M65 Hardware Design

GSM/GPRS Module Series

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About the Document

History

Revision	Date	Author	Description
1.0	2019-07-02	Brooke WANG/ Andrea ZHANG	Initial

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1 Introduction

This document defines the M65 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers quickly understand M65 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 M65 to design and set up mobile applications easily.

1.1. Safety Information

The following safety precautions must be observed during all phases of the operation, such as usage, service or repair of any cellular terminal or mobile incorporating M65 module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

2 Product Concept

2.1. General Description

M65 is an industrial grade quad-band GSM/GPRS module that works at frequencies of GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. Providing GPRS data transmission and GSM SMS service, M65 supports GPRS multi-slot class 1~12 (Class 12 by default) and 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***.

M65 is an SMD type module with LCC package, which can be easily embedded into applications. It provides abundant hardware interfaces.

With the ultra-small size of 17.7mm ×15.8mm × 2.4mm, M65 can meet almost all the requirements for M2M applications, including vehicles, personal tracking, security system, wireless POS, industrial PDA, smart metering, remote maintenance and control, etc.

Designed with power saving technique, the current consumption of M65 is as low as 1.2mA in sleep mode when DRX is 5.

M65 integrates various Internet service protocols, such as TCP, UDP, FTP and PPP. Extended AT commands have been developed so that users can use these Internet service protocols easily.

M65 module fully complies with the RoHS directive of the European Union.

2.2. Key Features

The following table describes the detailed features of M65 module.

Table 1: Key Features

Features	Implementation
Power Supply	Single supply voltage: 3.45V~4.25V Typical supply voltage: 4.0V
Power Saving	Typical power consumption in sleep mode: 1.2mA @DRX=5 1.1mA @DRX=9
Frequency Bands	● Quad-band: GSM850, EGSM900, DCS1800, PCS1900 ● The module can search these frequency bands automatically ● The frequency bands can be set by AT commands ● Compliant to GSM Phase 2/2+
GSM Power Class	● Class 4 (2W) at GSM850 and EGSM900 ● Class 1 (1W) at DCS1800 and PCS1900
GPRS Connectivity	● GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● GPRS mobile station class B
GPRS Data Features	● GPRS data downlink transfer: max. 85.6kbps ● GPRS data uplink transfer: max. 85.6kbps ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Support PAP (Password Authentication Protocol) and CHAP* (Challenge Handshake Authentication Protocol) protocols which are usually used for PPP connection ● Support Internet service protocols: TCP/UDP/PPP/HTTP/NTP/PING/ IPv6/TTS/FTP/SSL/MQTT/HTTPS* ● Support Unstructured Supplementary Service Data (USSD)
Temperature Ranges	● Operation temperature range: -35°C ~ +75°C [1)] ● Extended temperature range: -40°C ~ +85°C [2)] ● Storage temperature range: -40°C ~ +90°C
SMS	● Text and PDU mode ● SMS storage: (U)SIM card
(U)SIM Interface	Support (U)SIM card: 1.8V and 3.0V
Audio Features	Speech codec modes: ● Half rate (ETS 06.20) ● Full rate (ETS 06.10) ● Enhanced full rate (ETS 06.50/06.60/06.80) ● Adaptive multi-rate (AMR) ● Echo suppression ● Noise reduction
UART Interfaces	**Main UART port:** ● Full-function UART port ● Used for AT command communication and GPRS data transmission ● Support autobauding from 4800bps to 115200bps

	Debug UART port: ● Used for firmware upgrading and debugging ● Fixed baud rates: 921600bps **Auxiliary UART port:** ● Used for AT command communication only
Phonebook Management	● Support phonebook types: SM, ME, ON, MC, RC, DC, LD, LA
(U)SIM Application Toolkit	● Support SAT class 3, GSM 11.14 Release 99
Real Time Clock (RTC)	● Supported
Physical Characteristics	● Size: (17.7±0.15)mm × (15.8±0.15)mm × (2.4±0.2)mm ● Package: LCC ● Weight: Approx. 1.1g
Firmware Upgrade	● Firmware upgrade via debug UART port or DFOTA
Antenna Interface	● GSM antenna interface ● 50Ω impedance

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, 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

2.3. Functional Diagram

The following figure shows a block diagram of M65 and illustrates the major functional parts.

- Power Management
- Memory
- Radio Frequency
- Peripheral Interfaces
  — Power Supply
  — PWRKEY
  — UART Interfaces
  — Audio Interfaces
  — PCM Interface*
  — (U)SIM Interface
  — ADC Interface
  — RF Interface

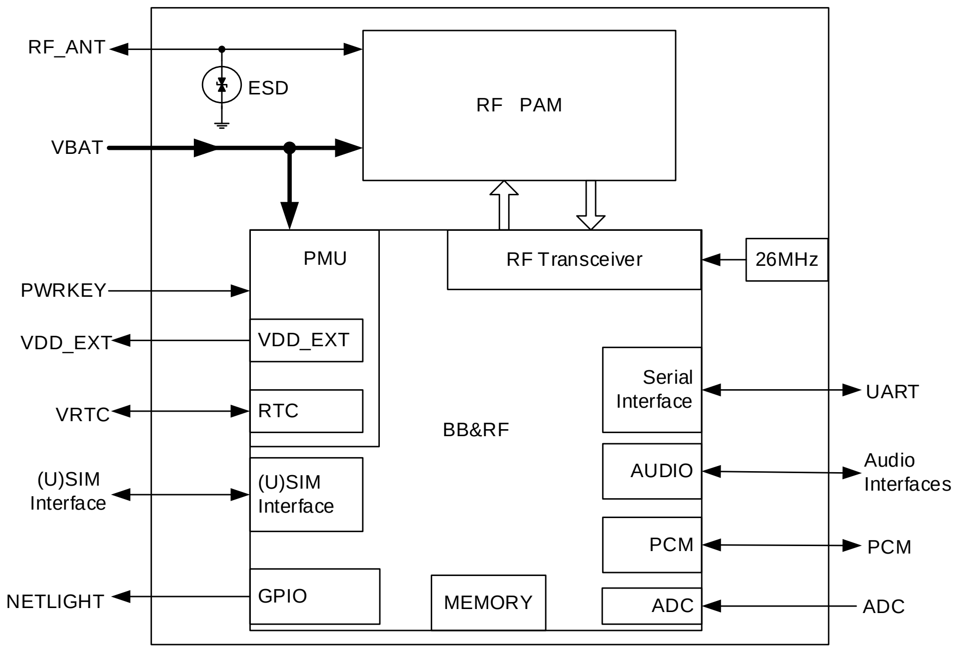

Figure 1: Module Functional Diagram

NOTE

"*" means under development.

2.4. Evaluation Board

Quectel provides a complete set of development tools to facilitate the use and testing of M65 module. Quectel supplies a GSM-EVB (evaluation board), USB to RS-232 cable, micro USB cable, power adapter, antenna, RF components, etc., to control or test M65 module. For details, please refer to ***document [3]***.

3 Application Interfaces

3.1. General Description

M65 module adopting LCC package has 44 pins. The subsequent chapters will provide detailed descriptions of the following interfaces/functions:

- Operating modes
- Power supply
- Power-on/off
- Power saving
- RTC
- UART interfaces
- Audio interfaces
- PCM interface*
- (U)SIM interface
- ADC interface
- Behaviors of the RI
- Network status indication
- RF transmitting signal indication

NOTE

"*" means under development.

3.2. Pin Assignment

The following figure shows the pin assignment of M65.

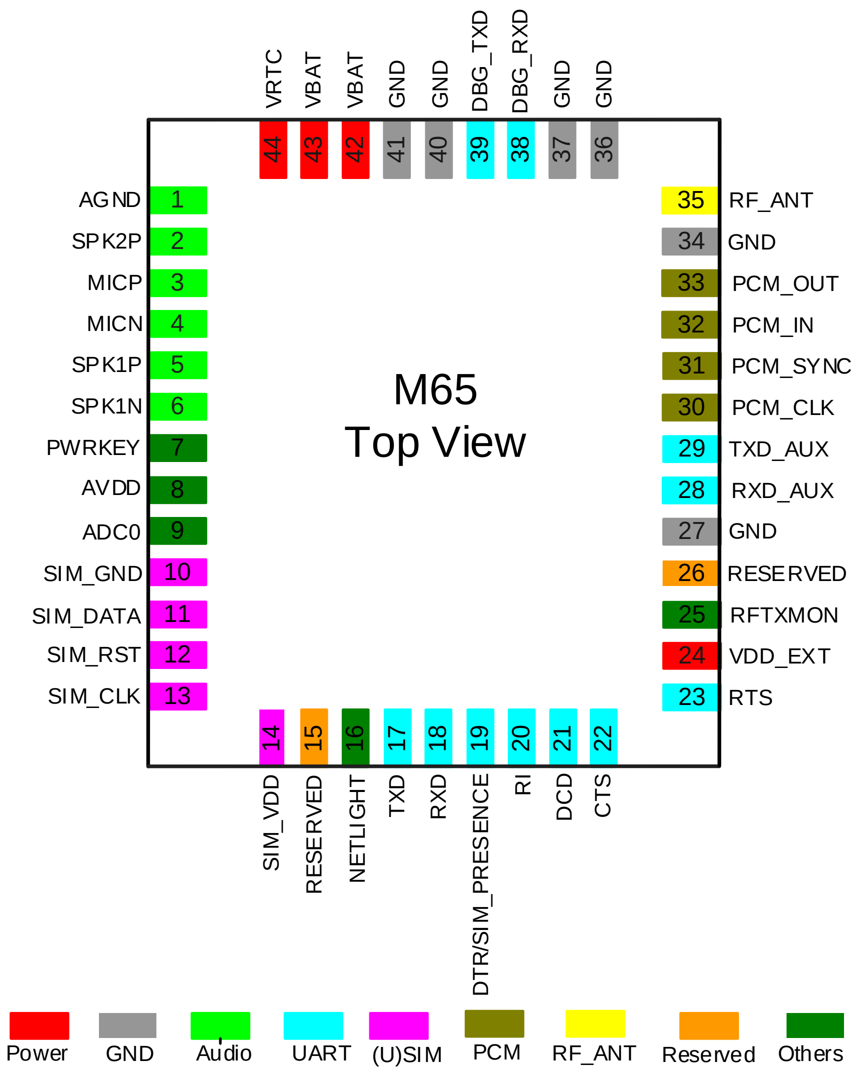

Figure 2: Pin Assignment

NOTE

Please keep all reserved pins open.

3.3. Pin Description

Table 3: IO Parameters Definition

Type	Description
AI	Analog input
AO	Analog output
DI	Digital input
DO	Digital output
IO	Bidirectional
PI	Power input
PO	Power output

Table 4: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	42, 43	PI	Main power supply of module: VBAT=3.45V~4.25V	$V_I$max=4.25V $V_I$min=3.45V $V_I$norm=4.0V	It must be provided with sufficient current up to 2.0A.
VRTC	44	IO	Input: Supply power to RTC when VBAT is removed. Output: Charge for backup battery or ultra-capacitor when VBAT is applied.	$V_I$max=3.5V $V_I$min=3.0V $V_I$norm=3.3V $V_O$max=3.39V $V_O$min=2.99V $V_O$norm=3.1V $I_O$max=1.9mA Iin≈21μA	If unused, keep this pin open.
VDD_EXT	24	PO	Supply 2.8V voltage for external circuit.	$V_O$max=2.9V $V_O$min=2.7V $V_O$norm=2.8V $I_O$max=20mA	1. If unused, keep this pin open. 2. It is recommended to add a 2.2μF ~4.7μF bypass

					capacitor when using this pin to supply power to external circuits.
GND	27, 34 36, 37 40, 41		Ground		
PWRKEY					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	7	DI	Turn-on/off key. PWRKEY should be pulled down for a moment to turn on/off the system.	$V_{IL}max$= 0.1×VBAT $V_{IH}min$= 0.6×VBAT $V_{IH}max$=3.1V	
Audio Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MICP, MICN	3, 4	AI	Audio differential input channel	Refer to ***Chapter 3.10***	If unused, keep these pins open.
SPK1P, SPK1N	5, 6	AO	Audio differential output channel 1		If unused, keep these pins open.
SPK2P	2	AO	Audio single-ended output channel 2		If unused, keep this pin open.
AGND	1		Analog ground. Separate ground connection for external audio circuits.		
Network Status Indicator					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
NETLIGHT	16	DO	Network status indication	$V_{OH}min$= 0.85×VDD_EXT $V_{OL}max$= 0.15×VDD_EXT	If unused, keep this pin open.
Main UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

TXD	17	DO	Transmit data	V_{IL}min=0V V_{IL}max= 0.25×VDD_EXT V_{IH}min= 0.75×VDD_EXT V_{IH}max= VDD_EXT+0.2 V_{OH}min= 0.85×VDD_EXT V_{OL}max= 0.15×VDD_EXT	If only TXD, RXD and GND are used for communication, it is recommended to keep all the other pins open.
RXD	18	DI	Receive data		
DTR	19	DI	Data terminal ready		
RI	20	DO	Ring indication		
DCD	21	DO	Data carrier detection		
CTS	22	DO	Clear to send		
RTS	23	DI	Request to send		
Debug UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_TXD	39	DO	Transmit data	V_{IL}min=0V V_{IL}max= 0.25×VDD_EXT V_{IH}min= 0.75×VDD_EXT V_{IH}max= VDD_EXT+0.2 V_{OH}min= 0.85×VDD_EXT V_{OL}max= 0.15×VDD_EXT	If unused, keep this pin open.
DBG_RXD	38	DI	Receive data		If unused, keep this pin open.
Auxiliary UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
TXD_AUX	29	DO	Transmit data	V_{IL}min=0V V_{IL}max= 0.25×VDD_EXT V_{IH}min= 0.75×VDD_EXT V_{IH}max= VDD_EXT+0.2 V_{OH}min= 0.85×VDD_EXT V_{OL}max= 0.15×VDD_EXT	If unused, keep this pin open.
RXD_AUX	28	DI	Receive data		If unused, keep this pin open.
(U)SIM Interface					

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
SIM_VDD	14	PO	Power supply for (U)SIM card	Either 1.8V or 3.0V, selected by software automatically.	All signals of (U)SIM interface should be protected against ESD with a TVS diode array. Maximum trace length from the module pad to (U)SIM card connector is 200mm.
SIM_CLK	13	DO	Clock signal of (U)SIM card	V_{OL}max= 0.15×SIM_VDD V_{OH}min= 0.85×SIM_VDD	
SIM_DATA	11	IO	Data signal of (U)SIM card	V_{IL}max= 0.25×SIM_VDD V_{IH}min= 0.75×SIM_VDD V_{OL}max= 0.15×SIM_VDD V_{OH}min= 0.85×SIM_VDD	
SIM_RST	12	DO	Reset signal of (U)SIM card	V_{OL}max= 0.15×SIM_VDD V_{OH}min= 0.85×SIM_VDD	
SIM_GND	10		Specified ground for (U)SIM card		
SIM_ PRESENCE	19	DI	(U)SIM card insertion detection	V IL min=0V V IL max= 0.25×VDD_EXT V IH min= 0.75×VDD_EXT V IH max= VDD_EXT+0.2	Function as DTR by default.
ADC					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
AVDD	8	PO	Reference voltage of ADC circuit	$V_O$max=2.9V $V_O$min=2.7V $V_O$norm=2.8V	If unused, keep this pin open.
ADC0	9	AI	General purpose analog to digital converter	Voltage range: 0V to 1.8V	If unused, keep this pin open.
PCM Interface*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_ CLK	30	DO	PCM clock	V_{IL}min= 0V V_{IL}max=	If unused, keep this pin open.

PCM_ SYNC	31	DO	PCM frame synchronization	V_{IH}min= 0.75×VDD_EXT V_{IH}max= VDD_EXT+0.2 V_{OH}min= 0.85×VDD_EXT V_{OL}max= 0.15×VDD_EXT	If unused, keep this pin open.
PCM_IN	32	DI	PCM data input		If unused, keep this pin open.
PCM_OUT	33	DO	PCM data output		If unused, keep this pin open.
Antenna Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RF_ANT	35	IO	GSM antenna pad		50Ω impedance
Transmitting Signal Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RFTXMON	25	DO	Transmission signal indication	V_{OH}min= 0.85×VDD_EXT V_{OL}max= 0.15×VDD_EXT	If unused, keep this pin open.
Other Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESERVED	15, 26				Please keep these pins open.

NOTE

"*" means under development.

3.4. Operating Modes

The following table briefly describes the various working modes of M65 module.

Table 5: Overview of Operating Modes

Mode	Function	
Normal operation	GSM/GPRS sleep	After enabling sleep mode by **AT+QSCLK=1**, the module will automatically enter sleep mode if DTR is set to high level and there is no interrupt (such as GPIO interrupt or data on UART port). In this case, the current consumption of module will reduce to the minimal level. During sleep mode, the module can still receive paging message and SMS from the system normally.
	GSM idle	Software is active. The module has registered to GSM network and is ready to send and receive GSM data.
	GSM talk	GSM connection is ongoing. In this mode, the power consumption of module is decided by the configuration of power control level (PCL), dynamic DTX control and the working RF band.
	GPRS idle	The module is not registered to GPRS network nor reachable through GPRS channel.
	GPRS standby	The module is registered to GPRS network, but no GPRS PDP context is active. The SGSN knows the routing area where the module is located at.
	GPRS ready	The PDP context is active, but no data transfer is ongoing. The module is ready to receive or send GPRS data. The SGSN knows the cell where the module is located at.
	GPRS data	There is GPRS data in transfer. In this mode, the power consumption of module is decided by the PCL, working RF band and GPRS multi-slot configuration.
Power down	Normal shutdown can be conducted by sending **AT+QPOWD=1** or using PWRKEY. In this case, operating voltage (connected to VBAT) remains applied; the power management ASIC disconnects the power supply from the base band part of the module while only power supply for RTC is remained. Software is not active and the UART port is not accessible.	
Minimum functionality mode (without removing power supply)	**AT+CFUN** can be used to set the module to minimum functionality mode without removing the power supply. In this case, either the module's RF part or (U)SIM card does not work, or both of them are disabled; but the UART port is still accessible. The power consumption in this case is very low.	

3.5. Power Supply

3.5.1. Power Features

Power supply design is an important part of M65 application design. Due to the 577us burst in GSM part every 4.615ms, in a burst period, power supply must be able to deliver high peak current and the supply voltage should not drop below the minimum working voltage of module.

The maximum current consumption of module could reach 2.0A during a burst transmission, which will cause a large voltage drop on VBAT. In order to ensure the stability of the module's operation, it is recommended that the maximum voltage drop during the burst transmission should not exceed 400mV.

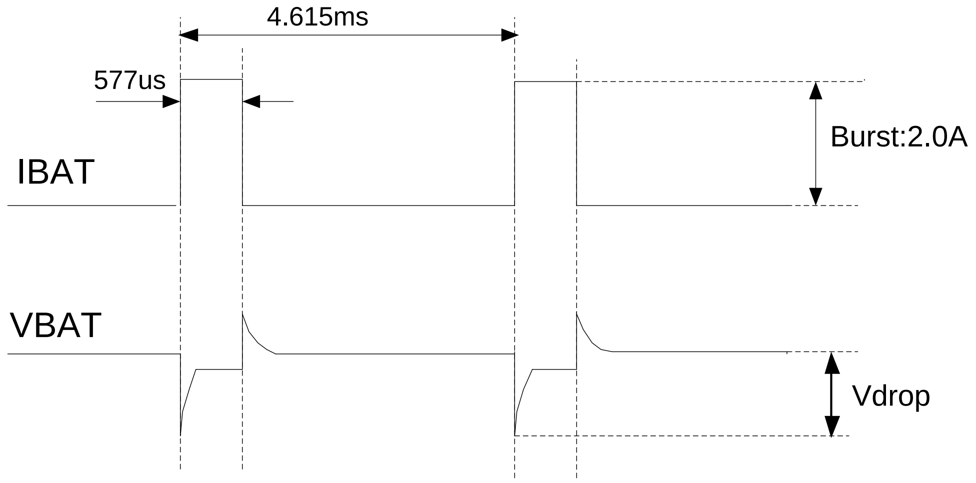

Figure 3: Voltage Ripple during Transmitting

3.5.2. Decrease Supply Voltage Drop

The power supply range of the module is 3.45V 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 could be turned off automatically. For better power performance, it is recommended to place a 100µF tantalum capacitor with low ESR (ESR=0.7Ω), ceramic capacitors of 100nF, 33pF and 10pF, and TVS near the VBAT pin. The 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 VBAT trace should be no less than 2mm; and in principle, the longer the trace is, the wider it will be.

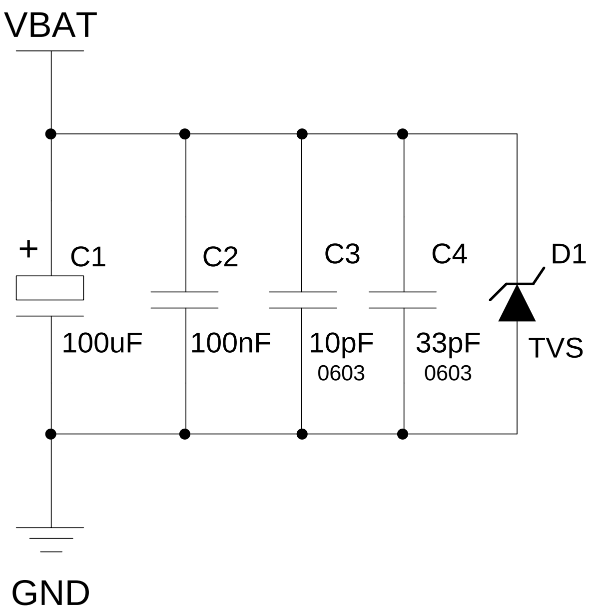

Figure 4: Reference Circuit for VBAT Input

3.5.3. Reference Design for Power Supply

Power design for the module is very important, as the performance of the module largely depends on the power source. The power supply should be provided with sufficient current up to 2.0A at least. If the voltage difference between the input and the output voltage is not too big, it is suggested to use an LDO to supply power for the module; if there is a big voltage difference between the input and the output voltage, a switcher power converter is preferred to be used.

The following figure shows a reference design for +5V input power supply. The designed output voltage for the power supply is 4.0V and the maximum load current is 3.0A. In order to ensure the stability of the output voltage, a zener diode is suggested to be placed close to VBAT pin. And it is suggested to use a zener diode whose reverse zener voltage is 5.1V and dissipation power is more than 1.0W.

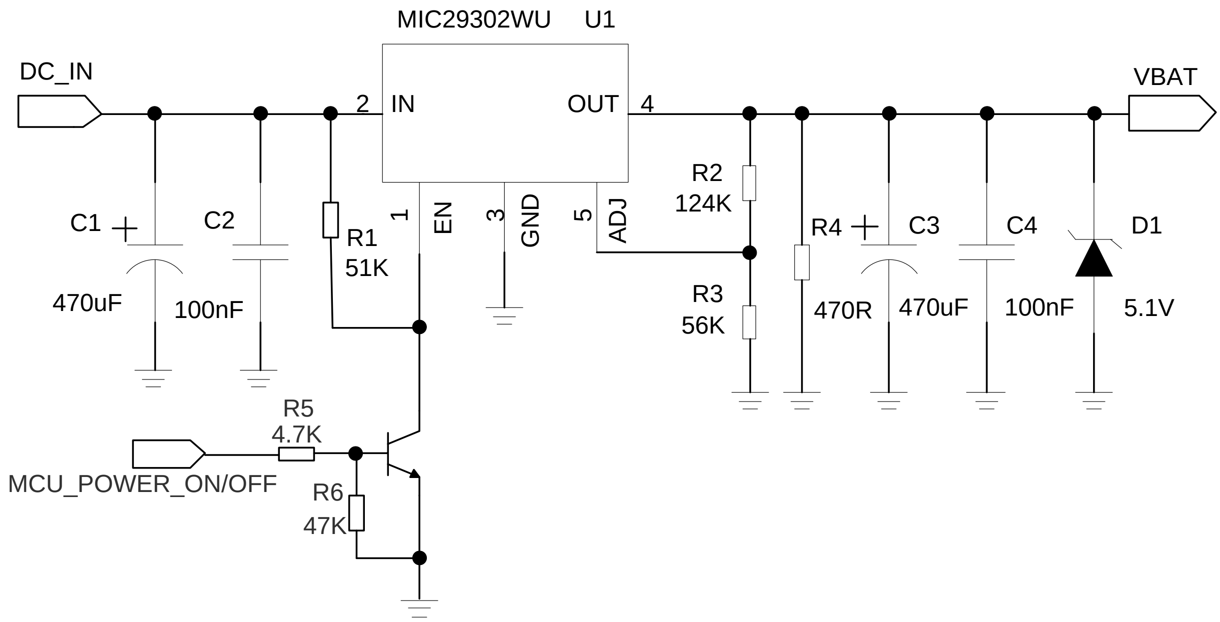

Figure 5: Reference Circuit for Power Supply

NOTE

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

3.5.4. Monitor Power Supply

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

3.6. Power-on/off Scenarios

3.6.1. Power-on

M65 module can be turned on by driving PWRKEY to a low level for 1.6s. It is recommended use an open drain/collector driver to control the PWRKEY. A simple reference circuit is illustrated as below.

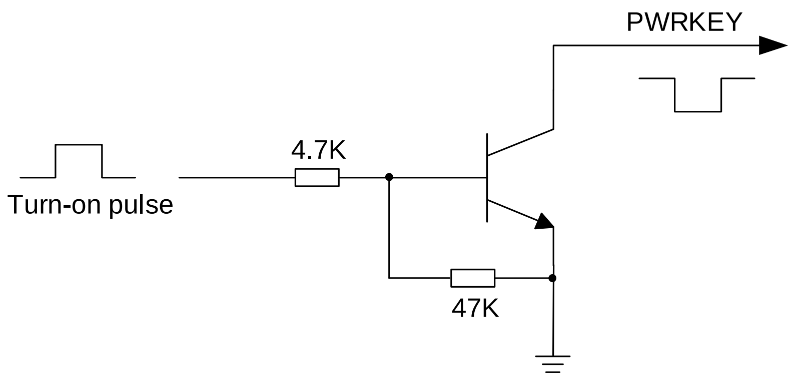

Figure 6: Turn on Module through an Open Collector Driver

NOTES

1. M65 is set to autobauding mode (**AT+IPR=0**) by default; in this mode, after module is powered on, URC "RDY" is not reported to the host controller. AT commands can be received by the module 4s~5s after it is powered on. Host controller should first send an "**AT**" string to the module so that the module can detect host controller's baud rate, and then continue to send the next "**AT**" string until "**OK**" returned from the module is received. Then **AT+IPR=x;&W** should be sent to set a fixed baud rate for the module and save the configuration to its flash memory. After the configuration is completed, URC "RDY" would be received from the main UART port every time the module is powered on. For more details, refer to the related content of **AT+IPR** in ***document [1]***.
2. If AT command is responded, it indicates the module is turned on successfully; otherwise it indicates the module fails to be turned on.

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

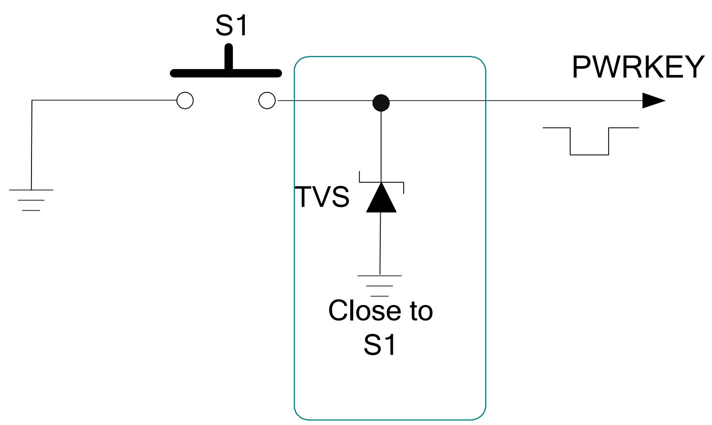

Figure 7: Turn on the Module through a Button

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

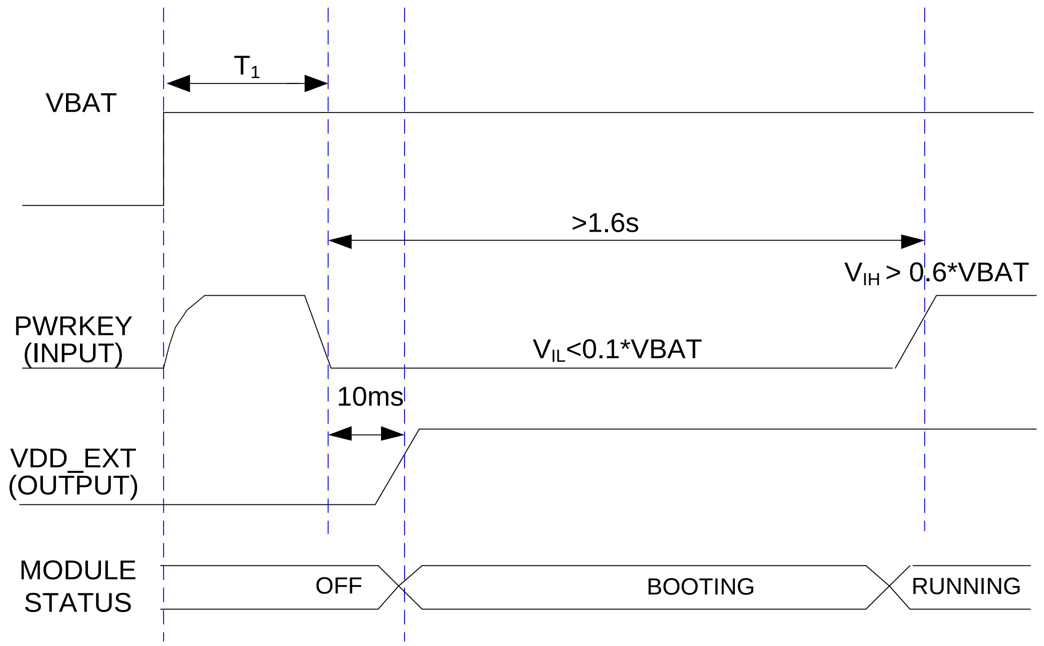

Figure 8: Timing of Turning on the Module

NOTE

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

3.6.2. Power-off

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

- Normal power-off procedure: Turn off module using PWRKEY.
- Normal power-off procedure: Turn off module using **AT+QPOWD=1**.
- Under-voltage automatic shutdown: Take effect when under-voltage is detected.

3.6.2.1. Turn off Module Using PWRKEY Pin

It is a safe way to turn off the module by driving PWRKEY to a low level for about 1.2s. The timing of turning off the module is illustrated below.

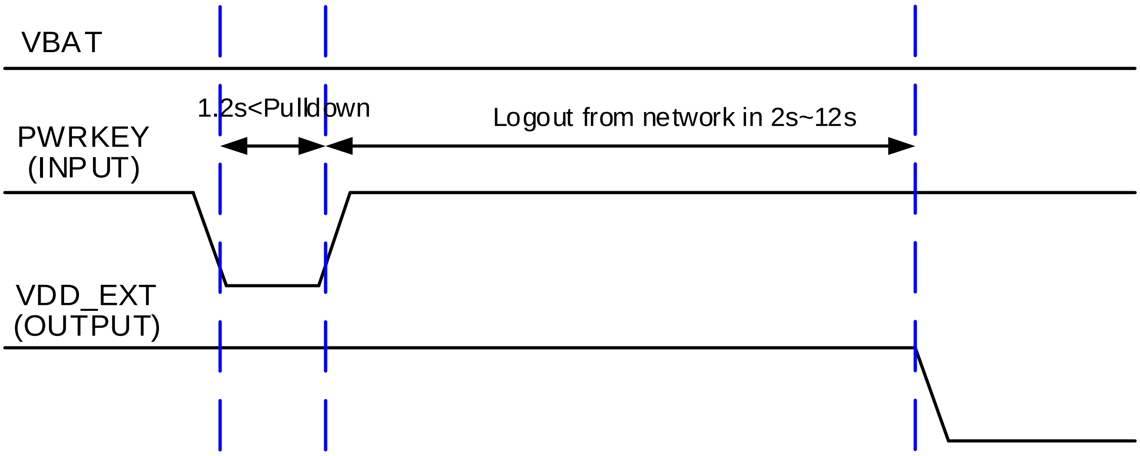

Figure 9: Timing of Turning off the Module

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 URC shown below:

NORMAL POWER DOWN

Since then, no further AT commands can be executed. Then the module enters power-down mode, while RTC is still active.

NOTE

1. This URC does not appear when autobauding is applied and DTE and DCE are not correctly synchronized after start-up. It is recommended to set the module to a fixed baud rate.
2. As time of network logout is related to the local mobile network, it is recommended to delay for about 12s before disconnecting the power supply or restarting the module.

3.6.2.2. Turn off Module Using AT Command

It is also a safe way to turn off the module via command **AT+QPOWD=1**. This command 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 URC shown below:

NORMAL POWER DOWN

Since then, no further AT commands can be executed. And then the module enters power-down mode, while only RTC is still active.

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

3.6.2.3. Under-voltage Automatic Shutdown

The module will constantly monitor the voltage applied on VBAT. If the voltage is ≤3.6V, 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.

If the voltage is <3.45V, the following URC will be presented:

UNDER_VOLTAGE POWER DOWN

Since then, no further AT commands can be executed. The module logs off from network and enters power-down mode, while only RTC is still active.

NOTE

These URCs do not appear when autobauding is applied and DTE and DCE are not correctly synchronized after start-up. It is recommended to set the module to a fixed baud rate.

3.6.3. Restart

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

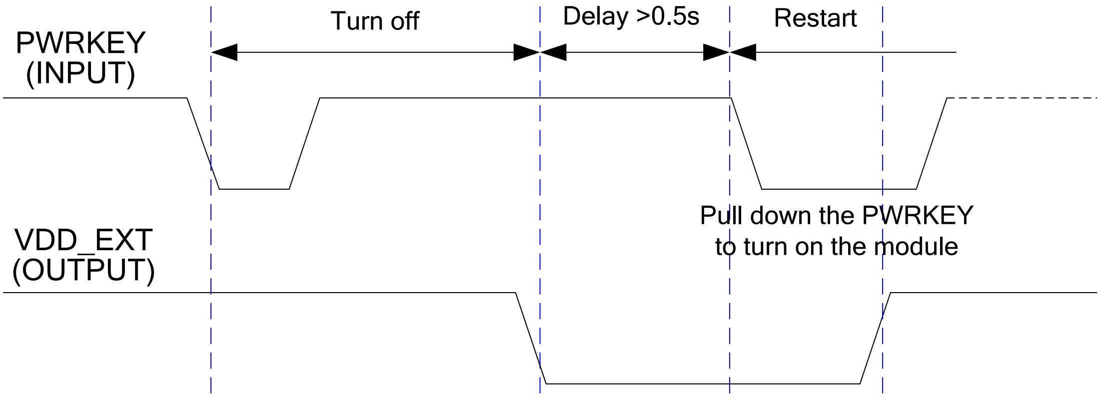

Figure 10: Timing of Restarting the Module

3.7. Power Saving

Based on system requirements, there are two ways to get M65 module into low current consumption status. One is to apply **AT+CFUN** to set module to minimum functionality mode, another is to apply **AT+QSCLK=1** to set module to sleep mode.

3.7.1. Minimum Functionality Mode

Minimum functionality mode reduces the functionality of M65 module to a minimum level, and the current consumption can also be minimized when slow clocking mode is activated at the same time. Minimum functionality mode is set by **AT+CFUN**, which provides the choice of the functionality levels <fun>=0, 1, 4.

- 0: minimum functionality
- 1: full functionality (default)
- 4: disable both transmitting and receiving of RF part

If M65 module is set to minimum functionality by **AT+CFUN=0**, RF and (U)SIM card functions would be disabled. In this case, the UART port is still accessible, but all AT commands related to RF or (U)SIM card functions will not be available.

If M65 module is set by **AT+CFUN=4**, RF function will be disabled, but the UART port is still active. In this case, all AT commands related to RF function will not be available.

For module already set by **AT+CFUN=0** or **AT+CFUN=4**, **AT+CFUN=1** can be used to set it back to full functionality.

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

3.7.2. Sleep Mode

The sleep mode is disabled by default. It can be enabled by **AT+QSCLK=1**.

If module is set by **AT+QSCLK=1**, customers can control the module to enter or exit from sleep mode through DTR pin. When DTR is set to high level, and there is no hardware interrupt such as GPIO interrupt or data on UART port, the module will enter sleep mode automatically. In this mode, the module can still receive voice, SMS or GPRS paging from network, but the UART port does not work.

3.7.3. Wake up Module from Sleep Mode

Module is in sleep mode can be woken up through the following ways.

- Pull down DTR pin for about 20ms.
- Receive a voice or data call from network.
- Receive an SMS from network.

NOTE

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

3.7.4. Summary of State Transition

Table 6: Summary of State Transition

Current Mode	Next Mode		
	Power Down	**Normal Mode**	**Sleep Mode**
Power Down		Use PWRKEY	
Normal Mode	Use **AT+QPOWD** or PWRKEY		Use **AT+QSCLK=1** and pull DTR up
Sleep Mode	Use PWRKEY	Pull DTR down or incoming call/SMS/GPRS	

3.8. RTC Backup Power

For M65 module, RTC function is supported, and it is designed to work with an internal power supply.

There are three kinds of designs for RTC backup power:

- Use VBAT as RTC's power source.

When module is turned off while the main power supply (VBAT) is remained, RTC is still active as the RTC core is powered by VBAT. In this case, VRTC pin can be kept open.

- Use VRTC as RTC's power source.

If the main power supply (VBAT) is removed after the module is turned off, a backup supply such as a coin-cell battery or an ultra-capacitor can be used to supply power to VRTC pin to keep RTC active.

- Use VBAT and VRTC as RTC's power source.

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

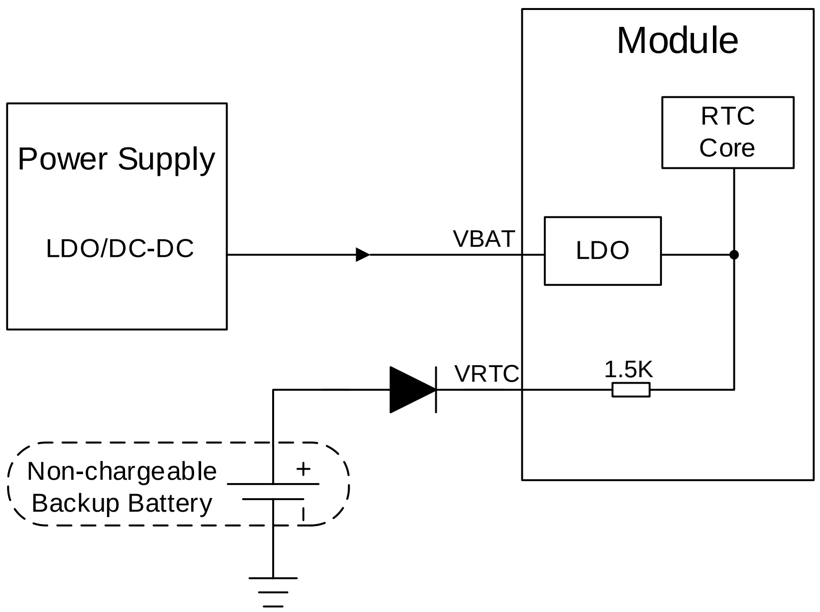

Figure 11: VRTC Supplied by a Non-chargeable Battery

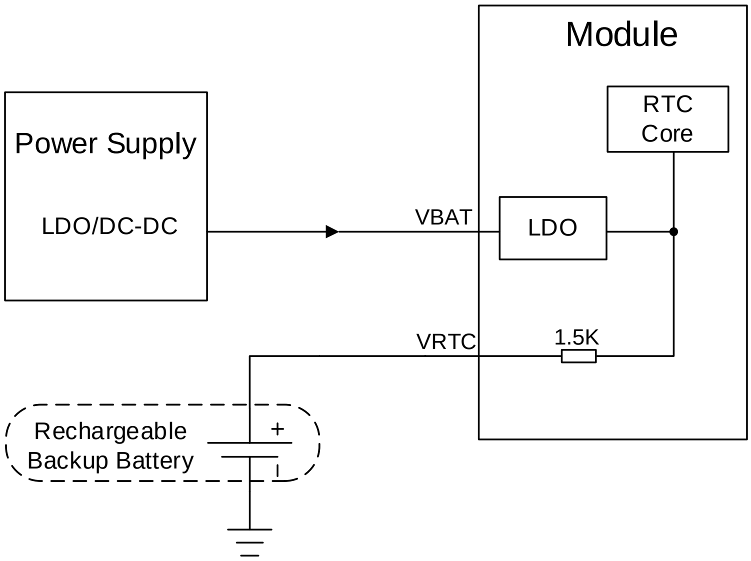

Figure 12: VRTC Supplied by a Rechargeable Battery

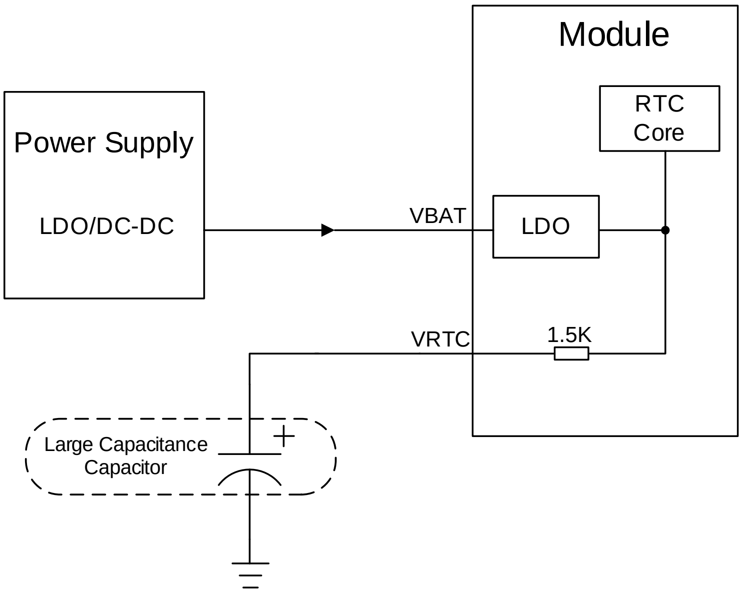

Figure 13: VRTC Supplied by a Capacitor

A rechargeable or non-chargeable coin-cell battery can also be used here, for more information, please visit http://www.sii.co.jp/en.

NOTE

Please keep the main power supply (VBAT) applied to ensure the accuracy of real time.

3.9. UART Interfaces

M65 provides three UART interfaces: main UART port, debug UART port and auxiliary UART port. The module is designed as a DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. Autobauding is supported ranging from 4800bps to 115200bps.

Pin definition of UART interfaces is as follows:

Table 7: Pin Definition of UART Interfaces

Interface	Pin Name	Pin No.	Description
Main UART Port	TXD	17	Transmit data
	RXD	18	Receive data
	DTR	19	Data terminal ready
	RI	20	Ring indication
	DCD	21	Data carrier detection
	CTS	22	Clear to send
	RTS	23	Request to send
Debug UART Port	DBG_RXD	38	Receive data
	DBG_TXD	39	Transmit data
Auxiliary UART Port	RXD_AUX	28	Receive data
	TXD_AUX	29	Transmit data

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 through RI pin).
- DCD: Data carrier detection (the validity of this pin demonstrates successful set-up of the

communication link).

Hardware flow control is disabled by default. When hardware flow control is required, RTS and CTS should be connected to the host. **AT+IFC=2,2** is used to enable hardware flow control while **AT+IFC=0,0** is used to disable it. For more details, please refer to the ***document [1]***.

Debug UART port:

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

Auxiliary UART port:

- TXD_AUX: Send data to the RXD of DTE.
- RXD_AUX: Receive data from the TXD of DTE.

Logic levels of UART interfaces are described in the following table.

Table 8: Logic Levels of UART Interfaces

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

3.9.1. Main UART Port

3.9.1.1. Features of Main UART Port

- 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.
- Support the following baud rates: 2400bps, 4800bps, 9600bps, 14400bps, 19200bps, 28800bps, 38400bps, 57600bps and 115200bps.
- Module is set by default with autobauding applied in a range of 4800bps, 9600bps, 19200bps, 38400bps, 57600bps and 115200bps.
- The module disables hardware flow control by default. **AT+IFC=2,2** is used to enable hardware flow control.

After fixed baud rates or autobauding is set, please send "**AT**" string at that rate. If the UART port is ready, "**OK**" will be returned.

Autobauding is enabled by default. It allows the module to detect the baud rate automatically upon receiving "**AT**" string from the host or PC, which offers module flexibility without needs to consider which baud rate is used by the host controller. To take advantage of autobauding, special attention should be paid to the following requirements.

Synchronization between DTE and DCE:

When DCE (the module) is powered on with autobauding, it is recommended to wait for 4s~5s before sending the first "**AT**" string. If "**OK**" is then received, it suggests that DTE and DCE are correctly synchronized.

If the host controller needs URC in autobauding mode, synchronization should be conducted firstly; otherwise URC will be discarded.

Restrictions on setting of autobauding:

- The UART port has to be operated at 8 data bits without parity check bit or 1 stop bit (factory setting).
- Only the string "**AT**" can be detected ("**At**", "**at**", or "**aT**" cannot be detected).
- URC like "RDY", "+CFUN: 1" and "+CPIN: READY" will not be indicated if the module is turned on with autobauding enabled while without synchronization conducted in the first place.
- The module detects the new baud rate upon receiving the first "**AT**" string, before this, some other URC will be sent using the previous baud rate. Therefore, DTE may receive unknown strings after switching to new baud rate.
- It is not recommended to switch to autobauding from fixed baud rates.
- If autobauding is active, it is not recommended to switch to multiplexing mode.

NOTE

To assure reliable communication and avoid problems caused by undetermined baud rate between DCE and DTE, it is strongly recommended to set up a fixed baud rate instead of using autobauding after start-up. For more details, please refer to the content related to **AT+IPR** in ***document [1]***.

3.9.1.2. Connection for Main UART Port

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

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

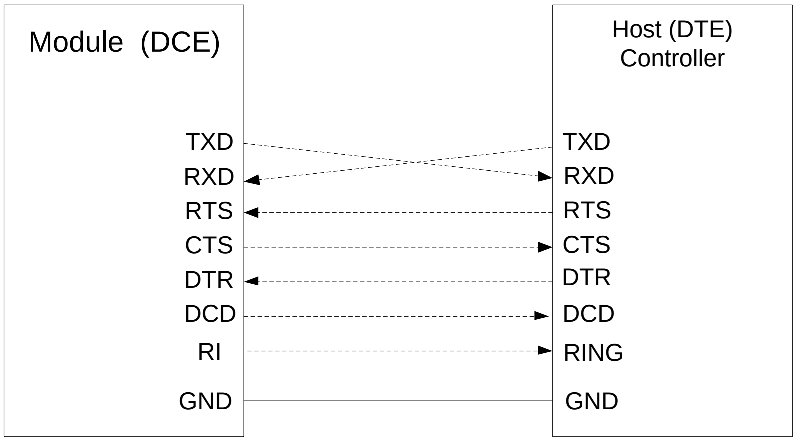

Figure 14: Reference Design for Full-Function UART Port

Three-wire UART port connection is shown as below.

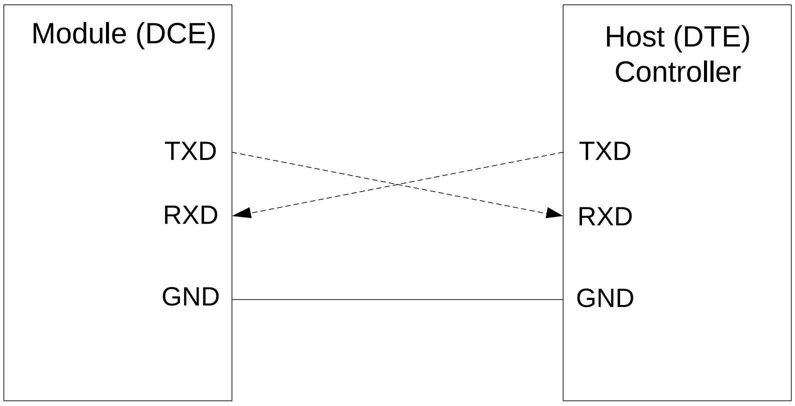

Figure 15: Reference Design for Three-wire UART Port

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

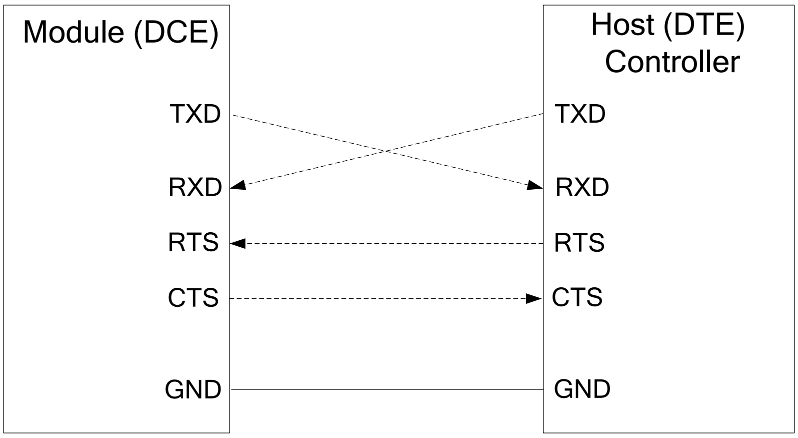

Figure 16: Reference Design for main UART Port with Hardware Flow Control

3.9.2. Debug UART Port

- Data lines: DBG_TXD and DBG_RXD.
- It outputs log information automatically.
- It is used for firmware debugging and upgrading with a fixed baud rate of 921600bps.

During the firmware upgrade process, the PWRKEY pin must be pulled down for more than 1.6s. For firmware upgrade, the following design can serve as a reference:

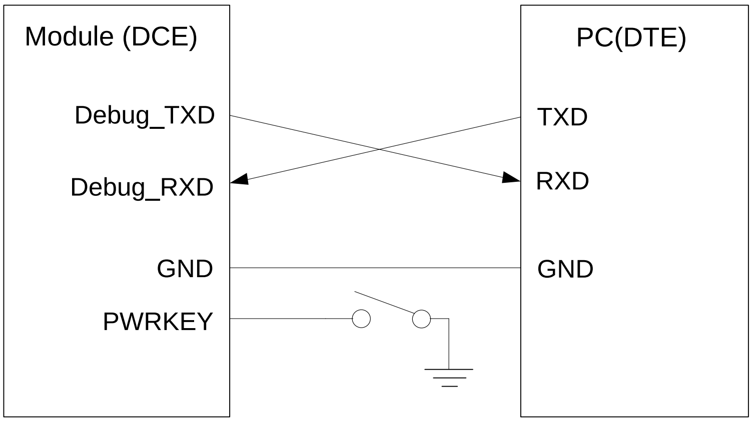

Figure 17: Reference Design for Firmware Upgrade

NOTE

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

3.9.3. Auxiliary UART Port

- Two data lines: TXD_AUX and RXD_AUX.
- Auxiliary UART port is used for AT command only and does not support GPRS data, multiplexing function, etc.
- Auxiliary UART port supports the following baud rates: 2400bps, 4800bps, 9600bps, 14400bps, 19200bps, 28800bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps and 921600bps.
- Auxiliary UART port could be used after sending **AT+QEAUART=1** on main UART port.
- The baud rate is set as 115200bps by default, and autobauding is not supported. The baud rates can be modified by **AT+QSEDCB**. For more details, please refer to the ***document [1]***.

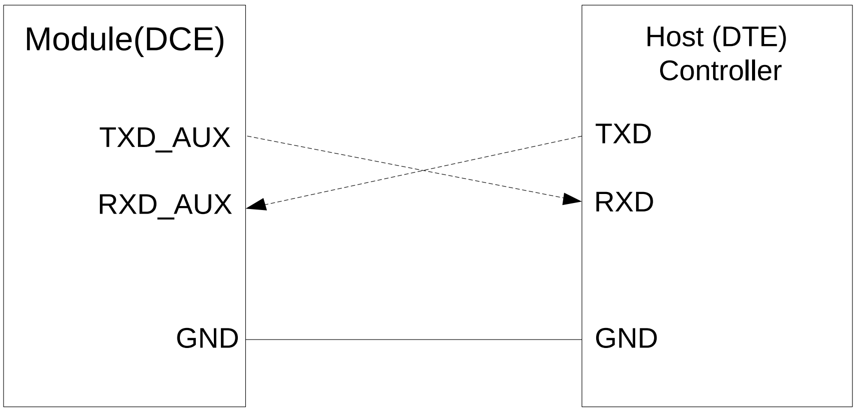

Figure 18: Reference Design for Auxiliary UART Port

3.9.4. UART Application

The reference design of 3.3V level match is shown as below. If the host is a 3.0V system, please use the 10K resistor instead of the 5.6K.

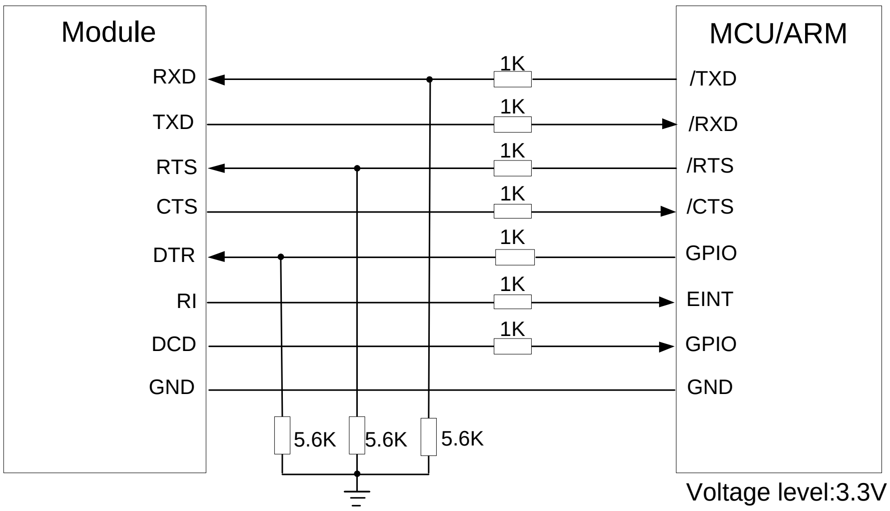

Figure 19: Level Match Design for 3.3V System

NOTE

If the level of the host is 3V or 3.3V, it is highly recommended to add resistor divider circuit to the UART signal lines. For higher voltage level system, the level shifter IC could be added between the host and the module. For more details about UART circuit design, please refer to ***document [6]***.

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

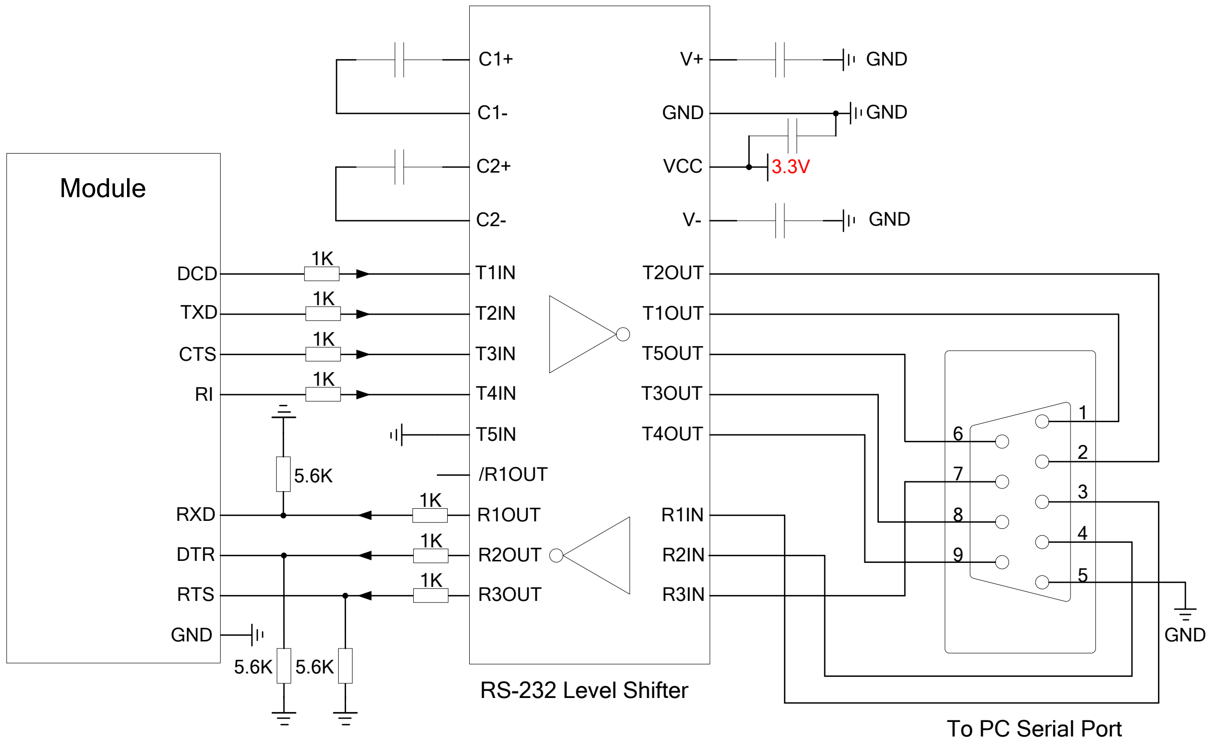

Figure 20: Sketch Map for RS-232 Interface Match

Please visit vendors' website to select 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 9: Pin Definition of Audio Interfaces

Interface	Pin Name	Pin No.	Description
AIN/AOUT1	MICP	3	Microphone input (positive)
	MICN	4	Microphone input (negative)
	SPK1P	5	Audio output Channel 1 (positive)
	SPK1N	6	Audio output Channel 1 (negative)
AIN/AOUT2	MICP	3	Microphone input (positive)
	MICN	4	Microphone input (negative)
	SPK2P	2	Audio output Channel 2 (positive)
	AGND	1	Form a pseudo-differential pair with SPK2P

AIN, which are differential input channels, can be applied for input of microphone (usually an electret microphone is used).

AOUT1 is used for output of receiver. It is a differential channel and typically applied for building a receiver into a handset.

AOUT2 is a single-ended channel and typically used for earphone. SPK2P and AGND can form a pseudo differential structure.

All these audio channels support voice and ringtone output, etc., and can be switched to each other by **AT+QAUDCH**. For more details, please refer to ***document [1]***.

Use **AT+QAUDCH** to select audio channel:

- **AT+QAUDCH=0**: AIN/AOUT1, the default value is 0.
- **AT+QAUDCH=1:** AIN/AOUT2, this channel is always used for earphone.

For each channel, customers can use **AT+QMIC** to adjust the input gain level of microphone and **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]***.

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) to filter out RF interference, thus reducing TDD noise. The 33pF capacitor is applied to filter out 900MHz RF interference when the module is transmitting at EGSM900MHz, and without placing this capacitor, TDD noise could be heard; while the 10pF capacitor is used to filter out 1800MHz RF interference. Please note that the frequency resonant 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 RF interference when the module is working at GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz separately.

The severity degree of the RF interference in the audio channel during GSM transmitting largely depends on the application design. In some cases, EGSM900 TDD noise is more severe; while in other cases, DCS1800 TDD noise is more obvious. Therefore, 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 interference 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 RF antenna should be placed away from audio interface and trace. The power trace could not be parallel with and also kept far away from the audio trace.

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 voltage for external electret microphone. A reference circuit is shown in the following figure.

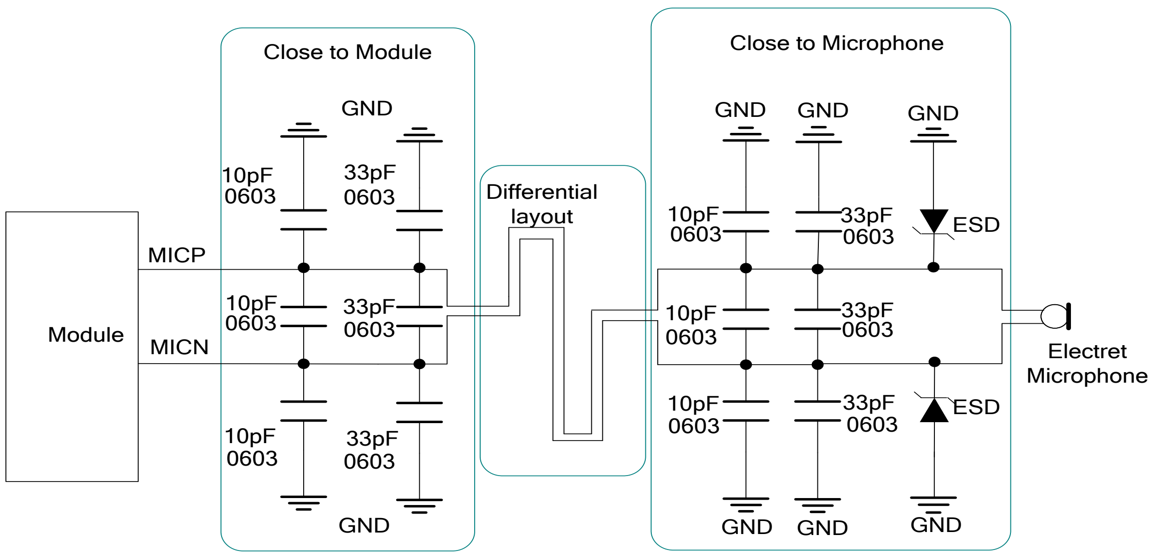

Figure 21: Reference Design for Microphone Interface

3.10.3. Speaker Interface Design

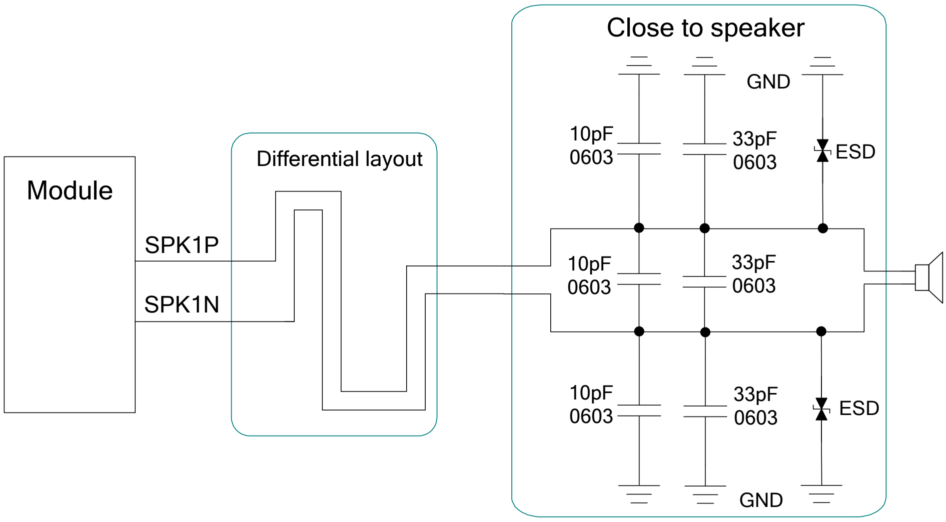

Figure 22: Reference Design for Speaker Interface

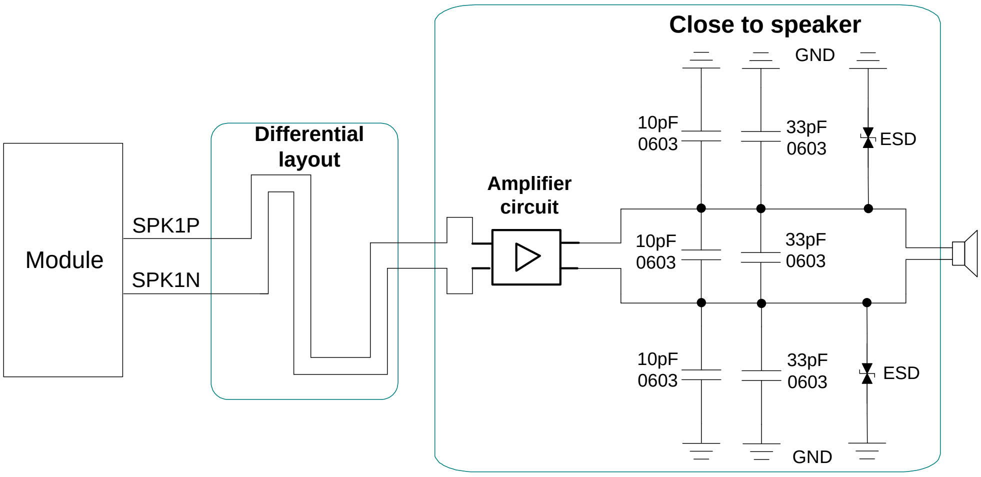

Figure 23: Reference Design for Speaker with an Amplifier

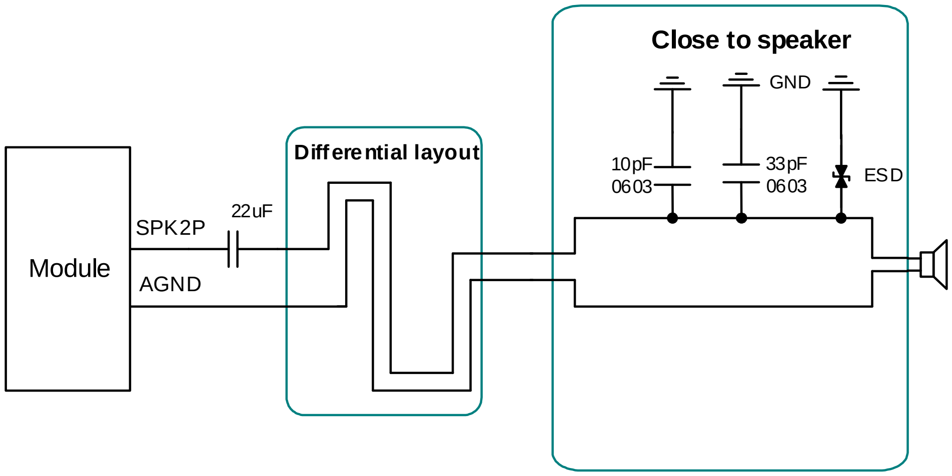

Figure 24: Reference Design for Handset Interface for AOUT2

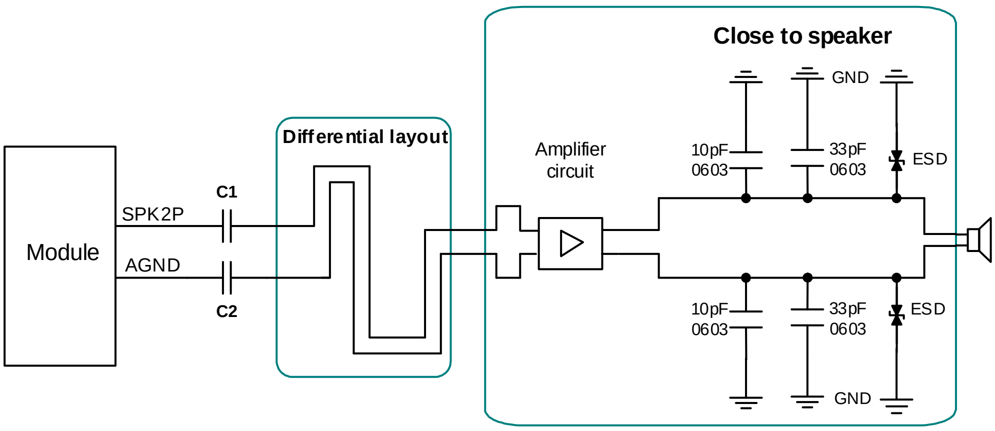

Figure 25: Reference Design for Speaker with an Amplifier for AOUT2

Customers can choose suitable differential audio amplifiers from *Texas Instrument*'s website (http://www.ti.com). There are also other excellent audio amplifier vendors in the market.

NOTE

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

3.10.4. Earphone Interface Design

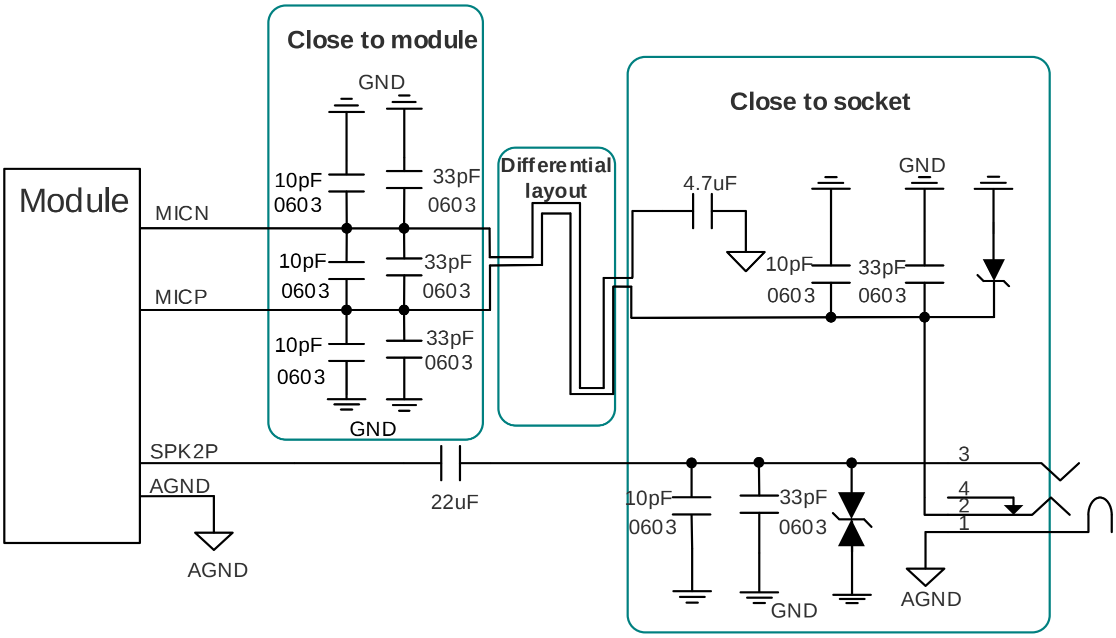

Figure 26: Reference Design for Earphone Interface

3.10.5. Audio Characteristics

Table 10: Typical Electret Microphone Characteristics

Parameter	Min.	Typ.	Max.	Unit
Working Voltage	1.8	2	2.4	V
Working Current			1000	µA
External Microphone Load Resistance	2			KΩ

Table 11: Typical Speaker Characteristics

Parameter			Min.	Typ.	Max.	Unit
AOUT1 Output	Single-ended	Load resistance		32		Ω
		Reference level	0		1.85	Vpp
	Differential	Load resistance		32		Ω

		Reference level	0		3.7	Vpp
AOUT2 Output	Single-ended	Load resistance		32		Ω
		Reference level	0		0.92	Vpp

3.11. PCM Interface*

TBD.

NOTE

"*" means under development.

3.12. (U)SIM Interface

The (U)SIM interface supports the functionality of the GSM Phase 1 specification, the functionality of the new GSM Phase 2+ specification, and FAST 64 kbps (U)SIM card (intended for use with (U)SIM application toolkit) as well.

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

Table 12: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	Description	Multiplexing Function [1)]
SIM_VDD	14	Supply power for (U)SIM card. Automatic detection of (U)SIM card voltage. 3.0V±5% and 1.8V±5%. Maximum supply current is around 10mA.	
SIM_CLK	13	Clock signal of (U)SIM card	
SIM_DATA	11	Data signal of (U)SIM card	
SIM_RST	12	Reset signal of (U)SIM card.	

SIM_GND	10	(U)SIM card ground.	
SIM_PRESENCE	19	(U)SIM card insertion detection.	DTR

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.

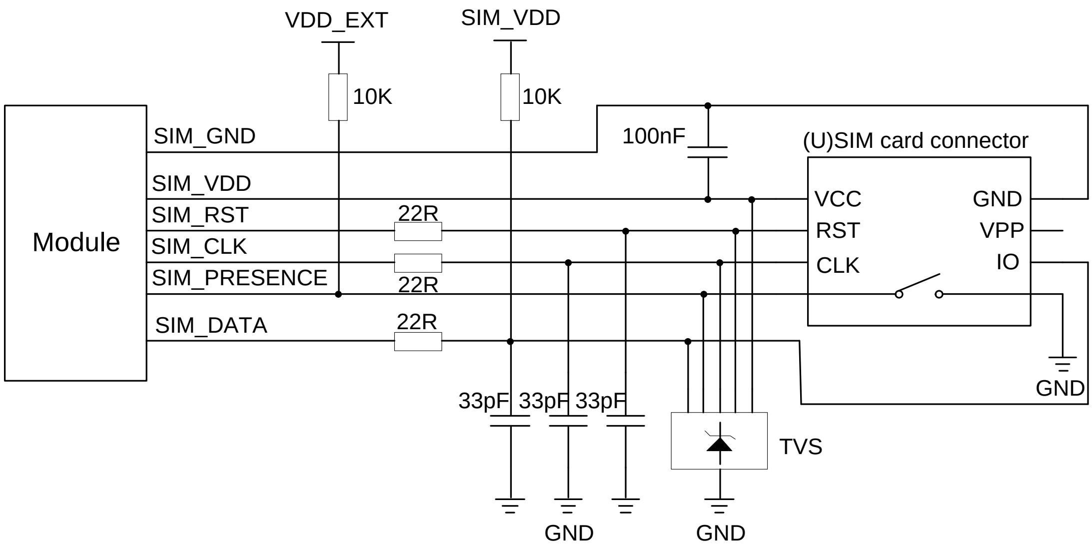

Figure 27: Reference Circuit for (U)SIM Interface with the 8-pin (U)SIM Card Connector

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.

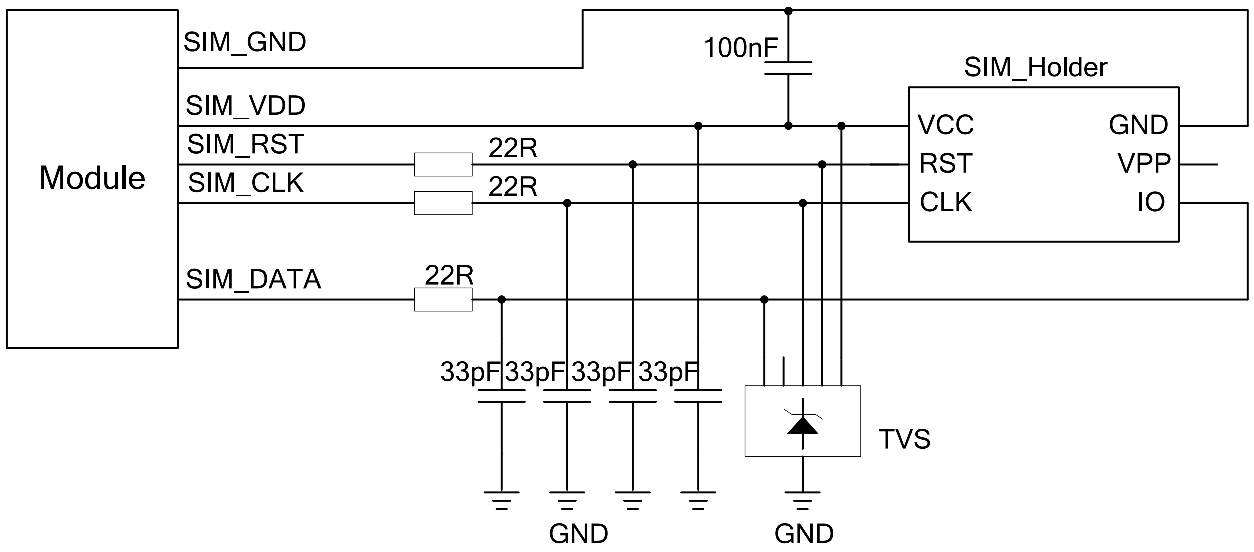

Figure 28: Reference Circuit for (U)SIM Interface with the 6-pin (U)SIM Card Connector

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

- Keep the placement of (U)SIM card connector as close as possible to the module. Keep the trace length less than 200mm as far as possible.
- Keep (U)SIM card signals away from RF and VBAT traces.
- Assure the trace between the ground of module and that of (U)SIM card connector is short and wide. Keep the trace width of ground no less than 0.5mm to maintain the same electric potential. The bypass capacitor between SIM_VDD and SIM_GND should be not 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 not 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 from (U)SIM card connector first 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 upon applying of long layout trace and sensitive occasion, and it should be placed close to the (U)SIM card connector.

3.13. ADC

The module provides an ADC channel to measure the value of voltage. Please give priority to the use of ADC0 channel. The value of voltage applied on ADC0 channel can be read by **AT+QADC**. For details of this AT command, please refer to the ***document [1]***.

In order to improve the accuracy of ADC, the layout of ADC should be surrounded by ground.

Table 13: Pin Definition of ADC

Pin Name	Pin No.	Description
AVDD	8	Reference voltage of ADC circuit
ADC0	9	Analog to digital converter.

Table 14: Characteristics of ADC

Item	Min.	Typ.	Max.	Units
Voltage Range	0		1.8	V
ADC Resolution		10		bits
ADC Accuracy		2.7		mV

3.14. RI Behaviors

Table 15: RI Behaviors

State	RI Response
Standby	HIGH
Voice call	Change to LOW, then: 1. Change to HIGH when call is established. 2. Use ATH to hang up the call; RI changes to HIGH. 3. Caller hangs up, RI changes to HIGH first, and changes to LOW for 120ms indicating URC “NO CARRIER”, then changes to HIGH again.

	4. Change to HIGH when SMS is received.
SMS	When a new SMS comes, RI changes to LOW and holds for about 120ms, then changes to HIGH.
URC	Certain URCs can cause RI staying in LOW for 120ms.

If the module is used as a caller, RI would remain in HIGH except URC or SMS is received.

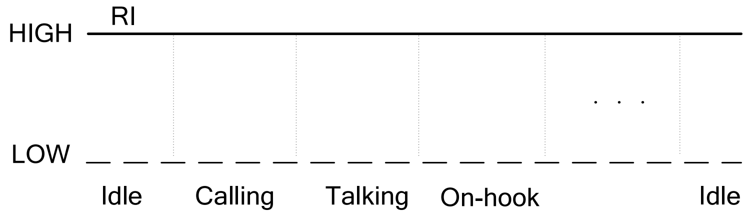

Figure 29: RI Behavior as a Caller

On the other hand, when it is used as a receiver, the timing of RI is shown below.

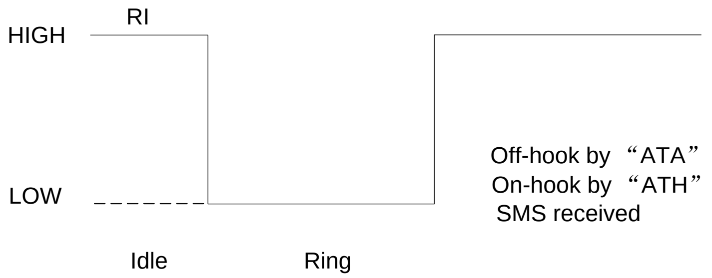

Figure 30: RI Behavior as a Receiver of Voice Calling

When URC or SMS is received, the timing of RI is shown below.

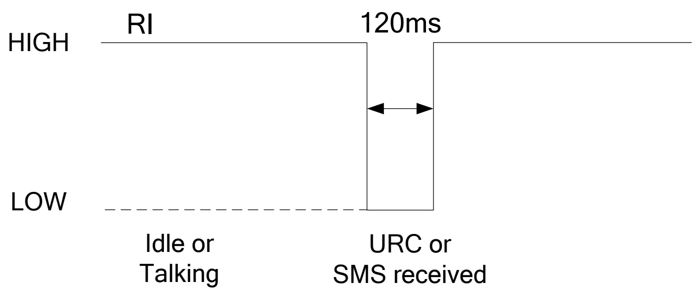

Figure 31: RI Behavior of URC or SMS Received

3.15. 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 16: Working State of NETLIGHT

State	Module Function
OFF	The module is not running.
64ms ON/800ms OFF	The module is not synchronized with network.
64ms ON/2000ms OFF	The module is synchronized with network.
64ms ON/600ms OFF	GPRS data transmission upon PPP dial-up connection.

A reference circuit is shown as below.

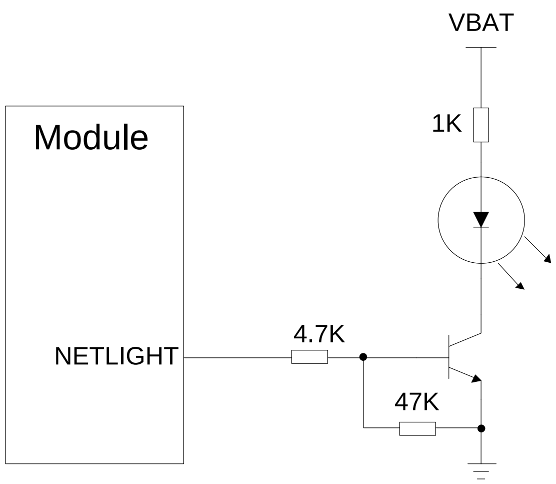

Figure 32: Reference Design for NETLIGHT

3.16. RF Transmitting Signal Indication

The module provides a RFTXMON pin which will rise when the transmitter is active and fall after the transmitting activity is completed.

Table 17: Pin Definition of RFTXMON

Pin Name	Pin No.	Description
RFTXMON	25	Transmission signal indication

There are two different modes for this function:

1) Active during the transmitting activity

RFTXMON is used to indicate the transmit burst. If it outputs a high level, there will be a transmit burst 220us later.

AT+QCFG="RFTXburst",1 can be executed to enable the function.

The timing of the RFTXMON signal is shown below.

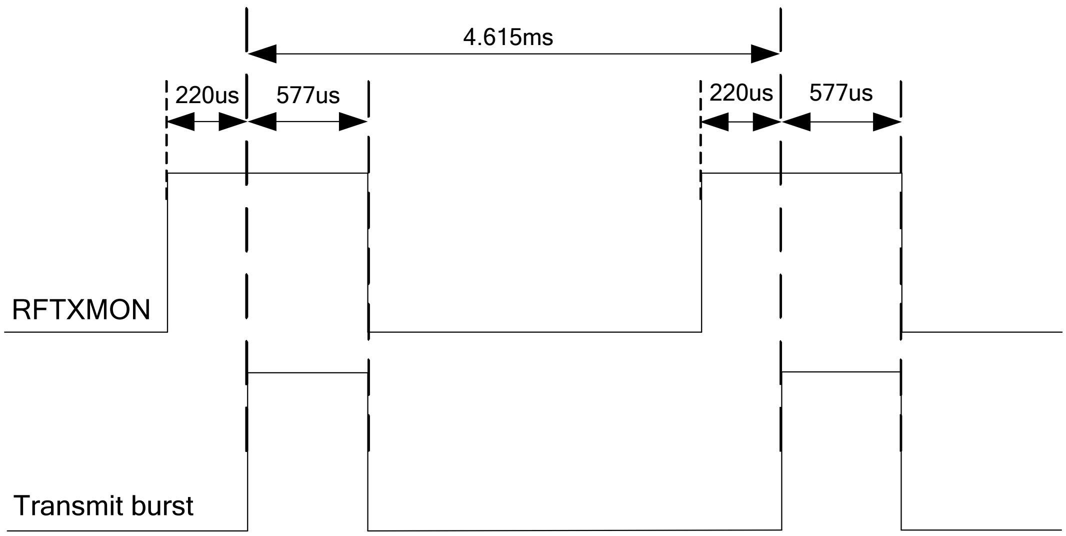

Figure 33: RFTXMON Signal During Burst Transmission

2) Active during the call

RFTXMON will output a high level during a call and the pin will output a low level after being hanged up.

AT+QCFG="RFTXburst",2 can be executed to enable the function.

The timing of the RFTXMON signal is shown below.

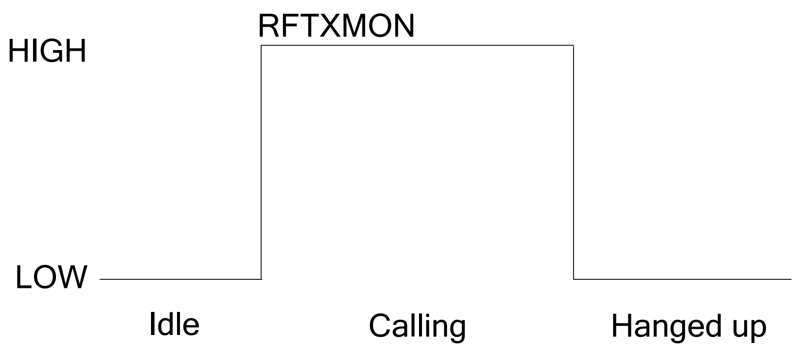

Figure 34: RFTXMON Signal During Call

4 Antenna Interface

4.1. GSM Antenna Interface

M65 has a GSM antenna interface with an impedance of 50Ω. The pin definition of GSM antenna interface is as follows:

Table 18: Pin Definition of GSM Antenna Interface

Pin Name	Pin No.	Description
RF_ANT	35	GSM antenna pad
GND	34, 36, 37	Ground

4.1.1. Reference Design

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

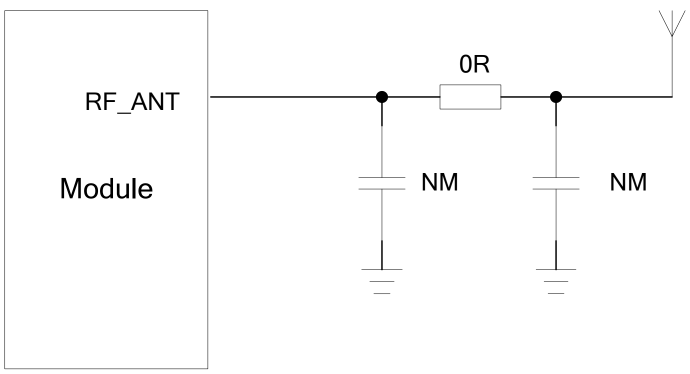

Figure 35: Reference Design for GSM Antenna

M65 provides an RF antenna pad for antenna connection. The RF trace in host PCB connected to the module RF antenna pad should be coplanar waveguide line or microstrip line, whose characteristic impedance should be close to 50Ω. M65 comes with grounding pads which are next to the antenna pad in order to give a better grounding. Besides, a π type match circuit is suggested to be used to adjust the RF performance.

To minimize the loss on RF trace and RF cable, please take design into account carefully. The following table shows the requirement on GSM antenna.

Table 19: Antenna Cable Requirements

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

Table 20: Antenna Requirements

Type	Requirements
Frequency Range	GSM850/EGSM900/DCS1800/PCS1900
VSWR	≤ 2
Gain (dBi)	1
Max Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Vertical

4.1.2. RF Output Power

Table 21: 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

4.1.3. RF Receiving Sensitivity

Table 22: RF Receiving Sensitivity

Frequency	Receive Sensitivity
GSM850	< -108dBm
EGSM900	< -108dBm
DCS1800	< -107dBm
PCS1900	< -107dBm

4.1.4. Operating Frequencies

Table 23: Operating Frequencies

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

4.1.5. RF Cable Soldering

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

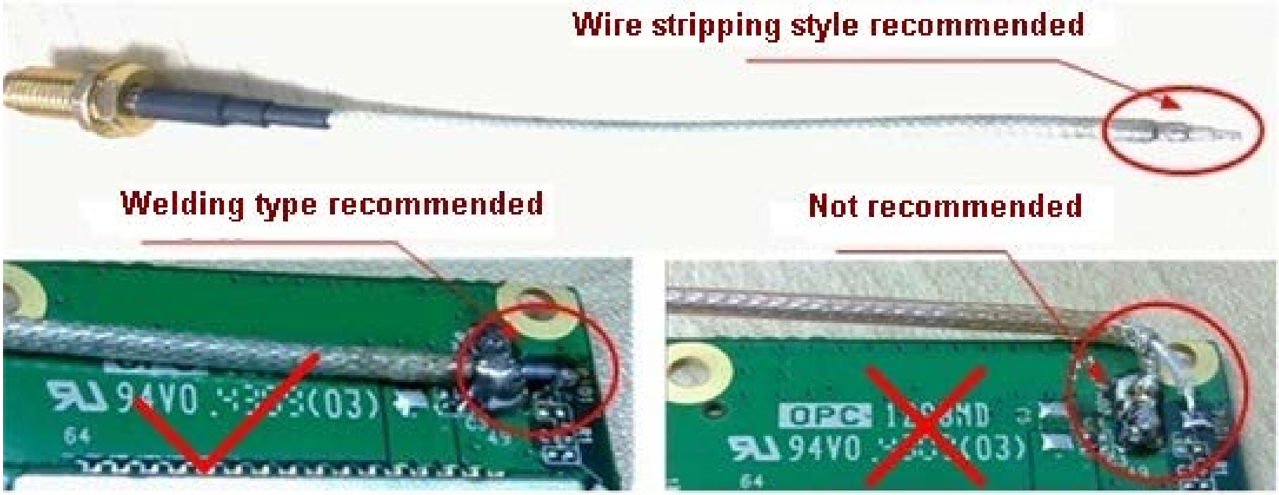

Figure 36: RF Soldering Sample

5 Electrical, Reliability and Radio Characteristics

5.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of module are listed in the following table:

Table 24: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT	-0.3	+4.5	V
Peak Current of Power Supply	0	2.0	A
RMS Current of Power Supply (during one TDMA-frame)	0	0.7	A
Voltage at Digital Pins	-0.3	3.08	V
Voltage at Analog Pins	-0.3	3.08	V

5.2. Operation and Storage Temperatures

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

Table 25: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operation temperature range [1)]	-35	+25	+75	°C
Extended temperature range [2)]	-40		+85	°C

Storage Temperature Range	-40		+90	°C

NOTES

1. 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, 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 26: The Module Power Supply Ratings

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 burst transmission	Maximum power control level on GSM850 and EGSM900.			400	mV
I_{VBAT}	Average supply current	Power down mode Sleep mode @DRX=5		39 1.2		μA mA
		Minimum functionality mode **AT+CFUN=0** Idle mode Sleep mode **AT+CFUN=4** Idle mode Sleep mode		 9.5 0.8 9.5 0.8		 mA mA mA mA
		Talk mode GSM850/EGSM900 [1)] DCS1800/PCS1900 [2)]		 241/229 178/156		 mA mA
		Data mode, GPRS (3 Rx, 2 Tx) GSM850/EGSM900 [1)] DCS1800/PCS1900 [2)]		 366/343 251/222		 mA mA
		Data mode, GPRS (2 Rx, 3 Tx) GSM850/EGSM900 [1)]		 423/397		 mA

		DCS1800/PCS1900 2)	283/254		mA
		Data mode, GPRS (4 Rx, 1 Tx) GSM850/EGSM900 1) DCS1800/PCS1900 2)	 234/221 165/149		 mA mA
		Data mode, GPRS (1 Rx, 4 Tx) GSM850/EGSM900 1) DCS1800/PCS1900 2)	 457/437 315/283		 mA mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM850 and EGSM900.	1.8	2	A

NOTES

1. 1) Power control level PCL 5.
2. 2) Power control level PCL 0.

5.4. Current Consumption

Table 27: The Module Current Consumption

Condition	Current Consumption
Voice Call	
GSM850	@power level #5 <300mA, Typical 241mA @power level #12, Typical 103mA @power level #19, Typical 73mA
EGSM900	@power level #5 <300mA, Typical 229mA @power level #12, Typical 102mA @power level #19, Typical 74mA
DCS1800	@power level #0 <250mA, Typical 177mA @power level #7, Typical 87mA @power level #15, Typical 68mA
PCS1900	@power level #0 <250mA, Typical 156mA @power level #7, Typical 85mA @power level #15, Typical 67mA
GPRS Data	
DATA Mode, GPRS (3 Rx, 2 Tx) CLASS 12	

GSM850	@power level #5 <550mA, Typical 366mA
EGSM900	@power level #5 <550mA, Typical 343mA
DCS1800	@power level #0 <450mA, Typical 251mA
PCS1900	@power level #0 <450mA, Typical 222mA
DATA Mode, GPRS (2 Rx, 3 Tx) CLASS 12	
GSM850	@power level #5 <640mA, Typical 423mA
EGSM900	@power level #5 <600mA, Typical 397mA
DCS1800	@power level #0 <490mA, Typical 283mA
PCS1900	@power level #0 <490mA, Typical 254mA
DATA Mode, GPRS (4 Rx,1 Tx) CLASS 12	
GSM850	@power level #5 <350mA, Typical 234mA
EGSM900	@power level #5 <350mA, Typical 221mA
DCS1800	@power level #0 <300mA, Typical 165mA
PCS1900	@power level #0 <300mA, Typical 149mA
DATA Mode, GPRS (1 Rx, 4 Tx) CLASS 12	
GSM850	@power level #5 <660mA, Typical 453mA
EGSM900	@power level #5 <660mA, Typical 437mA
DCS1800	@power level #0 <530mA, Typical 315mA
PCS1900	@power level #0 <530mA, Typical 283mA

NOTE

GPRS Class 12 is the default setting. The module can be configured from GPRS Class 1 to Class 12. Setting to lower GPRS class would make it easier to design the power supply for the module.

5.5. Electrostatic Discharge

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

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

Table 28: Electrostatic Discharge Characteristics (25ºC, 45% Relative Humidity)

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

6 Mechanical Dimensions

This chapter describes the mechanical dimensions of M65 module. All dimensions are measured in mm, and the tolerances for dimensions without tolerance values are ±0.05mm.

6.1. Mechanical Dimensions of the Module

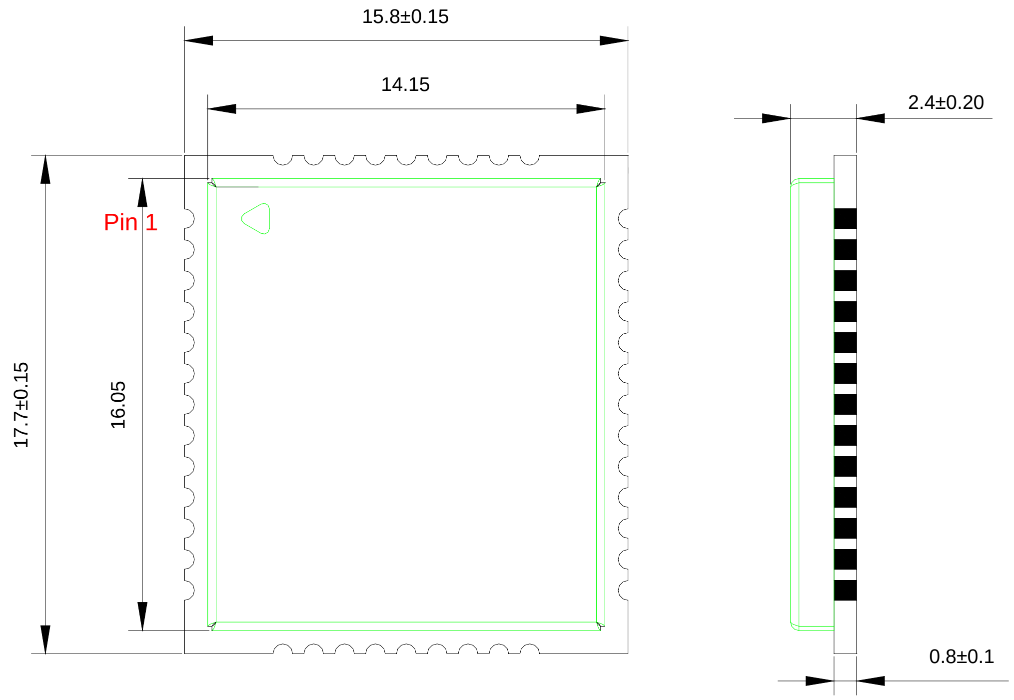

Figure 37: M65 Module Top and Side Dimensions

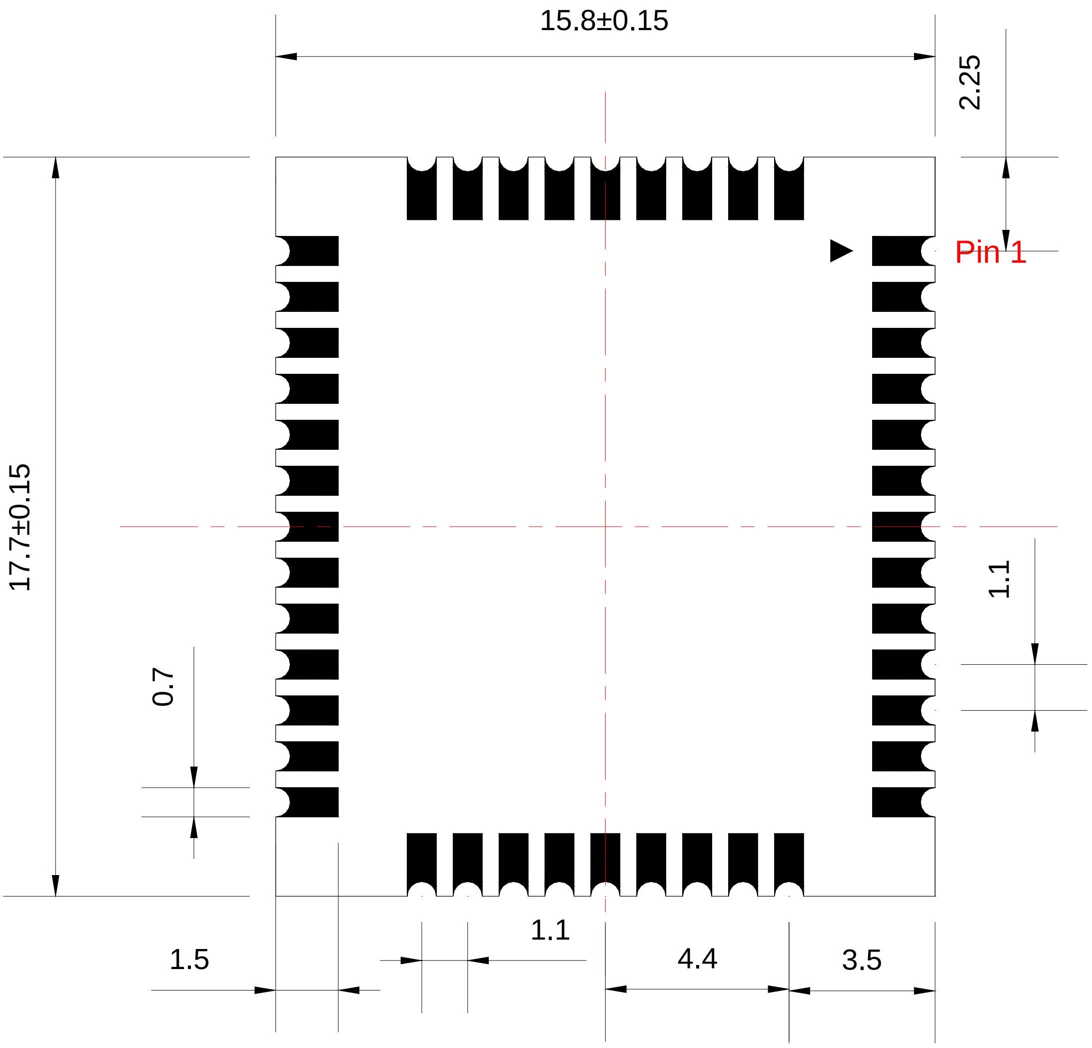

Figure 38: M65 Module Bottom Dimensions

6.2. Recommended Footprint

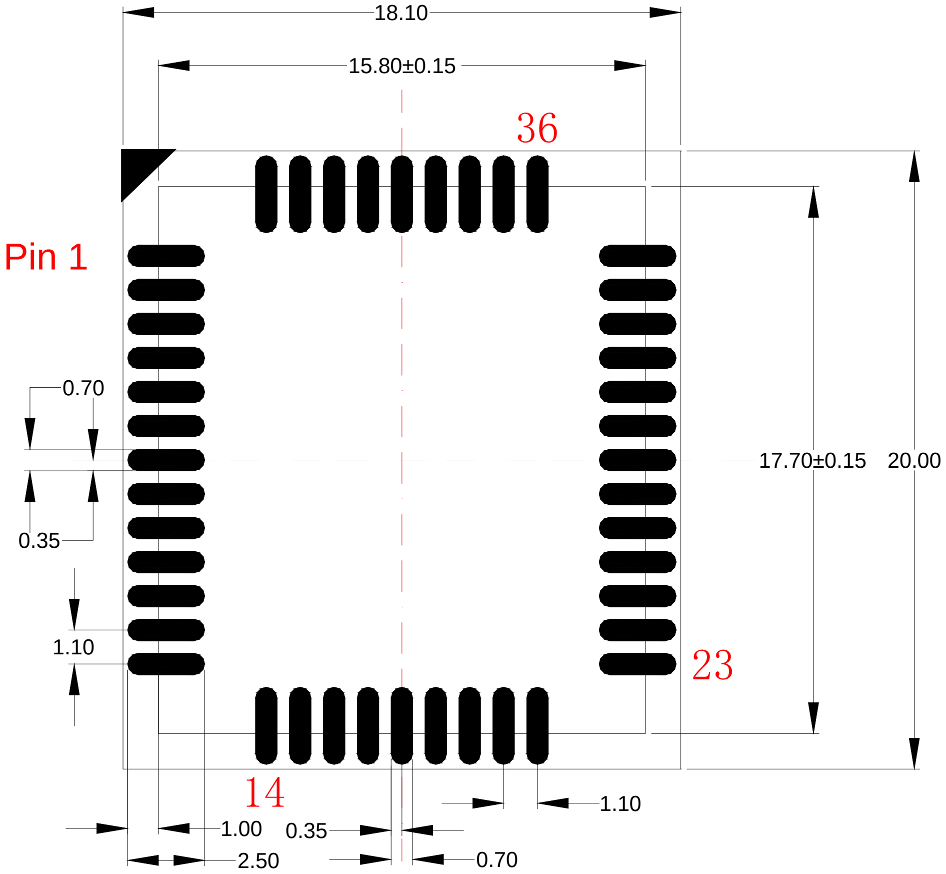

Figure 39: Recommended Footprint (Top View)

NOTES

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 40: Top View of the Module

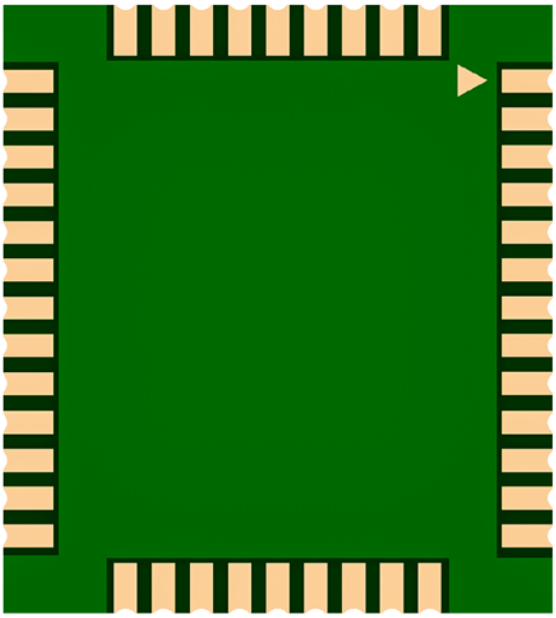

Figure 41: Bottom View of the Module

NOTE

These are renderings of M65 module. For authentic appearance, please refer to the module that you receive from Quectel.

7 Storage and Manufacturing

7.1. Storage

M65 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%.

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 0.15mm~0.18mm. For more details, please refer to ***document [5]***.

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.

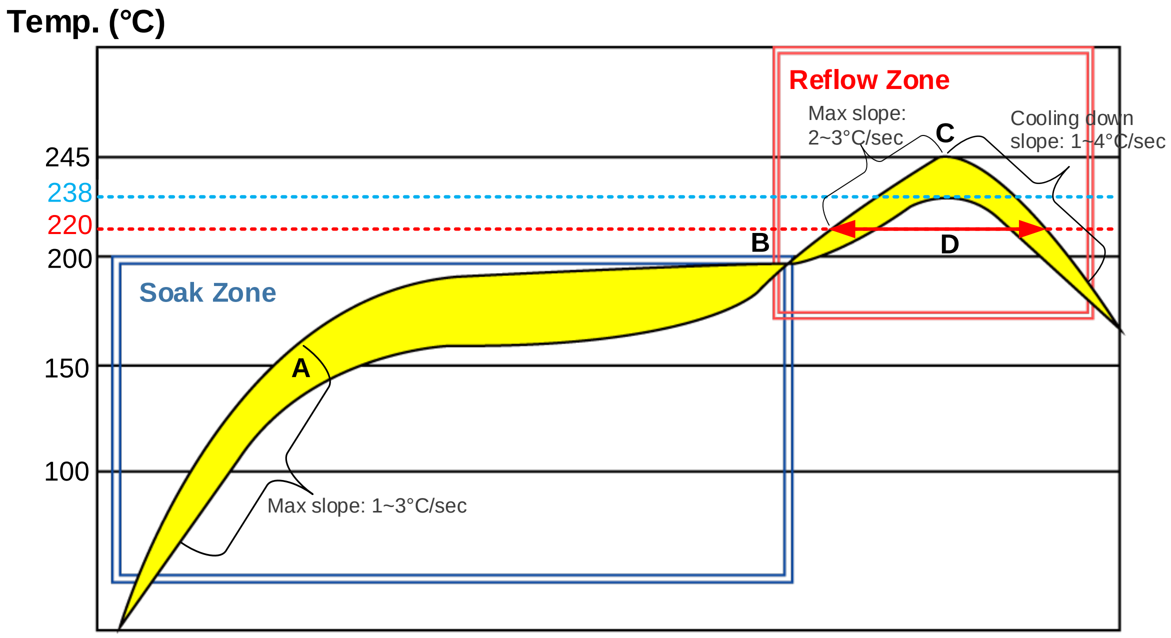

Figure 42: Recommended Reflow Soldering Thermal Profile

Table 29: 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°C ~ 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

M65 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.

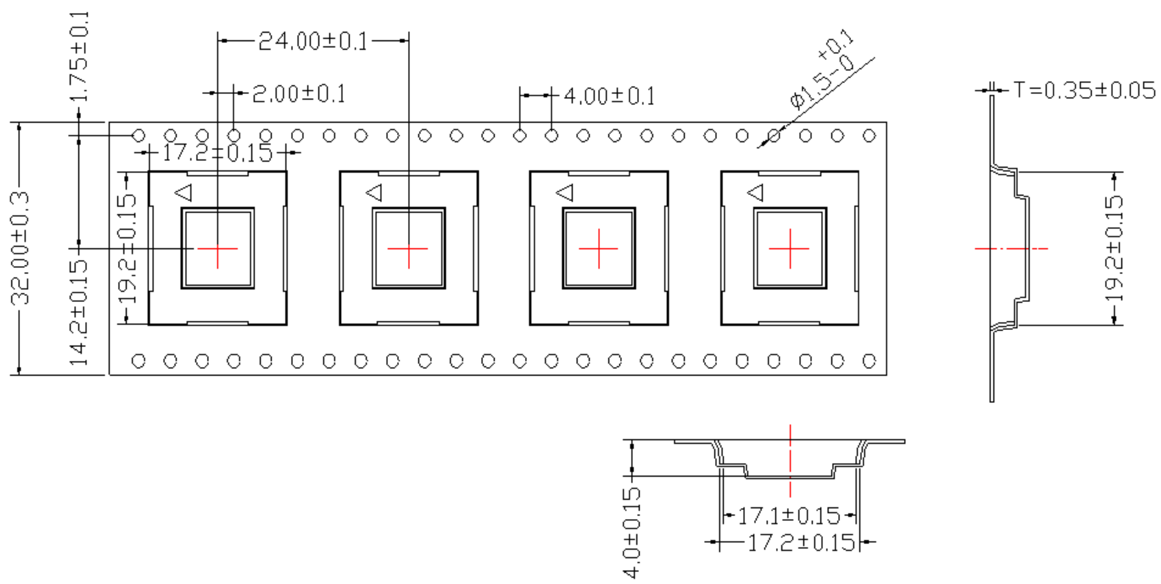

Figure 43: Tape Dimensions

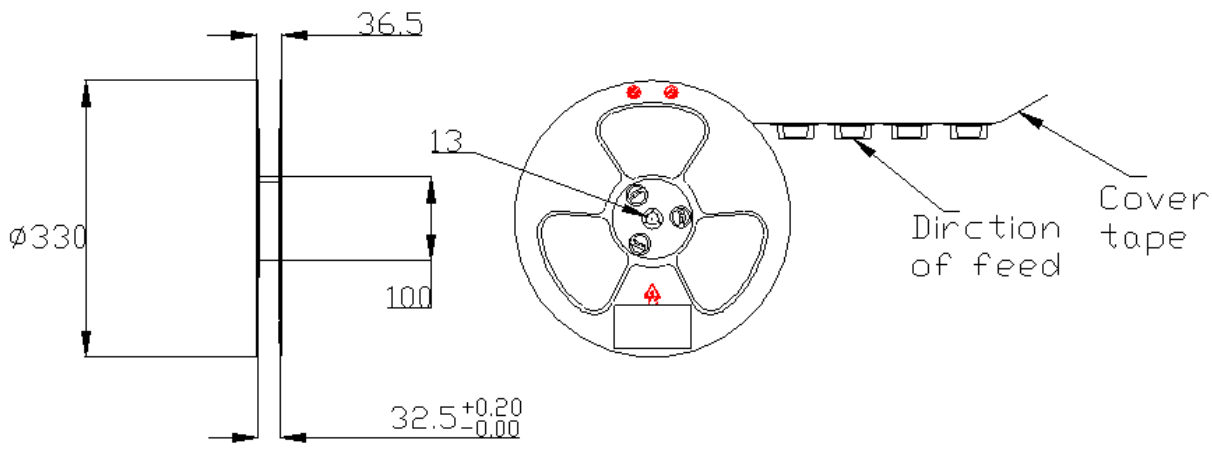

Figure 44: Reel Dimensions

Table 30: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 250pcs	Minimum Package x 4=1000pcs
M65	250pcs	Size: 370mm × 350mm × 56mm N.W: 0.32kg G.W: 1.08kg	Size: 380mm × 250mm × 365mm N.W: 1.28kg G.W: 4.8kg

8 Appendix A References

Table 31: Reference Documents

SN	Document Name	Remark
[1]	Quectel_M65_AT_Commands_Manual	M65 AT commands manual
[2]	Quectel_GSM_UART_Application_Note	GSM UART port application note
[3]	Quectel_GSM_EVB_User_Guide	GSM EVB user guide
[4]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[5]	Quectel_Module_Secondary_SMT_User_Guide	Module secondary SMT user guide
[6]	Quectel_GSM_Module_Digital_IO_Application_Note	GSM Module Digital IO Application Note
[7]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[8]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[9]	GSM 07.05	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[10]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the (U)SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment ((U)SIM – ME) interface
[11]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment ((U)SIM – ME) interface

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

Table 32: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
ARFCH	Absolute Radio Frequency Channel Number
ASIC	Application Specific Integrated Circuit
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CTS	Clear to Send
DRX	Discontinuous Reception
DCE	Data Communications Equipment (typically module)
DTE	Data Terminal Equipment (typically computer, external controller)
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FR	Full Rate
GPRS	General Packet Radio Service

GSM	Global System for Mobile Communications
G.W	Gross Weight
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
$I_O$max	Maximum Output Load Current
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
ME	Mobile Equipment
MOQ	Minimum Order Quantity
MP	Manufacture Product
MS	Mobile Station (GSM engine)
MT	Mobile Terminated
N.W	Net Weight
PAP	Password Authentication Protocol
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
RX	Receive Direction
(U)SIM	(Universal) Subscriber Identification Module
SMS	Short Message Service
TDMA	Time Division Multiple Access

TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code
USSD	Unstructured Supplementary Service Data
$V_O$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
Phonebook Abbreviations	
LD	(U)SIM Last Dialing phonebook (list of numbers most recently dialed)
MC	ME list of unanswered MT Calls (missed calls)
ON	(U)SIM (or ME) Own Numbers (MSISDNs) list
RC	ME 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 33: Description of Different Coding Schemes

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

Radio block structure of CS-1, CS-2 and CS-3 is shown as the figure below.

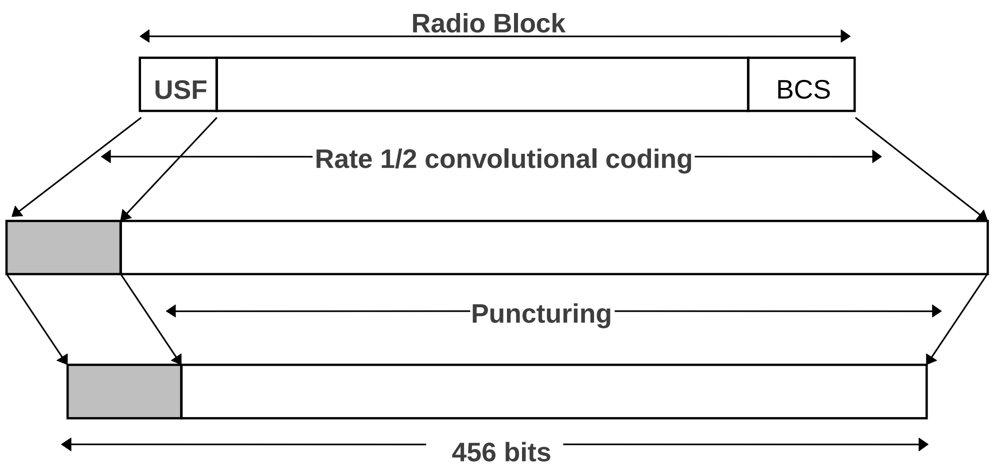

Figure 45: Radio Block Structure of CS-1, CS-2 and CS-3

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

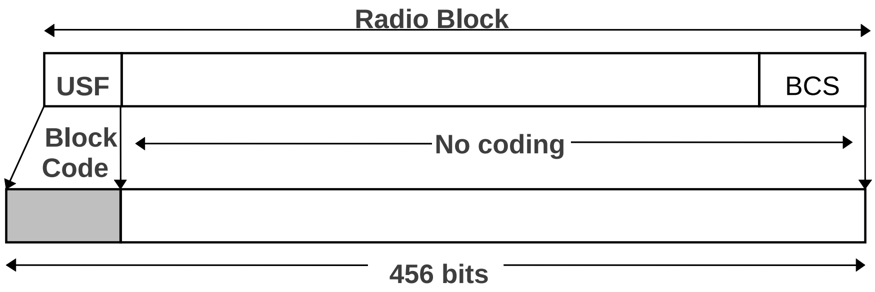

Figure 46: Radio Block Structure of CS-4

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 34: GPRS Multi-slot Classes

Multislot Class	Downlink Slots	Uplink Slots	Active Slots
1	1	1	2
2	2	1	3
3	2	2	3
4	3	1	4
5	2	2	4
6	3	2	4
7	3	3	4
8	4	1	5
9	3	2	5
10	4	2	5
11	4	3	5
12	4	4	5