 37: PPS VS. NMEA Timing**

MC65-OpenCPU supports timing by PPS vs. NMEA. The frequency of NMEA statement output is 1Hz, and the baud rate is fixed at 9600bps.

1PPS function is enabled by default.

# 4 Antenna Interfaces

MC65-OpenCPU module has two antenna interfaces which are used for GSM antenna and GNSS antenna, respectively. The Pin 41 is the GSM antenna pad and Pin 15 is the GNSS antenna pad. Both the two antenna ports have an impedance of 50Ω.

## 4.1. GSM Antenna Interface

There is a GSM antenna pad named GSM_ANT for MC65-OpenCPU, and the pin definition is as following table.

**Table 25: Pin Definition of GSM_Antenna Inferface**

| Pin Name | Pin No. | I/O | Description |
|---|---|---|---|
| GSM_ANT | 41 | IO | GSM antenna pad |
| GND | 42 | | Ground |

### 4.1.1. Reference Design

The external antenna should be matched properly to achieve the best performance, so a matching circuit is necessary. A reference design for GSM antenna is shown below.

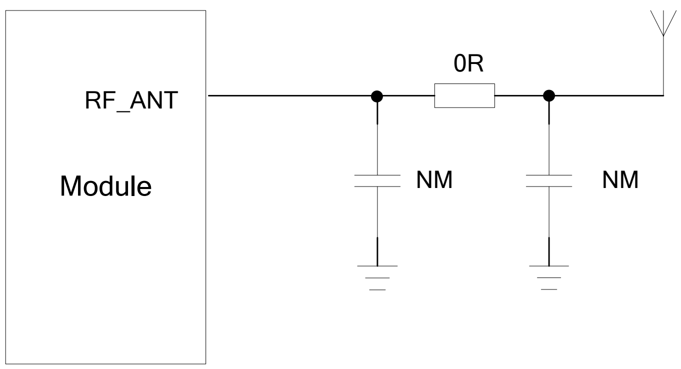



**Figure 38: Reference Design for GSM Antenna**

MC65-OpenCPU module provides an RF antenna pad for antenna connection. The RF trace in host PCB connected to the module's RF antenna pad should be coplanar waveguide line or microstrip line, whose characteristic impedance should be close to 50Ω. The module comes with grounding pads which are next to the antenna pad for a better grounding. Besides, a π type matching circuit is suggested to be used to adjust the RF performance.

To minimize the loss on RF trace and RF cable, please pay attention to the design. The following table shows the requirements 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 | Low frequency band: 820MHz~960MHz<br>Medium frequency band: 1710MHz~1990MHz |
| VSWR | ≤2 |
| Gain (dBi) | 1 |
| Max. Input Power (W) | 50 |
| Input Impedance (Ω) | 50 |
| Polarization Type | Vertical Polarization |

### 4.1.2. RF Output Power

**Table 28: 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 maximum output power is reduced by 4dB. This design conforms to the GSM specification as described in ***Chapter 13.16*** of *3GPP TS 51.010-1*. For detailed information about the GSM specification, please refer to the ***document [17]***.

### 4.1.3. RF Receiving Sensitivity

**Table 29: RF Receiving Sensitivity**

| Frequency | Receive Sensitivity |
|---|---|
| GSM850 | < -108dBm |
| EGSM900 | < -108dBm |
| DCS1800 | < -107.5dBm |
| PCS1900 | < -107.5dBm |

### 4.1.4. Operating Frequencies

**Table 30: Operating Frequencies**

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

### 4.1.5. 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 cable soldering.

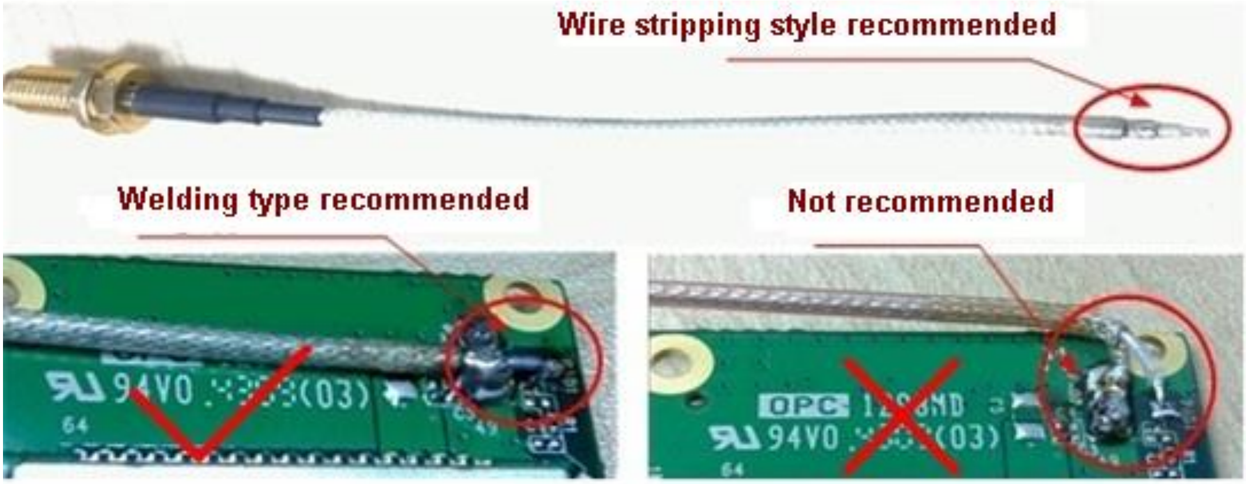



**Figure 39: RF Cable Soldering Sample**

## 4.2. GNSS Antenna Interface

The GNSS part of MC65-OpenCPU supports both GPS and GLONASS systems. The RF signal is obtained from the GNSS_ANT pin. The impedance of RF trace should be controlled as 50Ω, and the trace length should be kept as short as possible.

### 4.2.1. Antenna Specifications

The module can be connected to a dedicated GPS/GLONASS passive or active antenna to receive GPS/GLONASS satellite signals. The recommended antenna specifications are given in the following table.

**Table 31: Recommended Antenna Specifications**

| Antenna Type | Specifications |
|---|---|
| GNSS | Frequency band: GLONASS: 1602±3.9375MHz<br>GPS: 1575.42±1.023MHZ<br>Polarization: RHCP or Linear<br>VSWR: < 2 (Typ.)<br>Passive antenna gain: > 0dBi |

| | |
|---|---|
| | Active antenna noise figure: < 1.5dB<br>Active antenna gain: > 0dBi<br>Active antenna embedded LNA gain: ≤ 17dB |

### 4.2.2. Active Antenna

The following figure is a typical reference design for active antenna, which can be powered by a external 3.3V voltage system of the module.

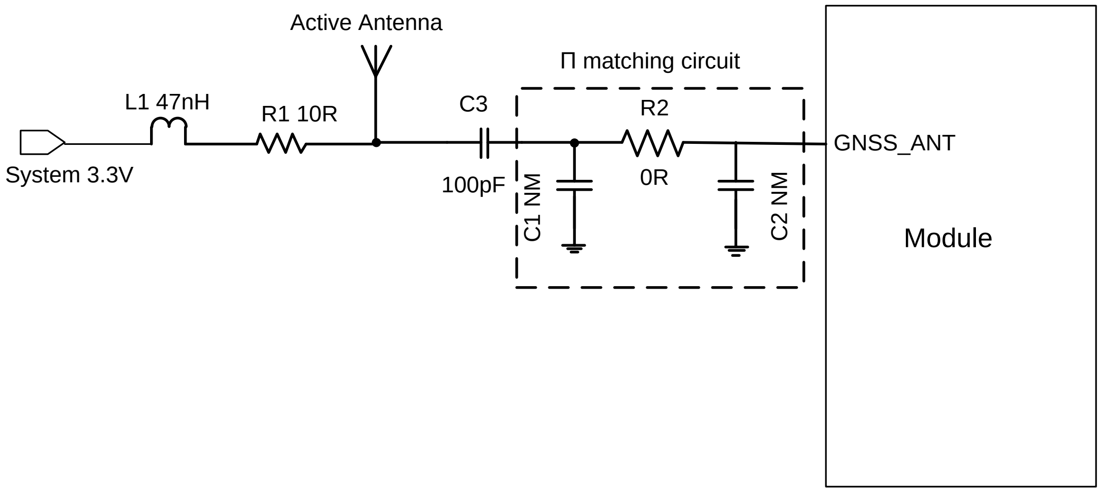



**Figure 40: Reference Design for Active Antenna**

C1, R2 and C2 are reserved matching circuits for antenna impedance modification. By default, C1 and C2 are not mounted, while a 0Ω R2 resistor and a 100pF C3 blocking capacitor are mounted.

Inductor L1 acts as an RF signal blocking function to isolate the RF signal from the system 3.3V. It is recommended that the value of L1 should be no less than 47nH. R1 protects the active antenna from short-circuiting to ground.

**NOTE**

LNA has been integrated inside the module, and passive antenna is recommended. If active antenna is used, the power supply of active antenna needs to be provided externally.

### 4.2.3. Passive Antenna

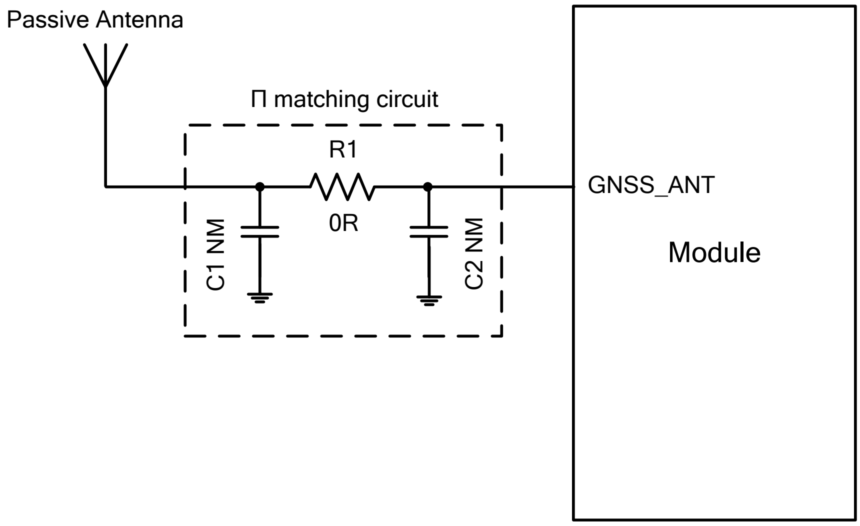



**Figure 41: Reference Design for Passive Antenna**

The above figure is a typical reference design for passive antenna.

C1, R1 and C2 are reserved matching circuit for antenna impedance modification. C1 and C2 are not mounted by default and R1 is 0Ω. Impedance of RF trace should be controlled as 50Ω and the trace length should be kept as short as possible.

# 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 the module are listed in the following table:

**Table 32: Absolute Maximum Ratings**

| Parameter | Min. | Max. | Unit |
|---|---|---|---|
| VBAT | -0.3 | +4.5 | V |
| Peak Current of Power Supply (VBAT) | 0 | 2 | A |
| RMS Current of Power Supply (VBAT, 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 |

## 5.2. Operation and Storage Temperatures

The following table lists the operation and storage temperatures of the module.

**Table 33: Operation Temperature**

| Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|
| Operation Temperature Range [1)] | -35 | +25 | +75 | ºC |

| | | | |
|---|---|---|---|
| Extended Temperature Range 2) | -40 | +85 | ºC |
| Storage Temperature Range | -40 | +90 | ºC |

**NOTES**

1. 1) Within operation temperature range, the module is 3GPP compliant.
2. 2) Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, 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.

## 5.3. Power Supply Ratings

**Table 34: Power Supply Ratings of GSM Part (GNSS is Powered off)**

| Parameter | Description | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| VBAT | Supply voltage | The actual input voltages must stay between the minimum and maximum values. | 3.45 | 4.0 | 4.25 | V |
| | Voltage drop during transmitting burst | Maximum power control level on GSM850 and EGSM900. | | | 400 | mV |
| $I_{VBAT}$ | Average supply current | Power down mode<br>Sleep mode @DRX=5 | | 38<br>1.1 | | uA<br>mA |
| | | Minimum functionality mode<br>**AT+CFUN=0**<br>Idle mode<br>Sleep mode<br>**AT+CFUN=4**<br>Idle mode<br>Sleep mode | | <br><br>9.0<br>0.9<br><br>9.0<br>0.9 | | <br><br>mA<br>mA<br><br>mA<br>mA |
| | | TALK mode<br>GSM850/EGSM900 1)<br>DCS1800/PCS1900 2) | | <br>248/247<br>169/152 | | <br>mA<br>mA |
| | | DATA mode, GPRS (3Rx, 2Tx)<br>GSM850/EGSM900 1) | | <br>372/387 | | <br>mA |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | DCS1800/PCS1900 2) | 253/223 | | | mA |
| | | DATA mode, GPRS (2 Rx, 3Tx)<br>GSM850/EGSM900 1)<br>DCS1800/PCS1900 2) | <br>457/438<br>285/255 | | | <br>mA<br>mA |
| | | DATA mode, GPRS (4 Rx, 1Tx)<br>GSM850/EGSM900 1)<br>DCS1800/PCS1900 2) | <br>248/254<br>174/156 | | | <br>mA<br>mA |
| | | DATA mode, GPRS (1Rx, 4Tx)<br>GSM850/EGSM900 1)<br>DCS1800/PCS1900 2) | <br>486/467 3)<br>299/270 | | | <br>mA<br>mA |
| | Peak supply current (during transmission slot) | Maximum power control level on GSM850 and EGSM900. | 1.6 | | 2 | A |

**NOTES**

1. 1) Power control level PCL 5.
2. 2) Power control level PCL 0.
3. 3) Under the EGSM900 spectrum, the maximum power of 1Rx and 4Tx is reduced.

## 5.4. Current Consumption

**Table 35: Current Consumption of GSM Part (GNSS is Powered off)**

| Condition | Current Consumption |
|---|---|
| **Voice Call** | |
| GSM850 | @power level #5 <300mA, typical 247mA<br>@power level #12, typical 106mA<br>@power level #19, typical 75mA |
| EGSM900 | @power level #5 <300mA, typical 247mA<br>@power level #12, typical 107mA<br>@power level #19, typical 77mA |
| DCS1800 | @power level #0 <250mA, typical 169mA<br>@power level #7, typical 86mA<br>@power level #15, typical 66mA |
| PCS1900 | @power level #0 <250mA, typical 152mA<br>@power level #7, typical 87mA |

| | |
|---|---|
| | @power level #15, typical 69mA |
| **GPRS Data** | |
| DATA Mode, GPRS (3 Rx, 2Tx) class 12 | |
| GSM850 | @power level #5 <550mA, typical 372mA |
| EGSM900 | @power level #5 <550mA, typical 387mA |
| DCS1800 | @power level #0 <450mA, typical 253mA |
| PCS1900 | @power level #0 <450mA, typical 223mA |
| DATA Mode, GPRS (2 Rx, 3Tx) class 12 | |
| GSM850 | @power level #5 <640mA, typical 457mA |
| EGSM900 | @power level #5 <600mA, typical 438mA |
| DCS1800 | @power level #0 <490mA, typical 285mA |
| PCS1900 | @power level #0 <480mA, typical 255mA |
| DATA Mode, GPRS (4 Rx, 1Tx) class 12 | |
| GSM850 | @power level #5 <350mA, typical 248mA |
| EGSM900 | @power level #5 <350mA, typical 254mA |
| DCS1800 | @power level #0 <300mA, typical 174mA |
| PCS1900 | @power level #0 <300mA, typical 156mA |
| DATA Mode, GPRS (1 Rx, 4Tx) class 12 | |
| GSM850 | @power level #5 <600mA, typical 486mA |
| EGSM900 | @power level #5 <600mA, typical 467mA |
| DCS1800 | @power level #0 <500mA, typical 299mA |
| PCS1900 | @power level #0 <500mA, typical 270mA |

**NOTE**

GPRS class 12 is the default setting. The GPRS multi-slot class supported by the module ranges from class 1 to 12 and can be set by the command **AT+QGPCLASS**. When setting a lower multi-slot class, the module's requirement for the power supply current will be reduced accordingly.

**Table 36: Current Consumption of GNSS Part**

| Parameter | Conditions | Typ. | Unit |
|---|---|---|---|
| $I_{VCC}$ @Acquisition | GPS | 23.8 | mA |
| $I_{VCC}$ @Tracking | GPS | 22.6 | mA |
| $I_{VCC}$ @Acquisition | GPS+GLONASS | 25.3 | mA |
| $I_{VCC}$ @Tracking | GPS+GLONASS | 24.7 | mA |
| $I_{BCKP}$ @backup | @V_BCKP=2.8V | 25 | uA |

**NOTE**

The tracking current is tested in following conditions:

- For Cold Start, 10 minutes after First Fix.
- For Hot Start, 15 seconds after First Fix.

## 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 electrostatic discharge characteristics.

**Table 37: Electrostatic Discharge Characteristics (25°C, 45% Relative Humidity)**

| Intterfaces | Contact Discharge | Air Discharge |
|---|---|---|
| VBAT, GND | +/-5KV | +/-10KV |

| | | |
|---|---|---|
| GSM_ANT | +/-5KV | +/-10KV |
| TXD, RXD | +/-2KV | +/-4KV |
| GNSS_TXD, GNSS_RXD | +/-2KV | +/-4KV |
| Others | +/-0.5KV | +/-1KV |

# 6 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.05mm unless otherwise specified.

## 6.1. Mechanical Dimensions of Module

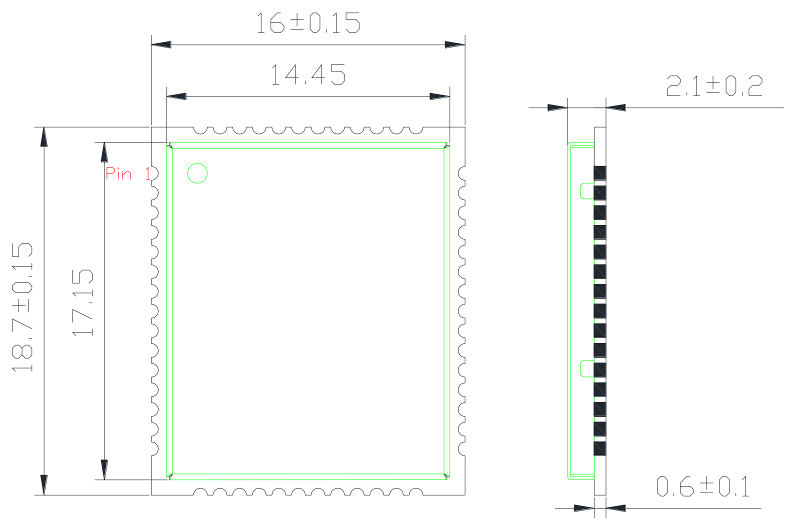



Figure 42: MC65-OpenCPU Top and Side Dimensions (Unit: mm)

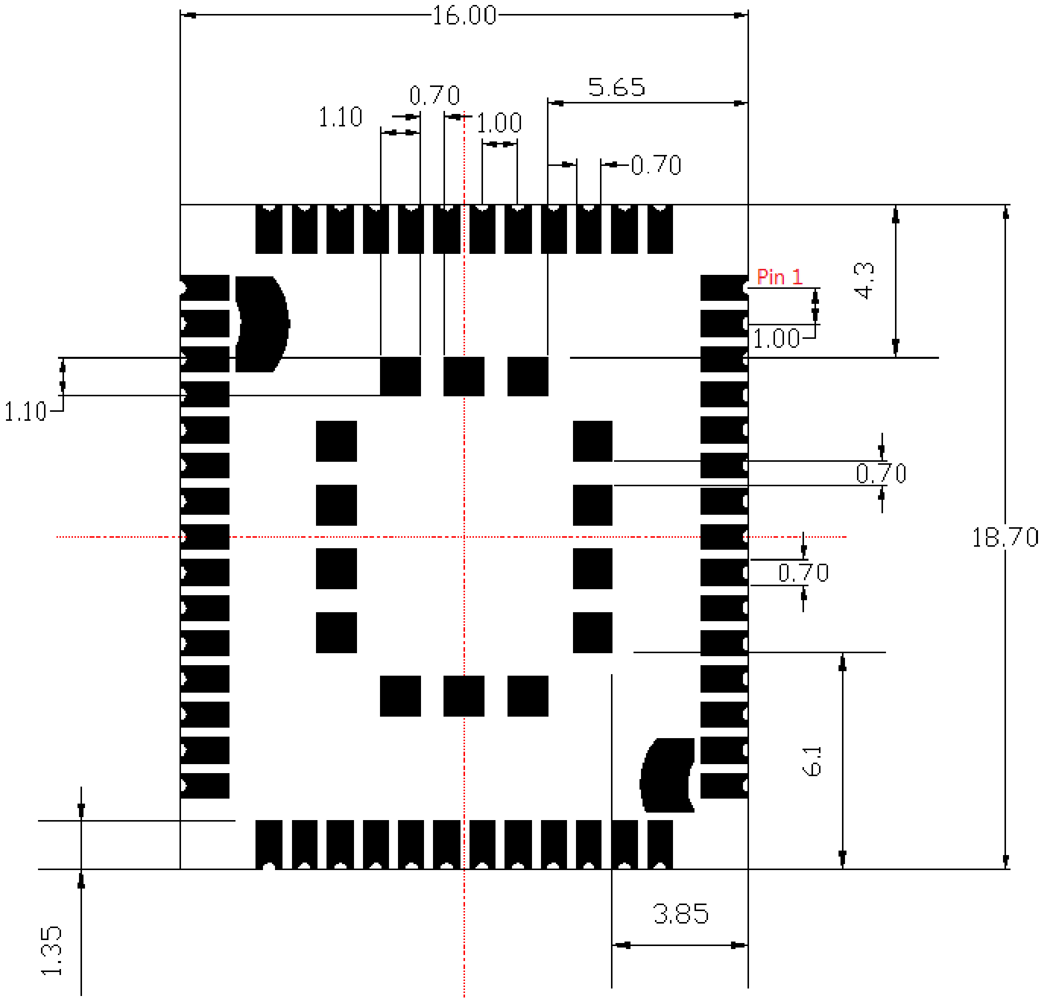



**Figure 43: MC65-OpenCPU Bottom Dimensions (Unit: mm)**

**NOTE**

The two arc test points in the above recommended footprint should be treated as keepout areas (“keepout” means do not pour copper on the mother board).

## 6.2. Recommended Footprint

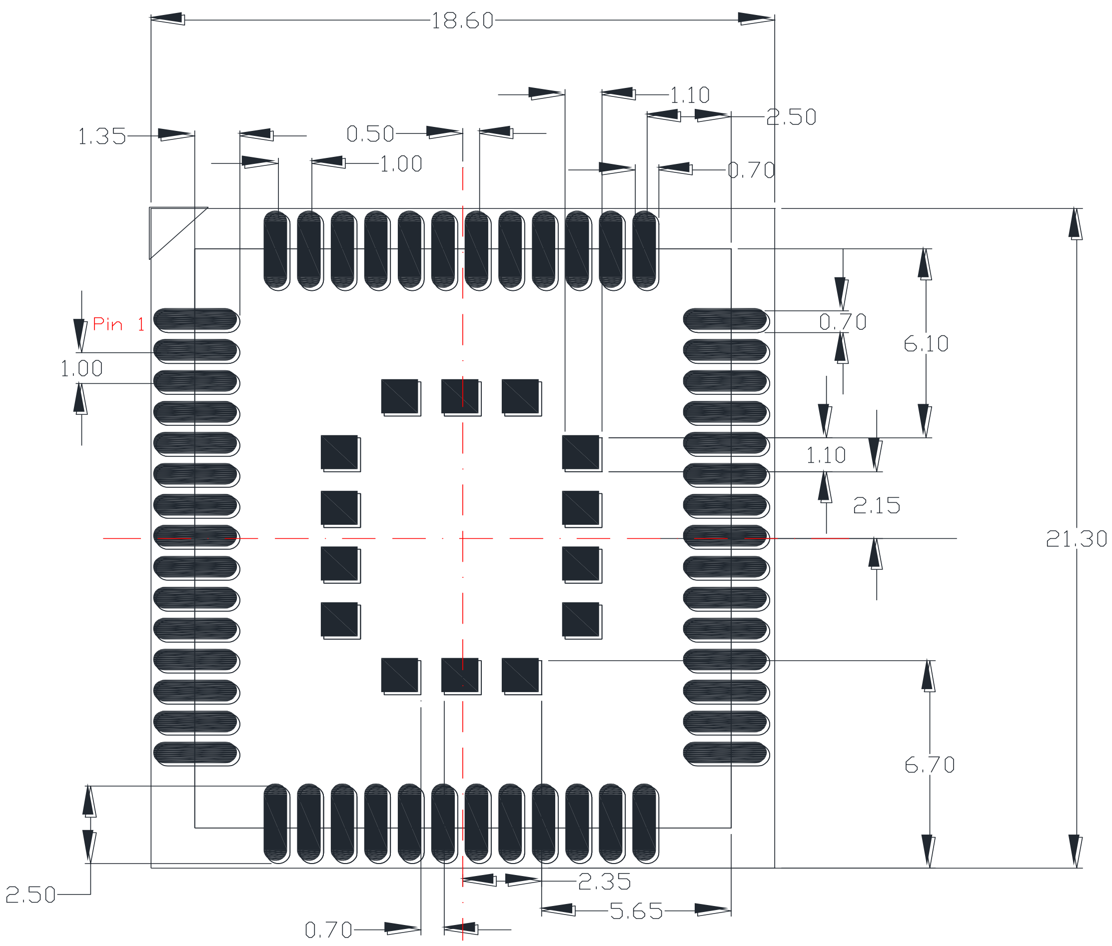



Figure 44: Recommended Footprint (Unit: mm)

NOTE

For easy maintenance of the module, please keep about 3mm between the module and other components in the host PCB.

## 6.3. Top and Bottom Views of the Module


Figure 45: Top View of the Module

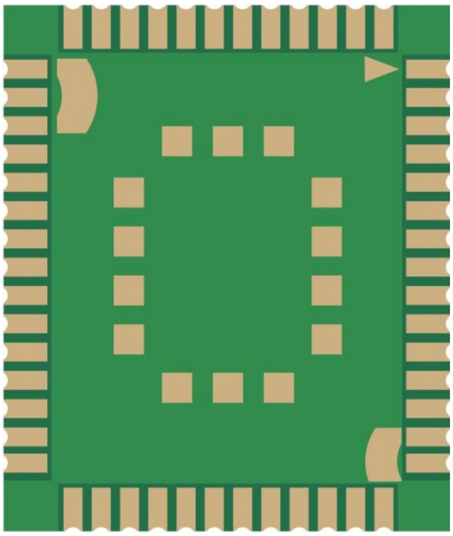


Figure 46: Bottom View of the Module

**NOTE**

These are renderings of MC65-OpenCPU module. For authentic appearance, please refer to the module that you receive from Quectel.

# 7 Storage, Manufacturing and Packaging

## 7.1. Storage

MC65-OpenCPU 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 <40ºC/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 ≤30ºC/60%RH.
   - Stored at <10%RH.

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

   - When the ambient temperature is 23ºC±5ºC 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 ≤30ºC/60%RH.

4. If baking is required, devices may be baked for 8 hours at 120ºC±5ºC.

**NOTE**

As the plastic package cannot be subjected to high temperature, it should be removed from devices before high temperature (120ºC) 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 0.18 to 0.20mm. For more details, please refer to ***document [12]***.

It is suggested that the peak reflow temperature is 238ºC~245ºC, and the absolute maximum reflow temperature is 245ºC. 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.

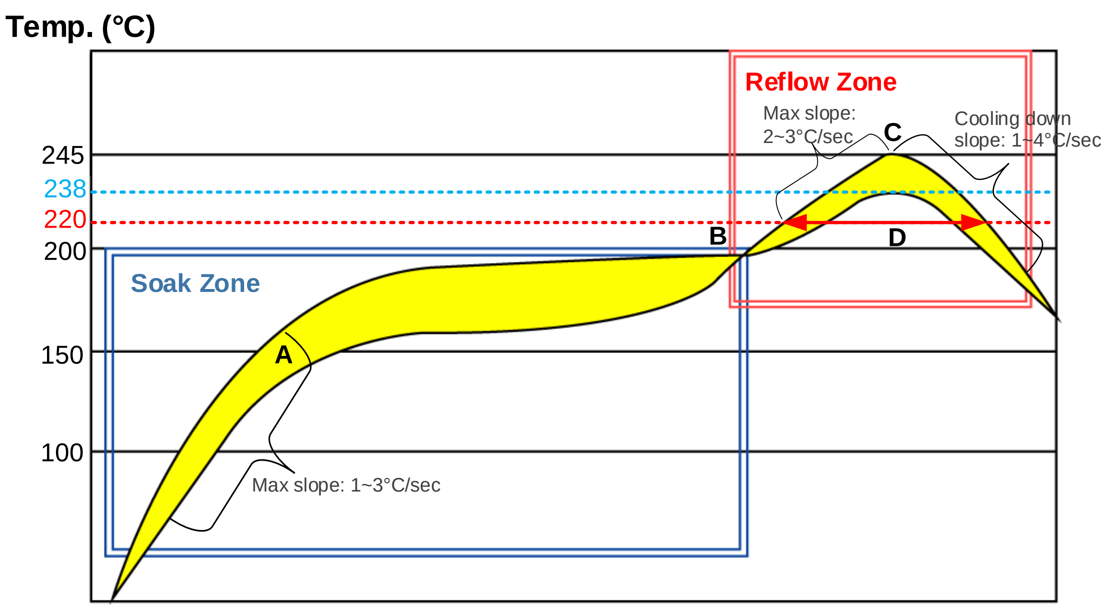



**Figure 47: Reflow Soldering Thermal Profile**

**Table 38: Recommended Thermal Profile Parameters**

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

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

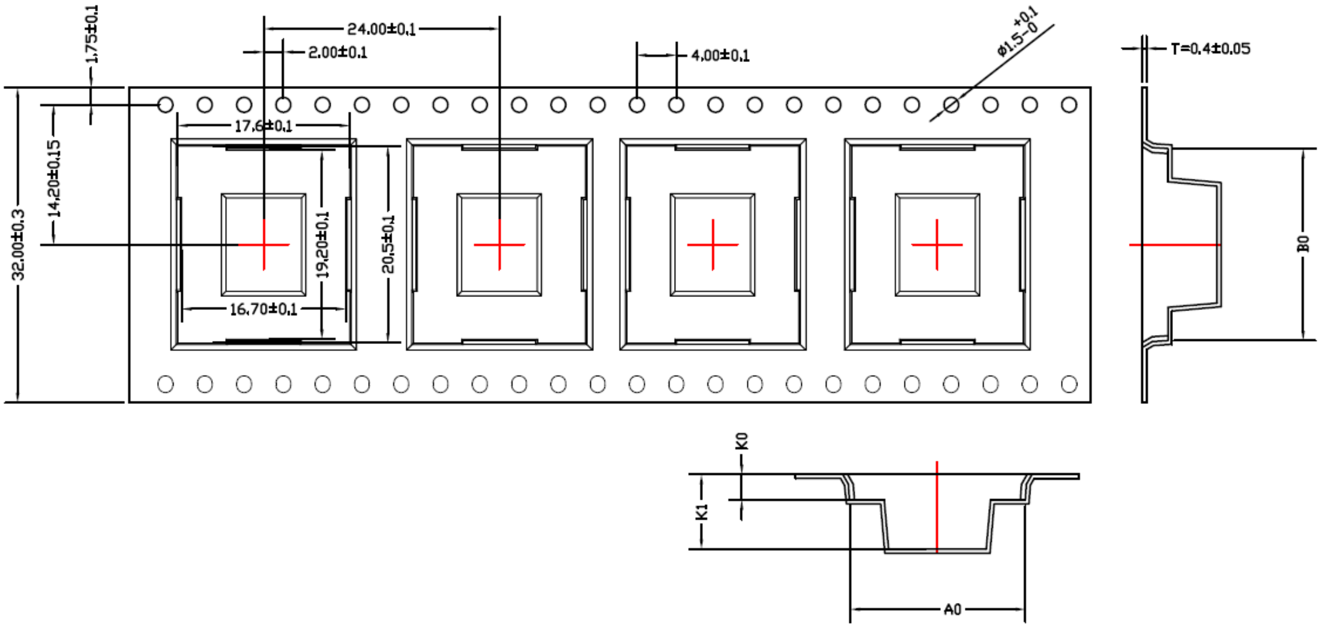
**NOTES**

1. During manufacturing and soldering, or any other processes that may contact the module directly, NEVER wipe the module's shielding can with organic solvents, such as acetone, ethyl alcohol, isopropyl alcohol, trichloroethylene, etc. Otherwise, the shielding can may become rusted.
2. The shielding can for the module is made of Cupro-Nickel base material. It is tested that after 12 hours' Neutral Salt Spray test, the laser engraved label information on the shielding can is still clearly identifiable and the QR code is still readable, although white rust may be found.

## 7.3. Packaging

MC65-OpenCPU is packaged in a vacuum-sealed bag which is ESD protected. The bag should not be opened until the devices are ready to be soldered onto the application.

The following figures show the packaging details, measured in mm.




| ITEM | W | T | A0 | A1 | B0 | B1 | B2 | K0 | K1 | P | F | E | D | P0 | P2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIM | 32.0 | 0.4 | 17.6 | | 20.5 | | | 2.6 | 7.6 | 24.0 | 14.2 | 1.75 | 1.5 | 4.0 | 2.0 |
| TOLE | ±0.3 | ±0.05 | ±0.1 | ±0.15 | ±0.10 | ±0.10 | ±0.10 | ±0.10 | ±0.10 | ±0.1 | ±0.10 | ±0.1 | +0.10 −0.00 | ±0.1 | ±0.1 |

**Figure 48: Tape Dimensions**

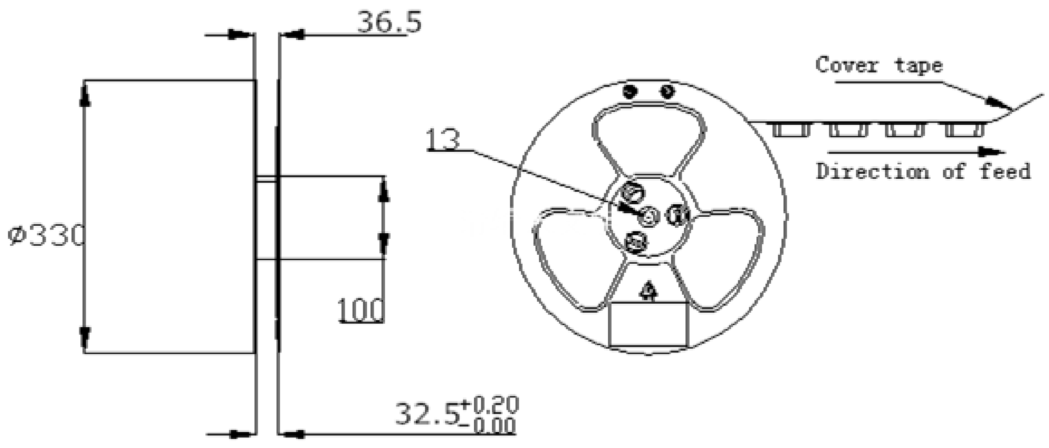



**Figure 49: Reel Dimensions**

**Table 39: Reel Packaging**

| Model Name | MOQ for MP | Minimum Package: 250pcs | Minimum Package x 4=1000pcs |
|---|---|---|---|
| MC65-OpenCPU | 250pcs | Size: 370mm × 350mm × 56mm<br>N.W: 0.32kg<br>G.W: 1.08kg | Size: 380mm × 250mm × 365mm<br>N.W: 1.28kg<br>G.W: 4.8kg |

# 8 Appendix A References

**Table 40: Related Documents**

| SN | Document Name | Remarks |
|---|---|---|
| [1] | Quectel_MC65-OpenCPU_AT_Commands_Manual | MC65-OpenCPU AT commands manual |
| [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 (U)SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment ((U)SIM – ME) interface |
| [7] | GSM 11.11 | Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment ((U)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] | Quectel_GSM_UART_Application_Note | GSM UART port application note |

| | | |
|---|---|---|
| [11] | Quectel_GSM_EVB_User_Guide | GSM EVB user guide |
| [12] | Quectel_Module_Secondary_SMT_User_Guide | Module secondary SMT user guide |
| [13] | Quectel_GSM_Module_Digital_IO_Application_Note | GSM module digital IO application note |
| [14] | Quectel_MC65-OpenCPU_GNSS_Protocol_ Specification | MC65-OpenCPU GNSS protocol specification |
| [15] | Quectel_MC65-OpenCPU-TE-A_User_Guide | MC65-OpenCPU-TE-A user guide |
| [16] | Quectel_MC65-OpenCPU_User_Guide | MC65-OpenCPU user guide |
| [17] | Quectel_OpenCPU_Watchdog_Application_Note | OpenCPU watchdog application note |
| [18] | GPP TS 51.010-1 | 3GPP GSM specification |

**Table 41: Terms and Abbreviations**

| Abbreviation | Description |
|---|---|
| ADC | Analog-to-Digital Converter |
| AG | Audio Gateway |
| AGPS | Assisted GPS |
| AIN | Audio In |
| AMR | Adaptive Multi-Rate |
| API | Application Program Interface |
| ARP | Antenna Reference Point |
| ASIC | Application Specific Integrated Circuit |
| ATH | Attention Hang–up |
| BER | Bit Error Rate |
| CS | Coding Scheme |
| CTS | Clear to Send |
| 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 |
| EGSM | Enhanced GSM |
| EMC | Electromagnetic Compatibility |
| ESD | Electrostatic Discharge |
| ETS | European Telecommunication Standard |
| FDMA | Frequency Division Multiple Access |
| FR | Full Rate |
| FS | File System |
| FTP | File Transfer Protocol |
| GAGAN | GPS Aided Geo Augmented Navigation |
| GGA | NMEA: Global Positioning System Fix Data |
| GLL | NMEA: Geographic Latitude and Longitude |
| GLONASS | Global Navigation Satellite System |
| GLP | GNSS Low Power |
| GMSK | Gaussian Minimum Shift Keying |
| GNSS | Global Navigation Satellite System |
| GPRS | General Packet Radio Service |
| GPS | Global Positioning System |
| GSA | NMEA: GPS DOP and Active Satellites |
| GSM | Global System for Mobile Communications |
| GSV | NMEA: GPS Satellites in View |
| G.W | Gross Weight |

| | |
|---|---|
| HFP | Hands-free Profile |
| HR | Half Rate |
| HTTP | Hypertext Transfer Protocol |
| I/O | Input/Output |
| IC | Integrated Circuit |
| IEEE | Institute of Electrical and Electronics Engineers |
| IMEI | International Mobile Equipment Identity |
| $I_{O}$max | Maximum Output Load Current |
| kbps | Kilo Bits Per Second |
| LCC | Leadless Chip Carriers |
| LED | Light Emitting Diode |
| LGA | Land Grid Array |
| Li-Ion | Lithium-Ion |
| LNA | Low Noise Amplifier |
| MCU | Micro Control Unit |
| MMS | Microsoft Media Server |
| MO | Mobile Originated |
| MOQ | Minimum Order Quantity |
| MP | Manufacture Product |
| MS | Mobile Station (GSM engine) |
| MSAS | Multi-Functional Satellite Augmentation System |
| MT | Mobile Terminated |
| NMEA | National Marine Electronics Association |
| NTP | Network Time Protocol |
| N.W | Net Weight |

| | |
|---|---|
| PAP | Password Authentication Protocol |
| PBCCH | Packet Switched Broadcast Control Channel |
| PCB | Printed Circuit Board |
| PCL | Power Control Level |
| PCM | Pulse Code Modulation |
| PDP | Packet Data Protocol |
| PDU | Protocol Data Unit |
| PING | Packet Internet Groper |
| PMOS | Positive Channel Metal Oxide Semiconductor |
| PMU | Power Management Unit |
| PPP | Point-to-Point Protocol |
| PPS | Pulse per Second |
| QZSS | Quasi-Zenith Satellite System |
| RF | Radio Frequency |
| RMC | NMEA: Recommended Minimum Position Data |
| RMS | Root Mean Square (value) |
| RoHS | Restriction of Hazardous Substances |
| RTC | Real Time Clock |
| RX | Receive Direction |
| SBAS | Satellite-based Augmentation System |
| SGSN | Serving GPRS Support Node |
| SIM | Subscriber Identification Module |
| SMD | Surface Mounted Devices |
| SMS | Short Message Service |
| SMTP | Simple Mail Transfer Protocol |

| | |
|---|---|
| SPI | Serial Peripheral Interface |
| SPP | Standard Parallel Port |
| TCP | Transmission Control Protocol |
| TDMA | Time Division Multiple Access |
| TE | Terminal Equipment |
| 3GPP | 3rd Generation Partnership Project |
| TTFF | Time to First Fix |
| TX | Transmitting Direction |
| UART | Universal Asynchronous Receiver & Transmitter |
| UDP | User Datagram Protocol |
| URC | Unsolicited Result Code |
| USIM | Universal Mobile Telecommunication System |
| USSD | Unstructured Supplementary Service Data |
| VSWR | Voltage Standing Wave Ratio |
| VTG | NMEA: Track Made Good and Ground Speed |
| $V_O$max | Maximum Output Voltage Value |
| $V_O$norm | Normal Output Voltage Value |
| $V_O$min | Minimum Output Voltage Value |
| $V_{IH}$max | Maximum Input High Level Voltage Value |
| $V_{IH}$min | Minimum Input High Level Voltage Value |
| $V_{IL}$max | Maximum Input Low Level Voltage Value |
| $V_{IL}$min | Minimum Input Low Level Voltage Value |
| $V_I$max | Absolute Maximum Input Voltage Value |
| $V_I$norm | Absolute Normal Input Voltage Value |
| $V_I$min | Absolute Minimum Input Voltage Value |

| | |
|---|---|
| $V_{OH}max$ | Maximum Output High Level Voltage Value |
| $V_{OH}min$ | Minimum Output High Level Voltage Value |
| $V_{OL}max$ | Maximum Output Low Level Voltage Value |
| $V_{OL}min$ | Minimum Output Low Level Voltage Value |
| WAAS | Wide Area Augmentation System |
| **Phonebook Abbreviations** | |
| LD | (U)SIM Last Dialing phonebook (list of numbers most recently dialed) |
| MC | Mobile Equipment list of unanswered MT Calls (missed calls) |
| ON | (U)SIM (or ME) Own Numbers (MSISDNs) list |
| RC | Mobile Equipment list of Received Calls |
| SM | (U)SIM phonebook |

# 9 Appendix B GPRS Coding Schemes

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

**Table 42: 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.

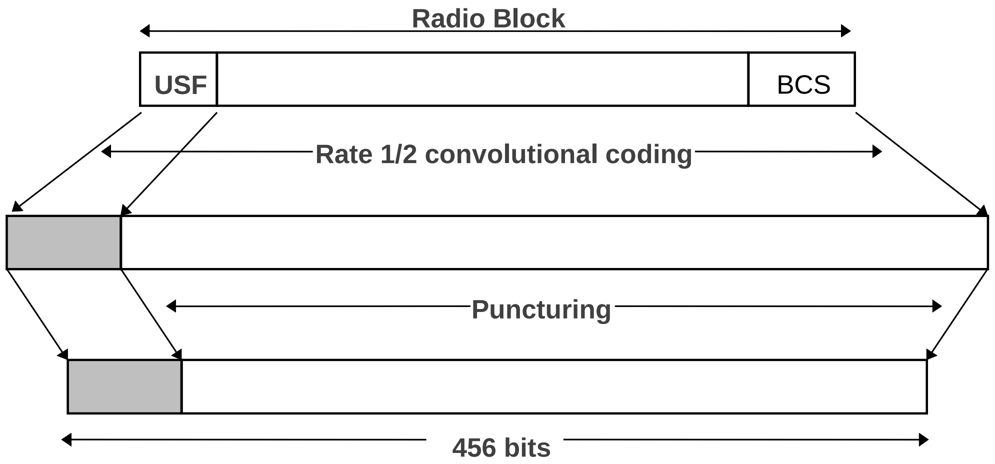



**Figure 50: Radio Block Structure of CS-1, CS-2 and CS-3**

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

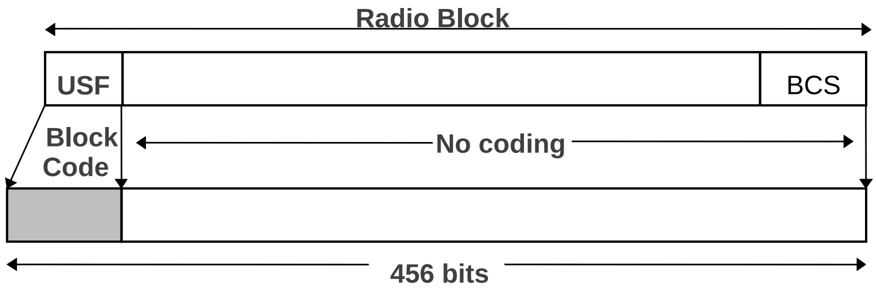



**Figure 51: Radio Block Structure of CS-4**

# 10 Appendix C GPRS Multi-slot Classes

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 43: 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 |