M66 R2.0 Hardware Design

GSM/GPRS Module Series

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About the Document

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1 Introduction

This document defines the M66 R2.0 module and describes its air interface and hardware interface which are connected with the customers' applications.

This document can help customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. Associated with application note and user guide, customers can use M66 R2.0 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 M66 R2.0 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. You must comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it is switched off. The operation of wireless appliances in an aircraft is forbidden, so as to prevent interference with communication systems. Consult the airline staff about the use of wireless devices on boarding the aircraft, if your device offers an Airplane Mode which must be enabled prior to boarding an aircraft.
	Switch off your wireless device when in hospitals, clinics or other health care facilities. These requests are designed to prevent possible interference with sensitive medical equipment.
	Cellular terminals or mobiles operating over radio frequency signal and cellular network cannot be guaranteed to connect in all conditions, for example no mobile fee or with an invalid (U)SIM card. While you are in this condition and need emergent help, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength.
	Your cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency energy. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with 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

M66 R2.0 is a quad-band GSM/GPRS engine that works at frequencies of GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. It features GPRS multi-slot class 12 and supports the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. For more details about GPRS multi-slot classes and coding schemes, please refer to the ***Appendix B*** and ***C.***

With an ultra-compact profile of 17.7mm × 15.8mm × 2.3mm, the module can meet almost all the requirements for M2M applications, including vehicles and personal tracking, security system, wireless POS, industrial PDA, smart metering, remote maintenance and control, etc.

M66 R2.0 is an SMD type module with LCC package, and thus can be easily embedded into applications. It provides abundant hardware interfaces including PCM, UART, (U)SIM, and more.

Due to adoption of power saving technique, the current consumption of M66 R2.0 is as low as 1.3 mA in sleep mode when DRX is 5.

M66 R2.0 is integrated with Internet service protocols, such as TCP/UDP, FTP, HTTP(S) and PPP. Extended AT commands have been developed for customers to use these Internet service protocols easily.

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

2.2. Key Features

The following table describes the detailed features of M66 R2.0 module.

Table 1: Module Key Features

Feature	Details
Power Supply	Supply voltage: 3.3V ~ 4.6V Typical supply voltage: 4.0V

Power Saving	Typical power consumption in sleep mode: 1.3 mA @DRX=5 1.2 mA @DRX=9
Frequency Bands	● Quad-band: GSM850, EGSM900, DCS1800, PCS1900. ● The module can search these frequency bands automatically ● The operation band can be set by AT command ● Compliant to GSM Phase 2/2+
GSM Class	Small MS
Transmitting Power	● Class 4 (2W) at GSM850 and EGSM900 ● Class 1 (1W) at DCS1800 and PCS1900
GPRS Connectivity	● GPRS multi-slot class 12 (default) ● GPRS multi-slot class 1~12 (configurable) ● GPRS mobile station class B
Data GPRS	● GPRS data downlink transfer: max. 85.6kbps ● GPRS data uplink transfer: max. 85.6kbps ● Coding scheme: CS-1, CS-2, CS-3 and CS-4 ● Support PAP (Password Authentication Protocol) usually used for PPP connections ● Internet service protocols TCP/UDP, FTP, PPP, HTTP(S), NTP and PING ● Support Packet Broadcast Control Channel (PBCCH) ● Support Unstructured Supplementary Service Data (USSD)
SMS	● Text and PDU mode ● SMS storage: (U)SIM card
(U)SIM Interface	Support (U)SIM card: 1.8V, 3.0V
Audio Features	Speech codec modes: ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10) ● Enhanced Full Rate (ETS 06.50/06.60/06.80) ● Adaptive Multi-Rate (AMR) ● Echo Suppression ● Noise Reduction
UART Interfaces	UART Port: ● Seven-wire UART interface Used for AT command communication and GPRS data transmission ● Multiplexing function supported ● Support autobauding from 4800bps to 115200bps Debug Port: ● Two-wire debug port: DBG_TXD and DBG_RXD ● Only used for firmware debugging Auxiliary UART Port: ● Used for AT command communication

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
Real Time Clock	Supported
Physical Characteristics	Size: (17.7±0.15) × (15.8±0.15) × (2.3±0.2)mm Weight: approx. 1.2g
Temperature Range	Operation temperature range: -35°C ~ +75°C [1)] Extended temperature range: -40°C ~ +85°C [2)] Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	Firmware upgrade via UART port
Antenna Interface	Connected to antenna pad with 50 ohm impedance control

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.

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 M66 R2.0 and illustrates the major functional parts.

- Radio frequency part
- Power management

- The peripheral interface
  - Power supply
  - Turn-on/off interface
  - UART interface
  - Audio interface
  - PCM interface
  - (U)SIM interface
  - SD card interface
  - ADC interface
  - RF interface

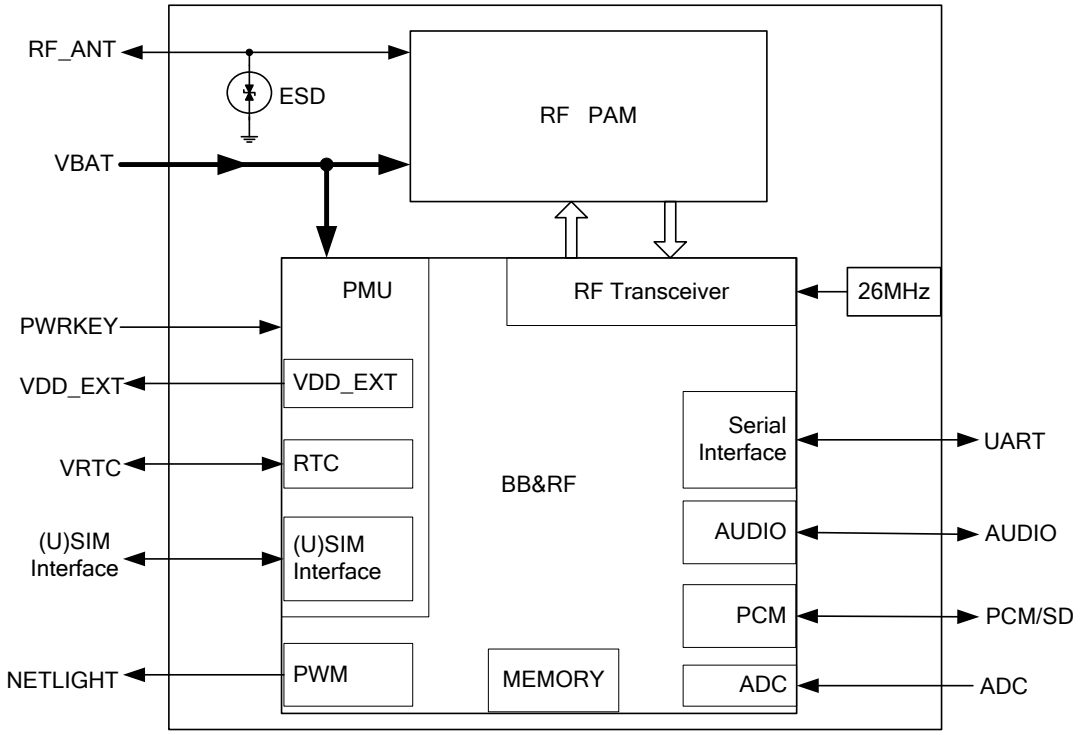

Figure 1: Module Functional Diagram

2.4. Evaluation Board

In order to help customer develop applications conveniently with M66 R2.0, Quectel supplies an evaluation board (GSM EVB), USB to RS-232 cable, power adapter, earphone, antenna and other peripherals to control or test the module. For details, please refer to the ***document [11]***.

3 Application Interfaces

3.1. General Description

The module adopts LCC package and has 44 pins. The following chapters provide detailed descriptions about these pins.

- Pin assignment
- Pin description
- Operating modes
- Power supply
- Power on/down
- Power saving
- RTC
- Serial interfaces
- Audio interfaces
- PCM interface
- (U)SIM interface
- SD card interface
- ADC
- RI behaviors
- Network status indication
- RF transmission signal indication

3.2. Pin Assignment

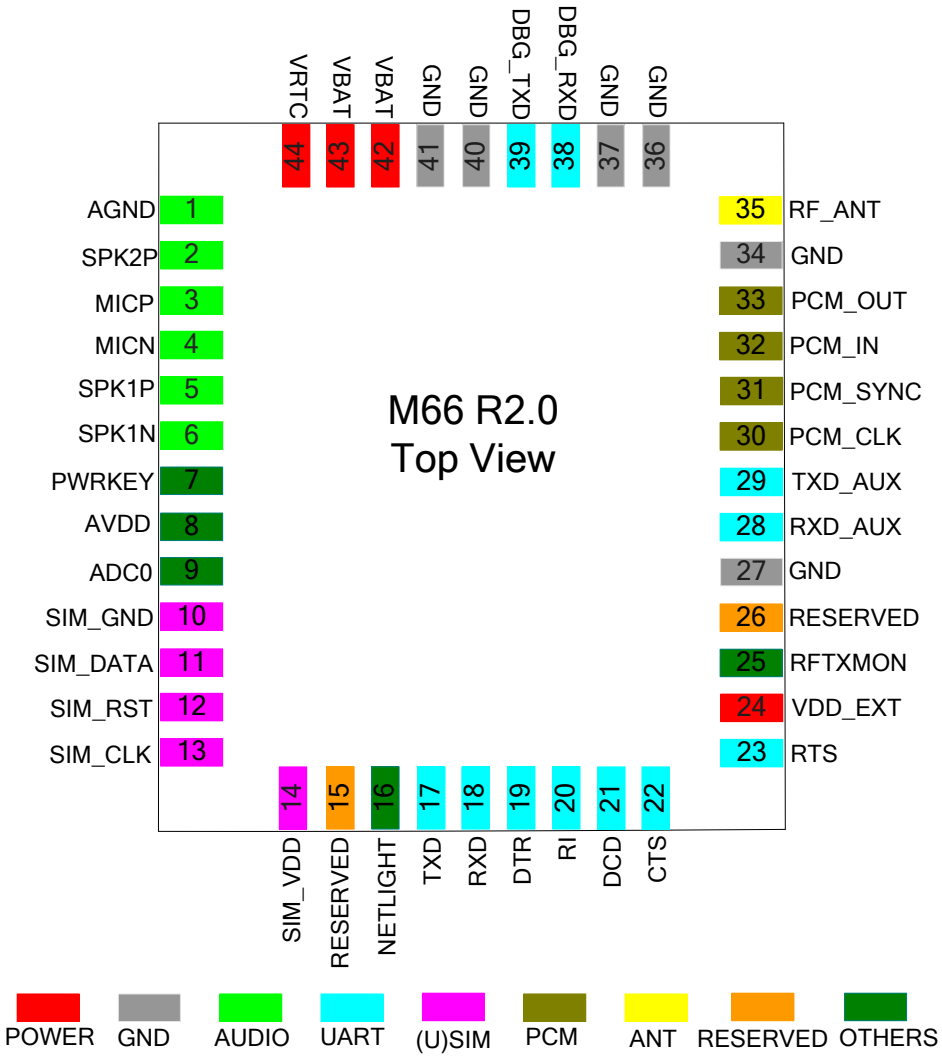

Figure 2: Pin Assignment

NOTE

Keep all reserved pins open.

3.3. Pin Description

Table 3: I/O Parameters Definition

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

Table 4: Pin Description

Power Supply Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	42,43	PI	Main power supply of module: VBAT=3.3V~4.6V	$V_I$max=4.6V $V_I$min=3.3V $V_I$norm=4.0V	It must be able to provide sufficient current up to 1.6A in a transmitting burst.
VRTC	44	IO	Power supply for RTC when VBAT power supply is not available for the system. Charging for backup battery or golden capacitor when VBAT is applied.	$V_I$max=3.3V $V_I$min=1.5V $V_I$norm=2.8V $V_O$max=3.0V $V_O$min=2.0V $V_O$norm=2.8V $I_O$max=2.0mA Iin≈10uA	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	If unused, keep this pin open. Recommend to

				$I_O$max=20mA	add a 2.2~4.7uF bypass capacitor, when using this pin for power supply.
GND	27, 34 36, 37 40, 41		Ground		
PWRKEY Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	7	DI	Power 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 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	Positive and negative voice input	Refer to ***Chapter 3.10***	If unused, keep these pins open.
SPK1P SPK1N	5, 6	AO	Channel 1 positive and negative voice output		If unused, keep these pins open.
SPK2P	2	AO	Channel 2 voice output		Support both voice and ringtone output.
AGND	1		Analog ground. Separate ground connection for external audio circuits.		If unused, keep this pin open.
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.

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 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 Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_TXD	39	DO	Transmit data	The same as UART port	If unused, keep these pins open.
DBG_RXD	38	DI	Receive data		

Auxiliary UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
TXD_AUX	29	DO	Transmit data	The same as UART port	If unused, keep these pins open.
RXD_AUX	28	DI	Receive data		

(U)SIM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SIM_ VDD	14	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. Maximum
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	trace length is 200mm from the module pad to (U)SIM card holder.
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		

ADC Interface

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 interface	Voltage range: 0V to 2.8V	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= 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.
PCM_ SYNC	31	DO	PCM frame synchronization		
PCM_ IN	32	DI	PCM data input		
PCM_ OUT	33	DO	PCM data output		

Antenna Interface

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
RF_ ANT	35	IO	GSM antenna pad	Impedance of 50Ω	

RF Transmission 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 Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RESERVED	15, 26				Keep these pins open.

Table 5: Multiplexed Functions

Pin Name	Pin No.	Function after Reset	Alternate Function [1)]
PCM_SYNC	31	PCM_SYNC	SD_DATA
PCM_IN	32	PCM_IN	SD_CMD
PCM_OUT	33	PCM_OUT	SD_CLK

NOTE

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

3.4. Operating Modes

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

Table 6: Overview of Operating Modes

Mode	Function	
Normal Operation	GSM/GPRS Sleep	After enabling sleep mode by **AT+QSCLK=1**, the module will automatically enter into Sleep Mode if DTR is set to high level and there is no interrupt (such as GPIO interrupt or data on UART port). In this case, the current consumption of module will reduce to the minimal level.

		During sleep mode, the module can still receive paging message and SMS from the system normally.
	GSM Idle	Software is active. The module has registered 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 module is not registered on GPRS network. It is not reachable through GPRS channel.
	GPRS Standby	The module is registered on GPRS network, but no GPRS PDP context is active. The SGSN knows the Routing Area where the module is located at.
	GPRS Ready	The PDP context is active, but no data transfer is ongoing. The module is ready to receive or send GPRS data. The SGSN knows the cell where the module is located at.
	GPRS Data	There is GPRS data in transfer. In this mode, power consumption is decided by the PCL, working RF band and GPRS multi-slot configuration.
Power down	Normal shutdown by sending the **AT+QPOWD=1** command or using the PWRKEY pin. The power management ASIC disconnects the power supply from the base band part of the module, and only the power supply for the RTC is remained. Software is not active. The UART interfaces are not accessible. Operating voltage (connected to VBAT) remains applied.	
Minimum Functionality Mode (without removing power supply)	**AT+CFUN** command can set the module to a minimum functionality mode without removing the power supply. In this case, the RF part of the module will not work or the (U)SIM card will not be accessible, or both RF part and (U)SIM card will be disabled, but the UART port is still accessible. The power consumption in this case is very low.	

3.5. Power Supply

3.5.1. Power Features

Power supply is one of the key issues in designing GSM terminals. Due to the 577us radio burst in GSM 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 must not exceed the minimum working voltage of module.

For M66 R2.0 module, the maximum current consumption 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 module, it is recommended that the maximum voltage drop during the burst transmission does not exceed 400mV.

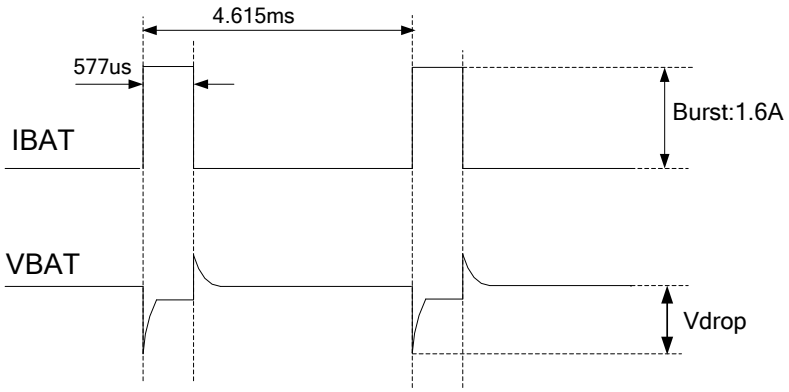

Figure 3: Voltage Ripple during Transmitting

3.5.2. Decrease Supply Voltage Drop

Power supply range of the module is from 3.3V to 4.6V. Please make sure that the input voltage will never drop below 3.3V even in a burst transmission. If the power voltage drops below 3.3V, 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 a ceramic capacitor array (100nF, 33pF and 10pF) near the VBAT pin. A reference circuit is illustrated in the figure below.

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.

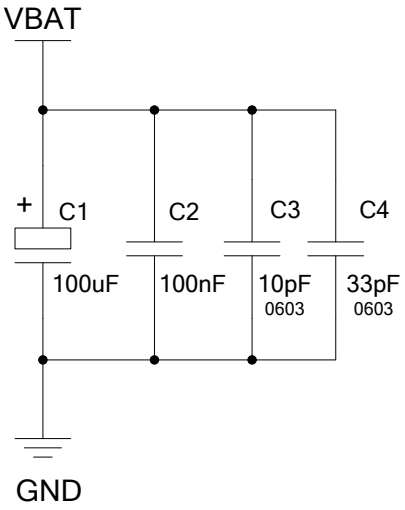

Figure 4: Reference Circuit for the VBAT Input

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 of M66 R2.0 should be able to provide sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is recommended to use an LDO to supply power for the module. If there is a big voltage difference between the input source and the desired output (VBAT), a switching power converter is recommended to be used as the power supply.

The following figure shows a reference design for +5V input power source. The designed output for the power supply is 4.0V and the maximum load current is 3.0A. In order to get a stable output voltage, it is recommended to use a zener diode with reverse zener voltage of 5.1V and dissipation power more than 1.0W, and place it as close to the VBAT pins as possible.

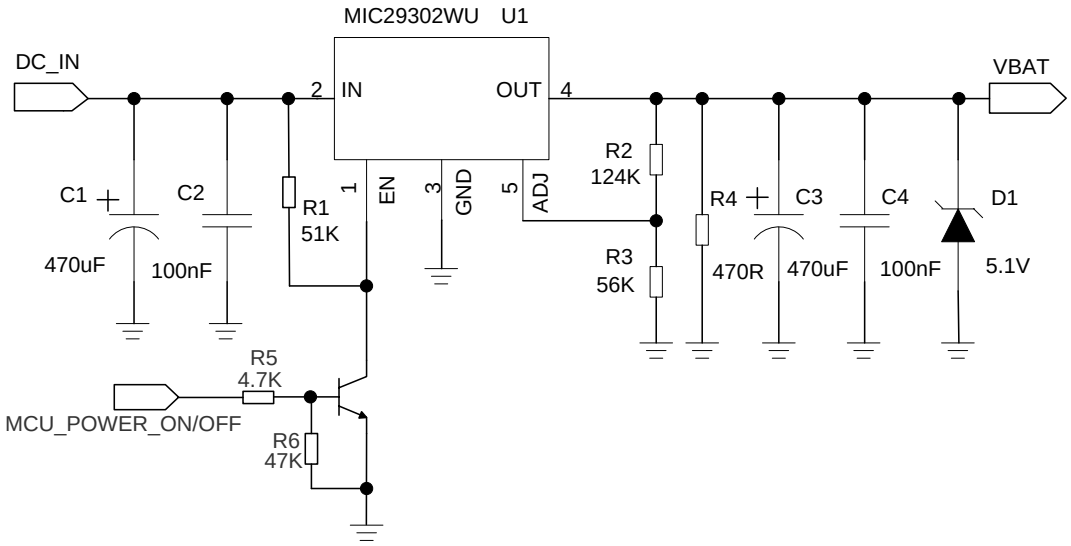

Figure 5: Reference Circuit for Power Supply

NOTE

It is recommended 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

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

3.6. Power on and down Scenarios

3.6.1. Power on

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

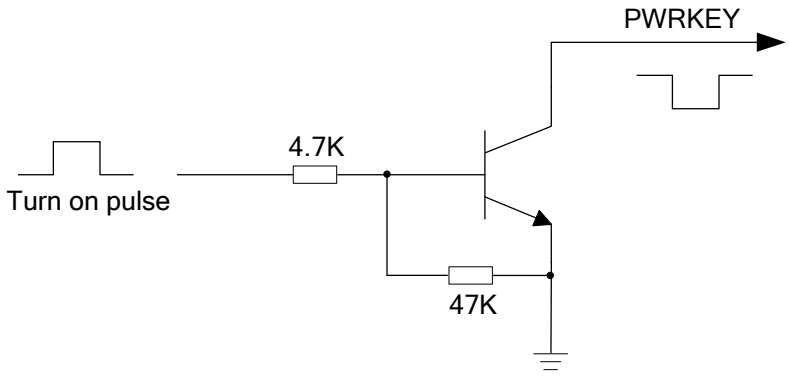

Figure 6: Turn on the Module with an Open-collector Driver

NOTES

1. M66 R2.0 module 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 4~5s, 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 UART port of the module every time when the module is powered on. For more details, refer to the **AT+IPR** command 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. When pressing the key, electrostatic strike may generate from 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.

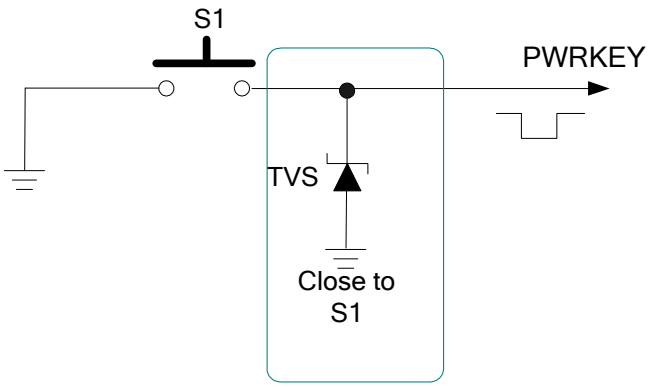

Figure 7: Turn on the Module with a Button

The turn-on scenario is illustrated in the following figure.

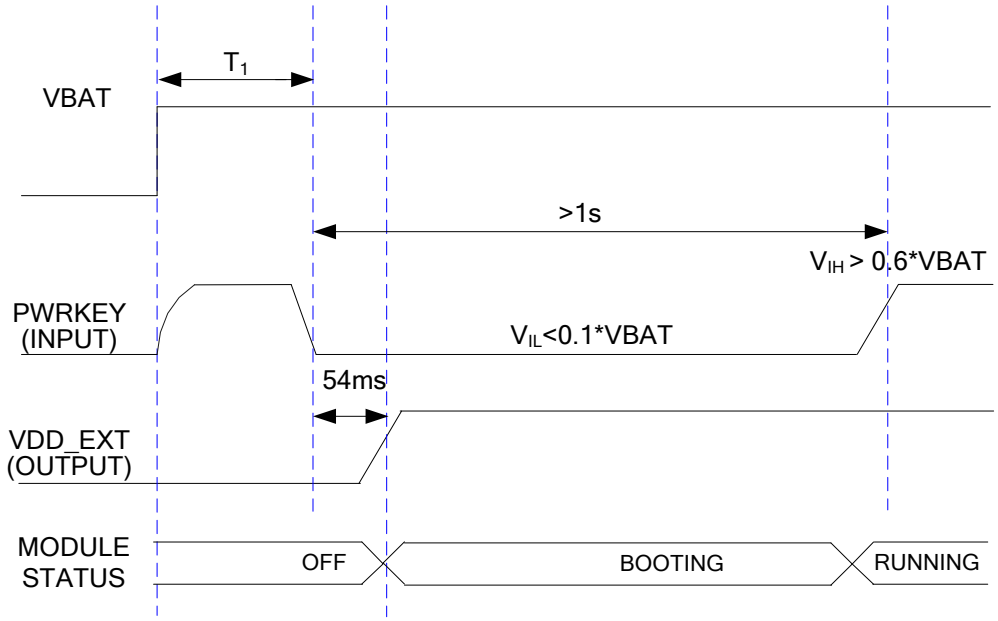

Figure 8: Turn-on Timing

NOTE

Make sure that VBAT is stable before pulling down PWRKEY pin. The time of T_1 is recommended to be 100ms.

3.6.2. Power down

Either of the following will turn off the module:

- Normal power down: Turn off module using the PWRKEY pin
- Normal power down: Turn off module using **AT+QPOWD** command
- Under-voltage automatic shutdown: Take effect when under-voltage is detected.

3.6.2.1. Power down Module Using the PWRKEY Pin

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

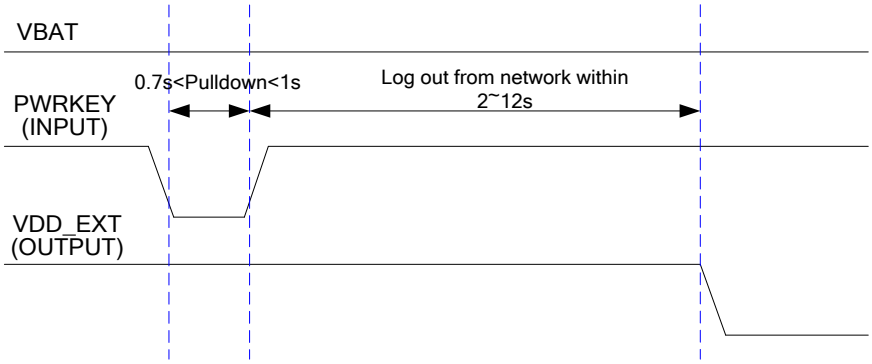

Figure 9: Turn-off Timing

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

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

NORMAL POWER DOWN

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

NOTES

1. When the above unsolicited result code does not appear when autobauding is active and DTE & DCE are not correctly synchronized after start-up, 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.

3.6.2.2. Power down Module Using AT Command

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

NORMAL POWER DOWN

After that moment, no further AT commands can be executed. And then the module enters the power down mode, only the RTC is still active.
Please refer to the ***document [1]*** for details about **AT+QPOWD** command.

3.6.2.3. Under-voltage Automatic Shutdown

The module will constantly monitor the voltage applied on the VBAT. If the voltage is ≤3.5V, the following URC will be presented:

UNDER_VOLTAGE WARNING

The normal input voltage range is from 3.3V to 4.6V. If the voltage is <3.3V, the module will automatically shut down.

If the voltage is <3.3V, the following URC will be presented:

UNDER_VOLTAGE POWER DOWN

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

NOTE

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

3.6.3. Reset the Module

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

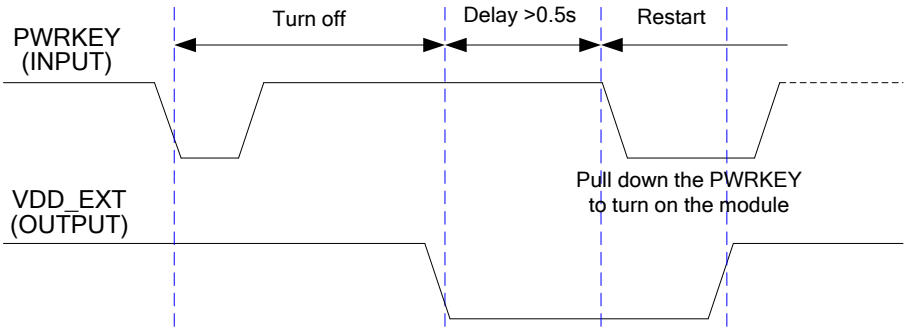

Figure 10: Timing of Resetting System

3.7. Power Saving

Based on system requirements, there are several actions to drive the module to enter low current consumption status. For example, **AT+CFUN** can be used to set module into minimum functionality mode and DTR hardware interface signal can be used to lead system to sleep mode.

3.7.1. Minimum Functionality Mode

Minimum functionality mode reduces the functionality of the module to a minimum level. The consumption of the current can be minimized when the slow clocking mode is activated at the same time. The mode is set via the **AT+CFUN** command which provides difference choices of functionality level as shown below.

- **AT+CFUN=0**: Minimum functionality mode. Both (U)SIM and RF functions are disabled.
- **AT+CFUN=1**: Full functionality mode (by default).
- **AT+CFUN=4**: RF function is disabled.

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

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

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

For more details about **AT+CFUN**, please refer to ***document [1]***.

3.7.2. Sleep Mode

Sleep mode is disabled by default. It can be enabled by **AT+QSCLK=1**. The default setting is **AT+QSCLK=0** and in this mode, the module cannot enter sleep mode.

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

3.7.3. Wake up Module from Sleep Mode

When the module is in sleep mode, it can be woken up through the following methods:

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

NOTE

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

3.7.4. Summary of Module Operation Status Transition

Table 7: Summary of Module Operation Status Transition

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

3.8. RTC Backup

M66 R2.0 supports RTC (Real Time Clock) function which is designed to work with an internal power supply.

There are three kinds of designs for RTC backup power:

- **Use VBAT as the RTC power source**

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

- **Use VRTC as the RTC power source**

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

- **Use VBAT and VRTC as the RTC power source**

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

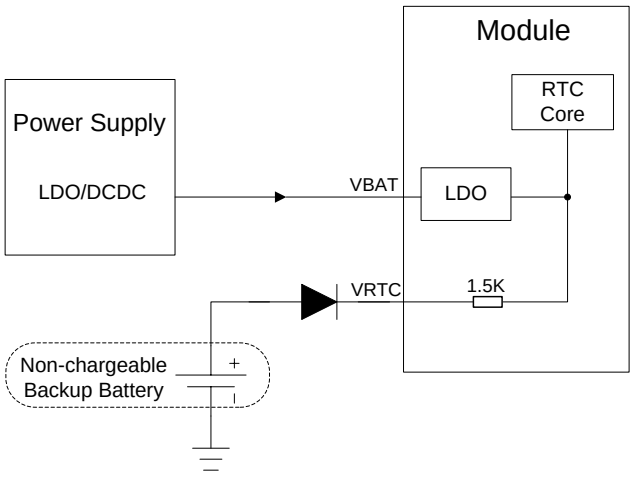

Figure 11: VRTC Powered by a Non-chargeable Battery

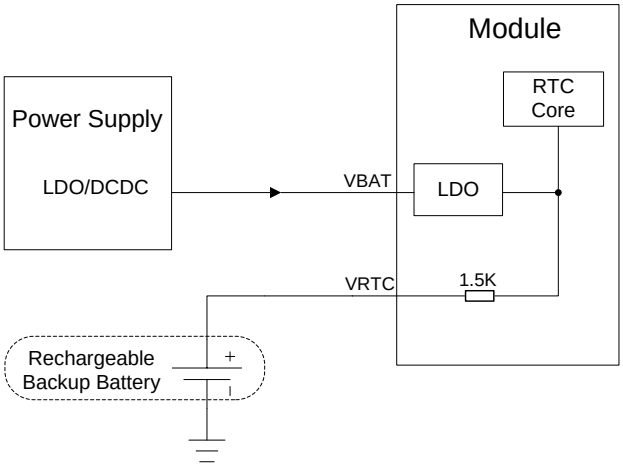

Figure 12: VRTC Powered by a Rechargeable Battery

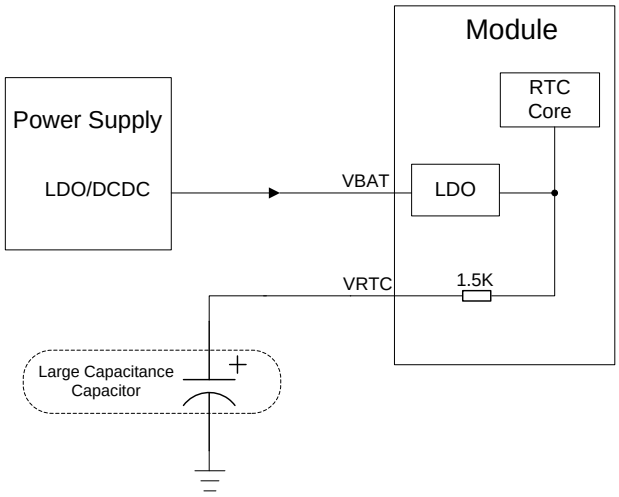

Figure 13: VRTC Powered by a Capacitor

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

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

3.9. Serial Interfaces

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

UART Port:

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

NOTE

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** command can be used to enable hardware flow control. **AT+IFC=0,0** command is used to disable the function. For more details, please refer to ***document [1]***.

Debug 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.

The logic levels are described in the following table.

Table 8: Logic Levels of UART Interfaces

Parameter	Min.	Max.	Unit
V_{IL}	0	0.25×VDD_EXT	V

V_{IH}	0.75×VDD_EXT	VDD_EXT +0.2	V
V_{OL}	0	0.15×VDD_EXT	V
V_{OH}	0.85×VDD_EXT	VDD_EXT	V

Table 9: Pin Definition of UART Interfaces

Interface	Pin Name	Pin No.	Description
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 Port	DBG_RXD	38	Receive data
	DBG_TXD	39	Transmit data
Auxiliary UART Port	RXD_AUX	28	Receive data
	TXD_AUX	29	Transmit data

3.9.1. UART Port

3.9.1.1. UART Port Features

- Seven-wire UART interface
- Contain data lines TXD and RXD, hardware flow control lines RTS and CTS, and other control lines DTR, DCD and RI.
- Used for AT command communication, GPRS data transmission, etc. Multiplexing function is supported on the UART Port. So far only the basic mode of multiplexing is available.
- Support the following communication baud rates (unit: bps): 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200.
- The default setting is autobauding mode. Support the following baud rates (unit: bps) for autobauding

function: 4800, 9600, 19200, 38400, 57600, 115200.

- The module disables hardware flow control by default. **AT+IFC=2,2** command can be used to enable hardware flow control.

After setting a fixed baud rate or autobauding, please send **AT** string at that rate. The UART port is ready when it responds **OK**.

Autobauding allows the module to detect the baud rate by receiving the string **AT** or **at** from the host or PC automatically, which gives module flexibility without considering which baud rate is used by the host controller. Autobauding is enabled by default. To take advantage of the autobauding mode, special attention should be paid according to the following requirements:

Synchronization between DTE and DCE:

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

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

Restrictions on autobauding operation:

- The UART port has to be operated at 8 data bits, no parity and 1 stop bit (factory setting).
- The **At** and **aT** commands cannot be used.
- Only the strings **AT** or **at** can be detected (neither **At** nor **aT**).
- The Unsolicited Result Codes like **RDY**, **+CFUN: 1** and **+CPIN: READY** will not be indicated when the module is turned on with autobauding enabled and not be synchronized.
- Any other Unsolicited Result Codes will be sent at the previous baud rate before the module detects the new baud rate by receiving the first **AT** or **at** string. The DTE may receive unknown characters after switching to new baud rate.
- It is not recommended to switch to autobauding from a fixed baud rate.
- If autobauding is active it is not recommended to switch to multiplex mode.

NOTE

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

3.9.1.2. UART Connection

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

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

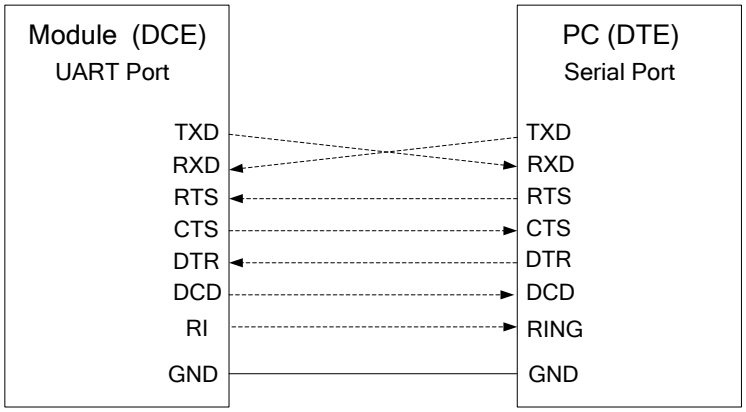

Figure 14: Reference Design for Full-Function UART

Three-line connection is shown as below.

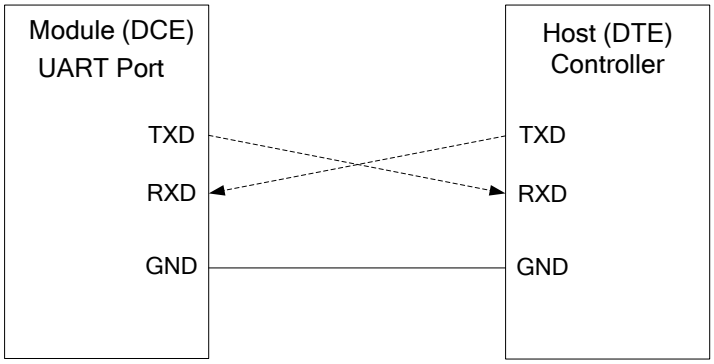

Figure 15: Reference Design for UART Port

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

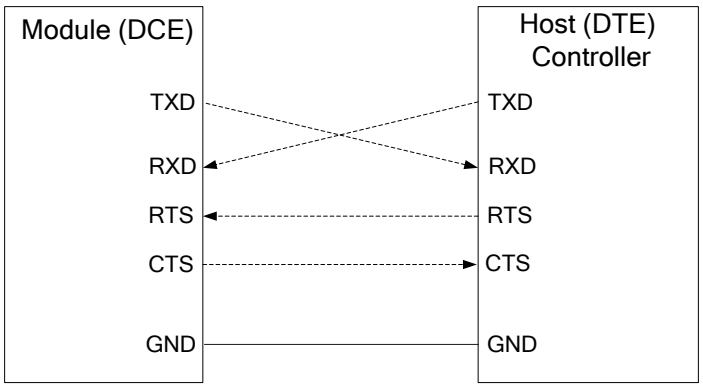

Figure 16: Reference Design for UART Port with Hardware Flow Control

3.9.1.3. Firmware Upgrade

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

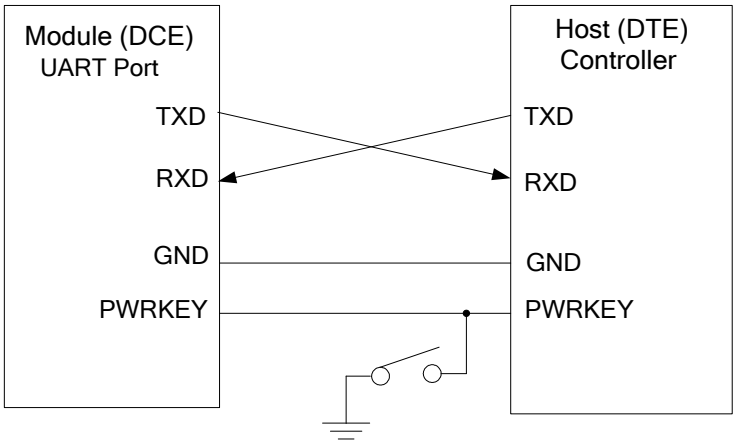

Figure 17: Reference Design for Firmware Upgrade

NOTE

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

3.9.2. Debug Port

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

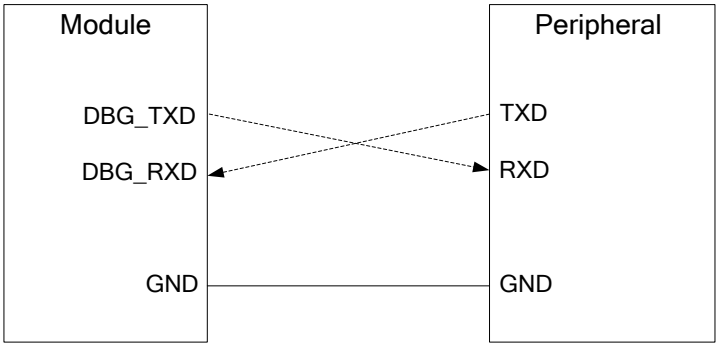

Figure 18: Reference Design for Debug Port

3.9.3. Auxiliary UART Port

- Two data lines: TXD_AUX and RXD_AUX.
- The auxiliary UART port is used for AT command communication only and does not support GPRS data transmission, multiplexing function, etc.
- The port supports the following communication baud rates (unit: bps): 1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 115200.
- Auxiliary UART port could be used when sending **AT+QEAUART=1** string on the UART port.
- The default baud rate setting is 115200bps, and the port does not support autobauding. The baud rate can be changed by **AT+QSEDCB** command. For more details, please refer to ***document [1]*.**

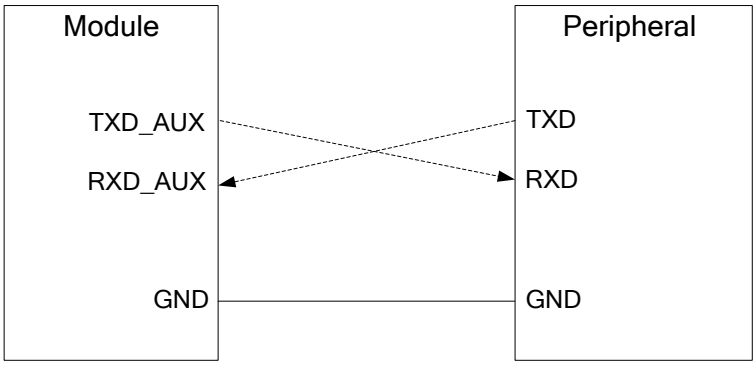

Figure 19: Reference Design for Auxiliary UART Port

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 into 10K ones.

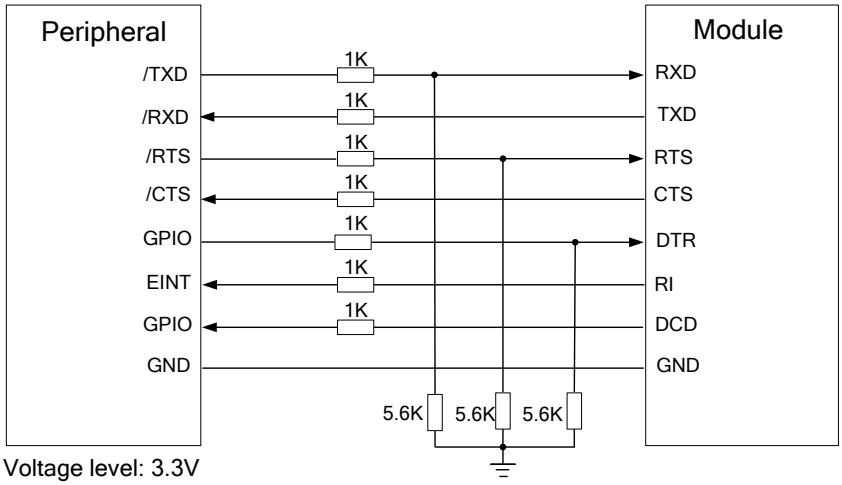

Figure 20: Level Match Design for 3.3V System

NOTE

It is highly recommended to add the resistor divider circuit on the UART signal lines when the host's level is 3.0V or 3.3V. For the higher voltage level system, a level shifter IC could be used between the host and the module. For more details about UART circuit design, please refer to ***document [13]***.

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

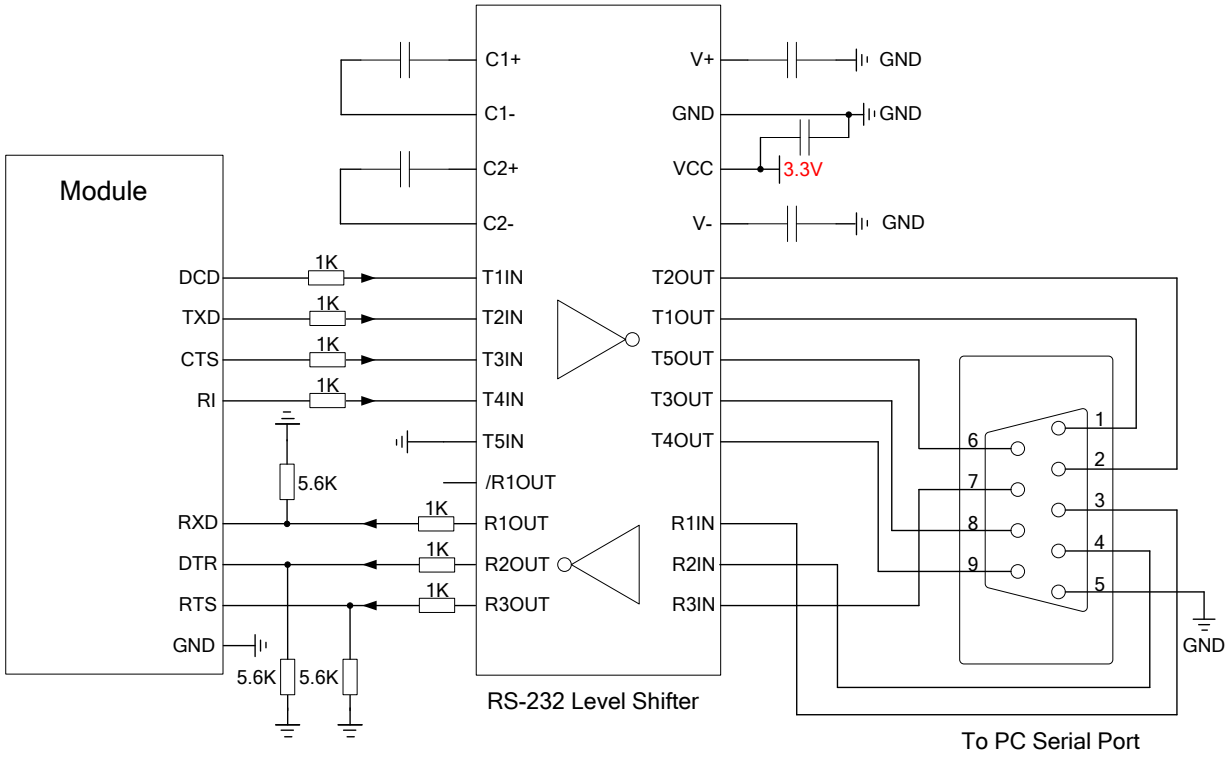

Figure 21: Sketch Map for RS-232 Interface Match

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 channels and two analog output channels.

Table 10: Pin Definition of Audio Interface

Interface	Pin Name	Pin No.	Description
AIN/AOUT1	MICP	3	Microphone positive input
	MICN	4	Microphone negative input
	SPK1P	5	Channel 1 audio positive output
	SPK1N	6	Channel 1 audio negative output

AIN/AOUT2	MICP	3	Microphone positive input
	MICN	4	Microphone negative input
	SPK2P	2	Channel 2 audio positive output
	AGND	1	Form a pseudo-differential pair with SPK2P

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

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

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

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

AT+QAUDCH command can be used to select audio channel:

- **AT+QAUDCH=0**: AIN/AOUT1
- **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. They 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]***.

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 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 capacitor for filtering out GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz noises separately.

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

The capacitor which is used for filtering out RF noise should be close to the audio device or audio interface. The audio traces should be as short as possible.

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

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

3.10.2. Reference Design of Microphone Interface

AIN channel comes with internal bias power supply for the external electret microphone. A reference circuit is shown in the following figure.

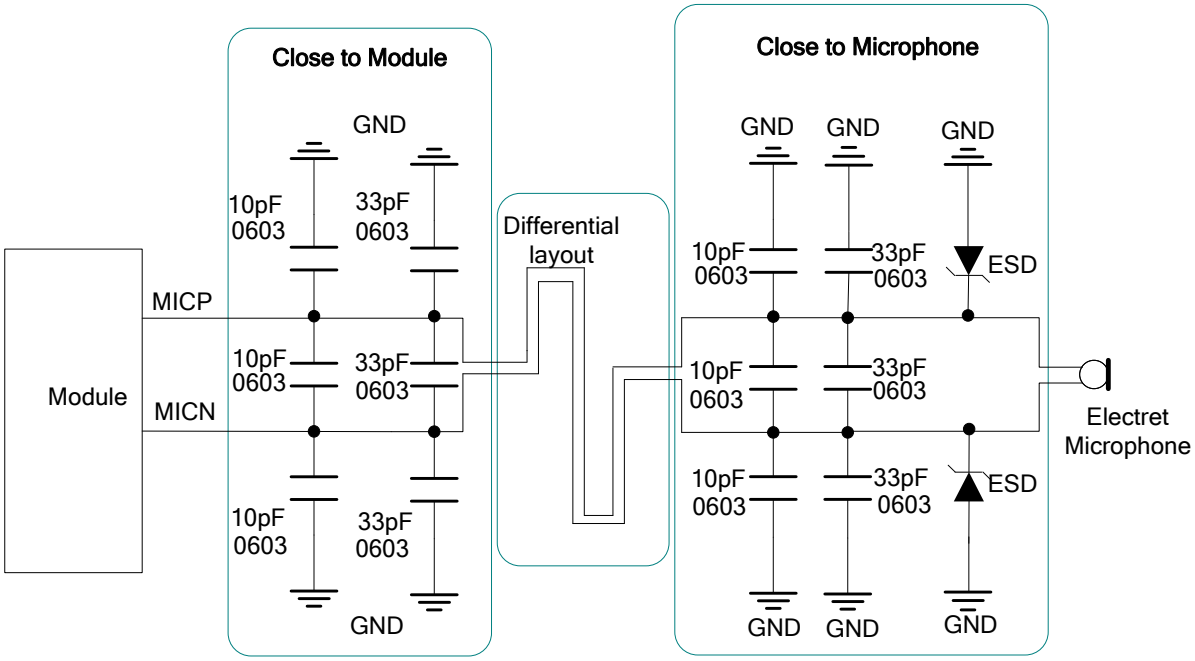

Figure 22: Microphone Interface Reference Design (AIN)

3.10.3. Reference Design of Receiver and Speaker Interfaces

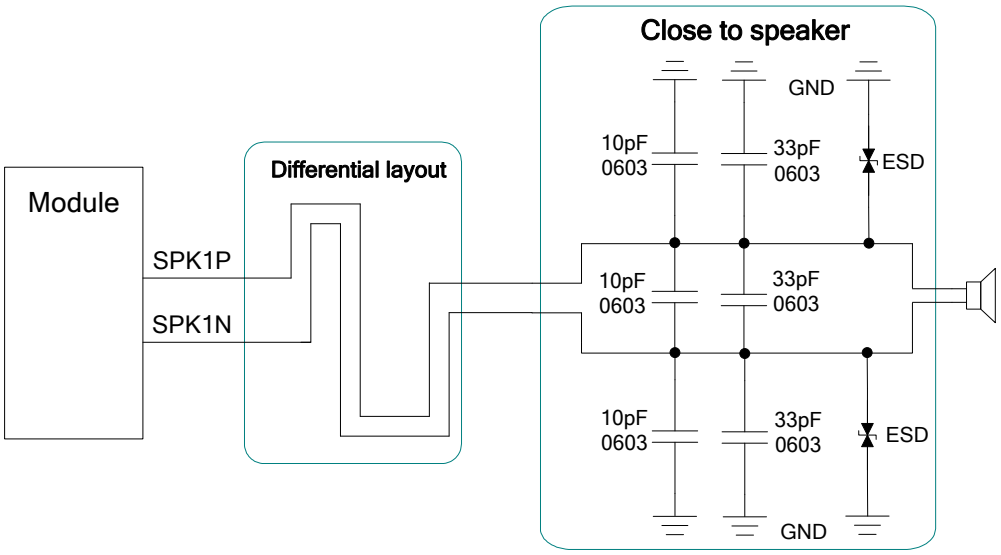

Figure 23: Handset Interface Reference Design (AOUT1)

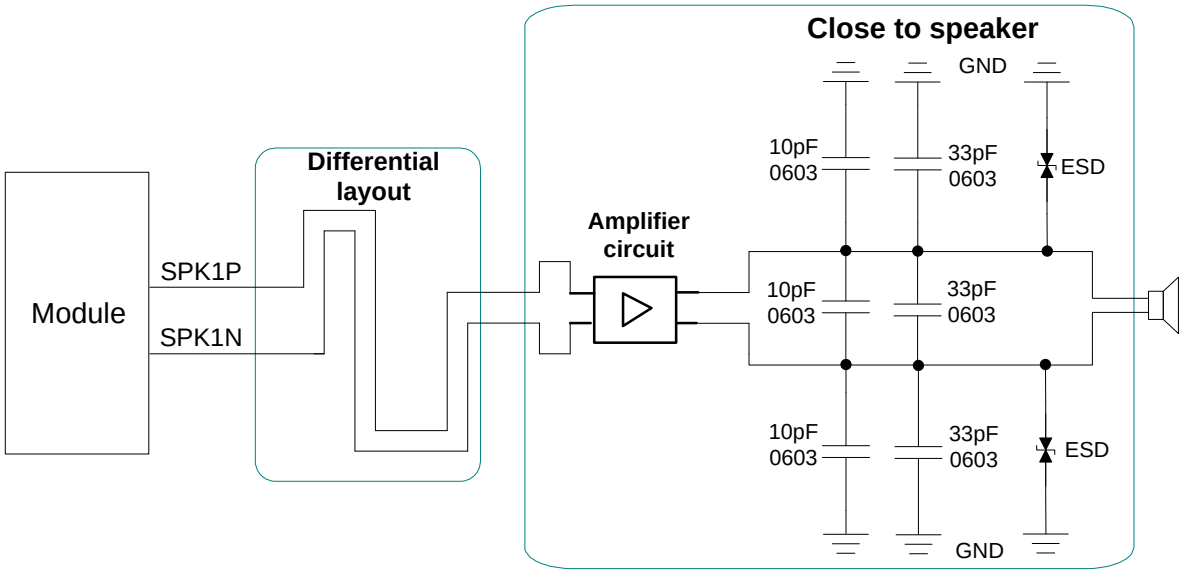

Figure 24: Speaker Interface Reference Design with an Amplifier (AOUT1)

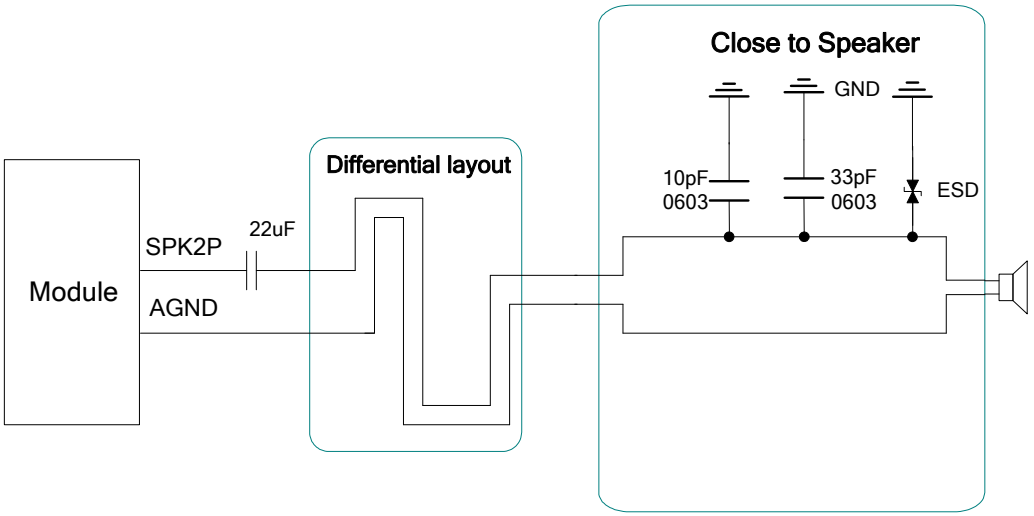

Figure 25: Handset Interface Reference Design (AOUT2)

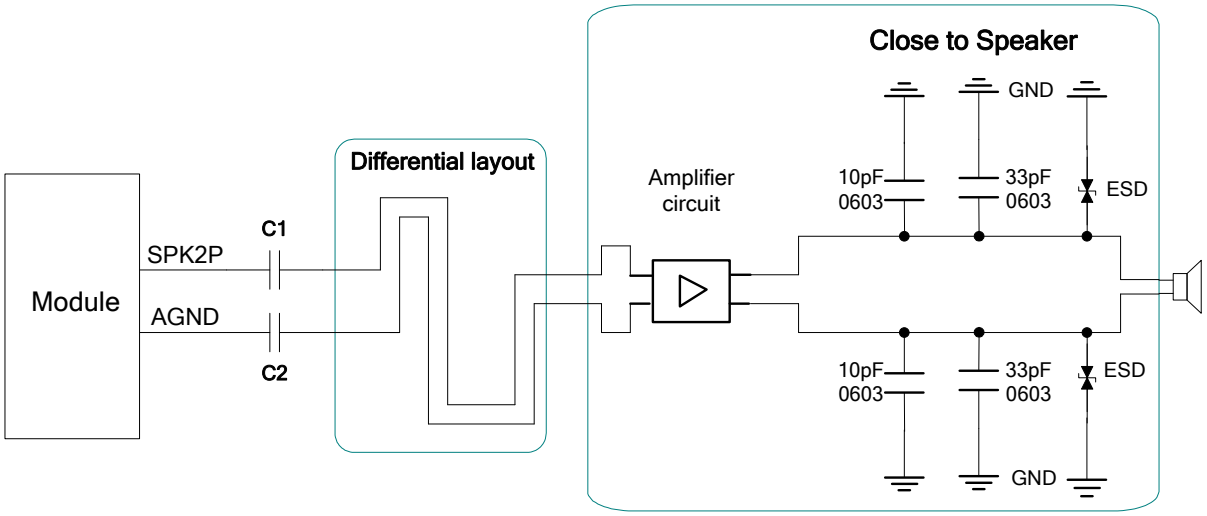

Figure 26: Speaker Interface Reference Design with an Amplifier (AOUT2)

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

NOTE

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

3.10.4. Reference Design of Earphone Interfaces

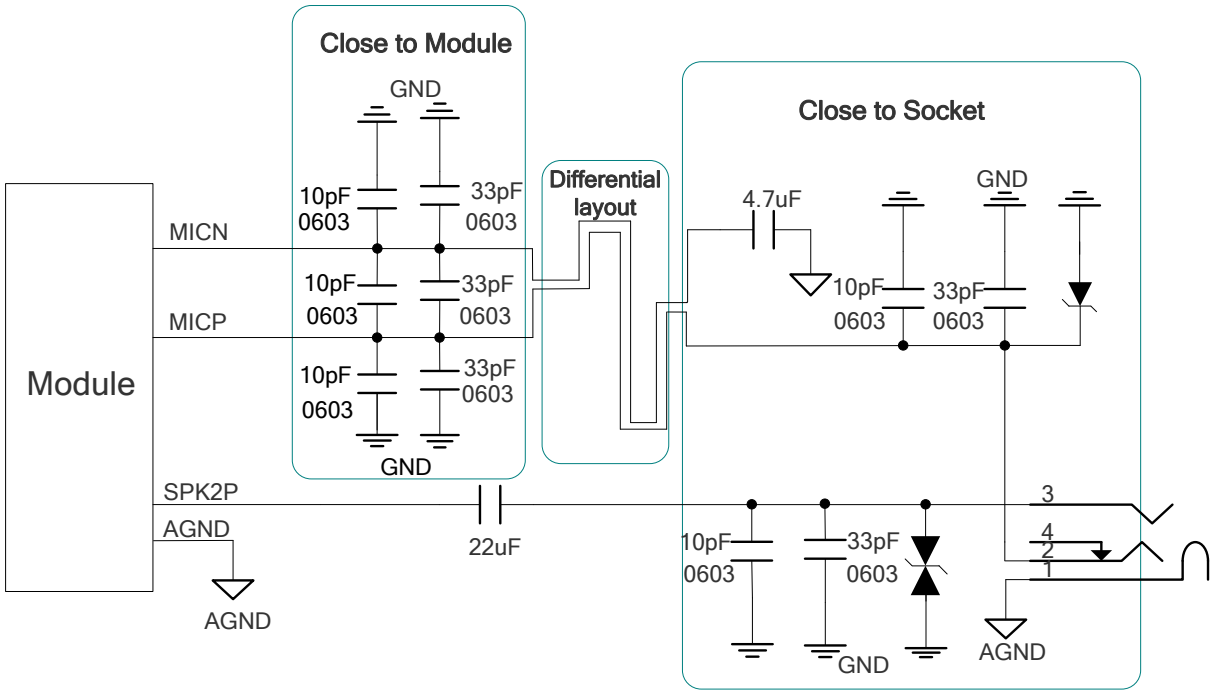

Figure 27: Earphone Interface Reference Design

3.10.5. Audio Characteristics

Table 11: Typical Electret Microphone Characteristics

Parameter	Min.	Typ.	Max.	Unit
Working Voltage	1.2	1.5	2.0	V
Working Current	200		500	uA
External Microphone Load Resistance		2.2		K ohm

Table 12: Typical Speaker Characteristics

Parameter			Min.	Typ.	Max.	Unit
AOUT1 Output	Single-ended	Load resistance		32		ohm
		Reference level	0		2.4	Vpp

	Differential	Load resistance		32	ohm
		Reference level	0	4.8	Vpp
AOUT2 Output	Single-ended	Load resistance		32	ohm
		Reference level	0	2.4	Vpp

3.11. PCM Interface

M66 R2.0 provides a PCM interface. The interface is used for digital audio transmission between the module and the device. This interface is composed of PCM_CLK, PCM_SYNC, PCM_IN and PCM_OUT signal lines.

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

Table 13: Pin Definition of PCM Interface

Pin Name	Pin No.	Description	Alternate Function [1)]
PCM_CLK	30	PCM clock output	
PCM_SYNC	31	PCM frame synchronization output	SD_DATA
PCM_IN	32	PCM data input	SD_CMD
PCM_OUT	33	PCM data output	SD_CLK

NOTE

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

3.11.1. Parameter Configuration

M66 R2.0 supports 16-bit linear code PCM format. The sample rate is 8 KHz and the clock source is 256 KHz. The module can only act in master mode. The PCM interface supports both long and short frame synchronization, and it only supports MSB first. For more detailed information, please refer to the table below.

Table 14: PCM Interface Configuration

Parameter	Description
Interface Format	Linear
Data Length	Linear: 16 bits
Sample Rate	8KHz
PCM Clock/Synchronization Source	Module acts in master mode: clock and synchronization sources are generated by module
PCM Synchronization Rate	8KHz
PCM Clock Rate	Module acts in master mode: 256KHz (linear)
PCM Synchronization Format	Long/short frame synchronization
PCM Data Ordering	MSB first
Zero Padding	Not supported
Sign Extension	Not supported

3.11.2. Timing Diagram

The sample rate of the PCM interface is 8KHz and the clock source rate is 256KHz, so every frame contains 32-bit data. M66 R2.0 supports 16-bit linear code PCM format. The left 16 bits are valid, and the data of the left 16 bits and the right 16 bits are the same. The following are the timing diagrams of different frame synchronization formats.

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

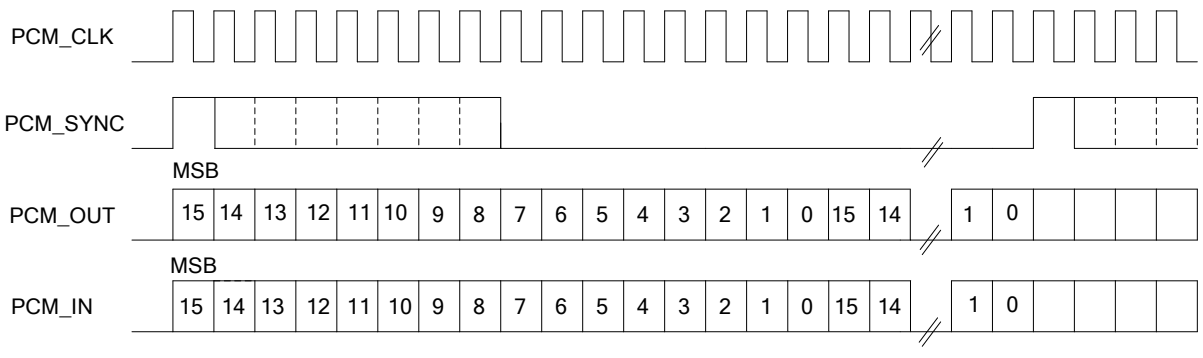

Figure 28: Long Frame Synchronization Timing Diagram

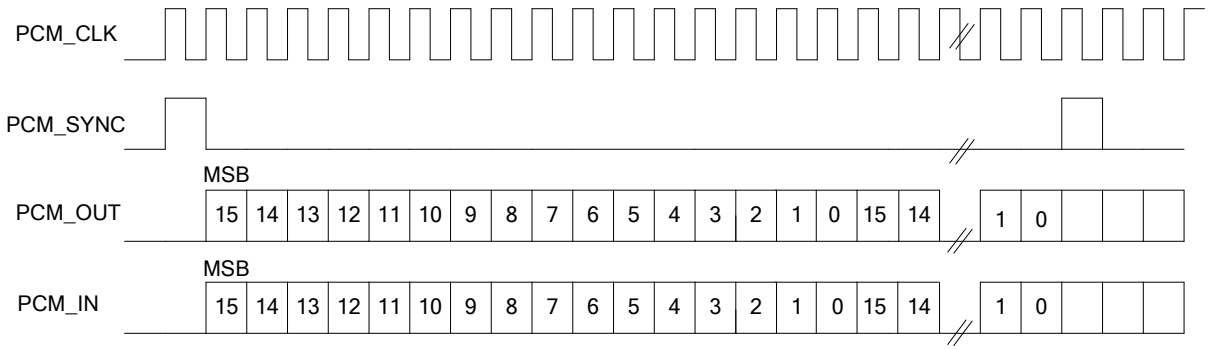

Figure 29: Short Frame Synchronization Timing Diagram

3.11.3. Reference Design

M66 R2.0 can only work as a master, providing clock and synchronization source for PCM bus. A reference design for PCM is shown below.

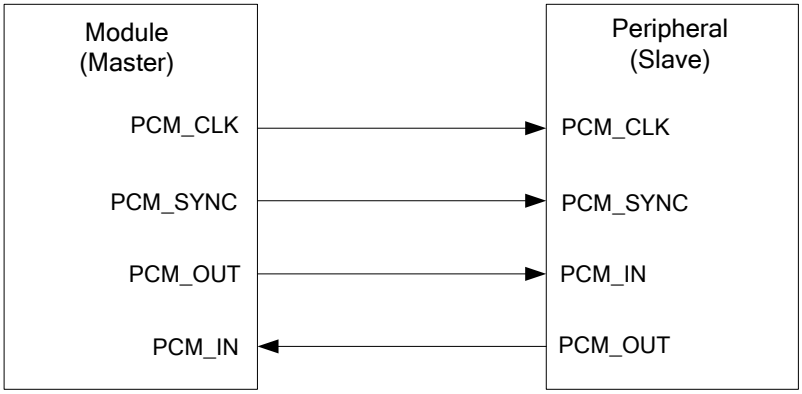

Figure 30: Reference Design for PCM

3.11.4. PCM Related AT Commands

There are two AT commands for the configuration of PCM: **AT+QPCMON** and **AT+QPCMVOL**. Details are illustrated below.

- **AT+QPCMON** is used to configure the operating mode of PCM

Command format: **AT+QPCMON=mode, Sync_Type, Sync_Length, SignExtension, MSBFirst**

Table 15: AT+QPCMON Command Parameter Description

Parameter	Scope	Description
Mode	0, 2	0: Close PCM 2: Open PCM when audio talk is set up
Sync_Type	0~1	0: Short frame synchronization 1: Long frame synchronization
Sync_Length	1~8	Programmable from one bit to eight bits via software configuration in long frame synchronization format
SignExtension	0~1	Not supported
MSBFirst	0~1	0: MSB first 1: Not supported

- **AT+QPCMVOL** is used to configure the input and output volume of PCM.

Command format: **AT+QPCMVOL=vol_pcm_in, vol_pcm_out**

Table 16: AT+QPCMVOL Command Parameter Description

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

3.12. (U)SIM Interface

The (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 SIM application tool-kit).

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 17: Pin Definition of (U)SIM Interface

Pin Name	Pin No.	Description
SIM_VDD	14	Supply power for (U)SIM card. Automatic detection of (U)SIM card voltage.

		Voltage accuracy: 3.0V±5% and 1.8V±5%. Maximum supply current: about 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	Specified ground for (U)SIM card

A reference circuit design for (U)SIM interface with a 6-pin (U)SIM card connector is illustrated below.

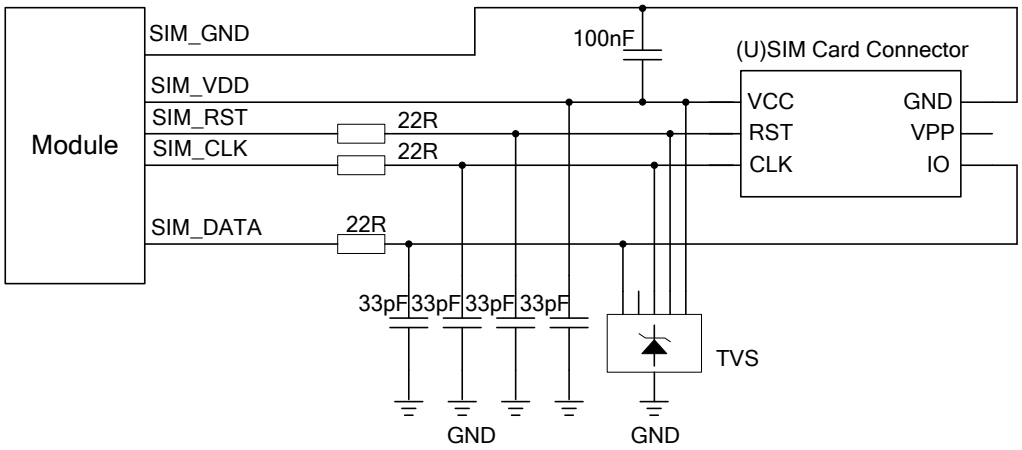

Figure 31: Reference Circuit for (U)SIM Interface with a 6-pin (U)SIM Card Connector

For more information of (U)SIM card connector, you can visit http://www.amphenol.com or http://www.molex.com.

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

- Keep 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.
- Assure the ground between the module and the (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 decouple capacitor between SIM_VDD and 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 with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVS diode array. For more information of TVS diode, please visit http://www.onsemi.com. The 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 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.

- Place the RF bypass capacitors (33pF) close to the (U)SIM card on all signal lines for improving EMI.

3.13. SD Card Interface

The module provides an SD card interface which is multiplexed from PCM interface. The SD card interface supports many types of memory, such as Memory Stick, SD/MCC card and T-Flash (or Micro SD) card. The following are the main features of the interface.

- Only support 1 bit serial mode
- Not support the SPI mode for SD memory card
- Not support multiple SD memory cards
- Not support hot plug
- The data rate up to 48MHz in serial mode
- Support memory cards with maximum capacity up to 32GB

With the SD card interface features and reference circuit shown as below, customers can easily design the SD card application circuit to enhance the memory capacity of the module. The users can store some high-capacity files to external memory card. For instance, in automobile application system, the module can record and store the audio file to the SD card, and also can play the audio files in SD card.

Table 18: Pin Definition of SD Card Interface (Multiplexed from PCM Interface)

Pin Name	Pin No.	Description
SD_CMD	32	Command signal of SD card output
SD_CLK	33	Clock signal of SD card output
SD_DATA	31	Data output and input signal of SD card

A reference design for SD card interface is shown below.

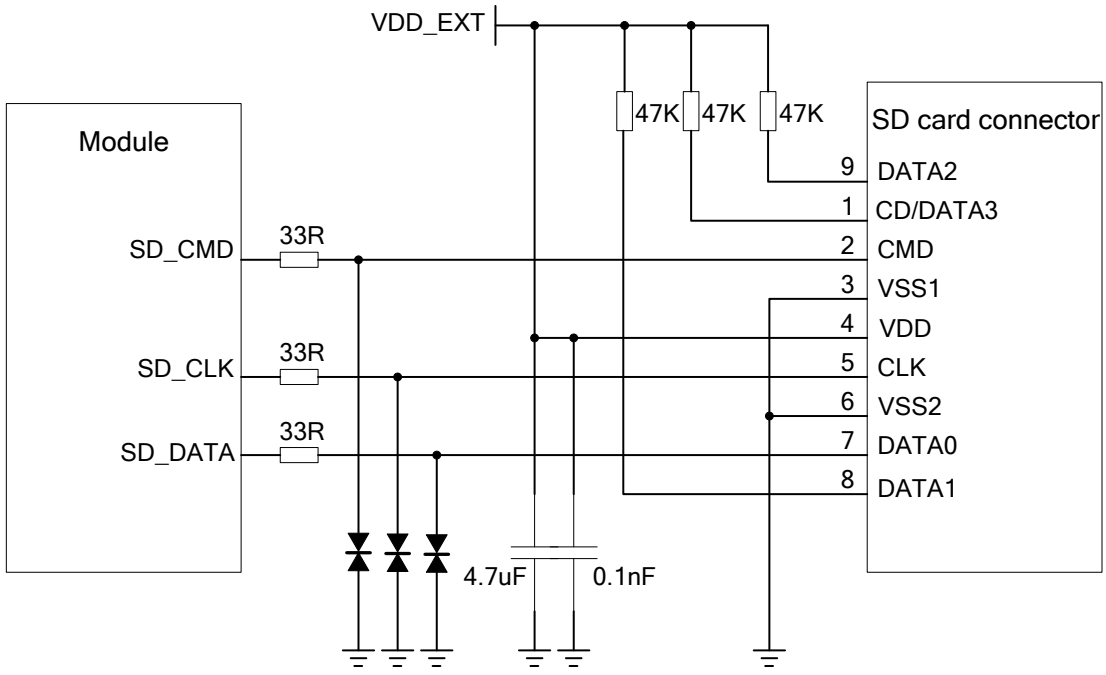

Figure 32: Reference Circuit for SD Card Interface

Table 19: Pin Definition of SD Card and T-Flash (Micro SD) Card

Pin No.	Pin Name of SD Card	Pin Name of T-Flash (Micro SD) Card
1	CD/DATA3	DATA2
2	CMD	CD/DATA3
3	VSS1	CMD
4	VDD	VDD
5	CLK	CLK
6	VSS2	VSS
7	DATA0	DATA0
8	DATA1	DATA1
9	DATA2	

In SD card interface designing, in order to ensure good communication performance with SD card, the following design principles should be complied with:

- Keep all the SD card signals far away from VBAT and RF traces.
- Make sure the length of SD card signal lines does not exceed 10cm and be as short as possible.
- The traces of SD_CLK, SD_DATA and SD_CMD are recommended to be routed together and be of equal length; the length difference should be less than 10mm.
- 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, and should be placed as close as possible to the SD card connector.
- Reserve external pull-up resistors for other data lines except the DATA0 signal.
- The SD_CLK and SD_DATA traces should be shielded by ground in order to improve EMI suppression capability and prevent the crosstalk.

3.14. ADC

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

Table 20: Pin Definition of ADC Interface

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

Table 21: Characteristics of ADC Interface

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

3.15. RI Behaviors

Table 22: Behaviors of the RI

State	RI Response
Standby	HIGH
Voice Call	Change to LOW, and then: ● Change to HIGH when a call is established. ● Change to HIGH when use ATH to hang up the call. ● Change to HIGH first when the calling part hangs up and then change to LOW for 120ms indicating **NO CARRIER** as an URC. After that, RI changes to HIGH again. ● Change to HIGH when SMS is received.
SMS	When a new SMS comes, the RI changes to LOW and holds low level for about 120ms, then changes to HIGH.
URC	Certain URCs can trigger 120ms low level on RI. For more details, please refer to ***document [1]***.

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

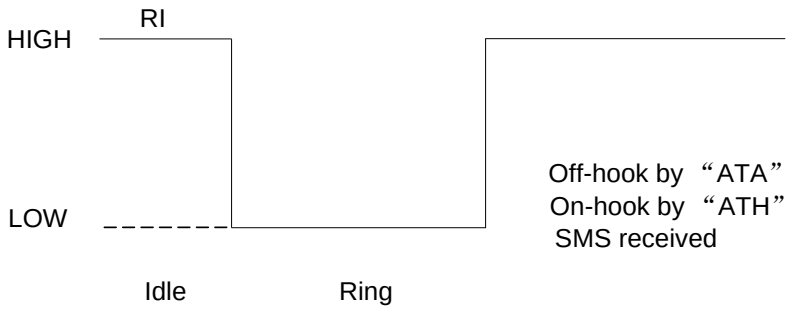

Figure 33: RI Behavior as a Receiver When Voice Calling

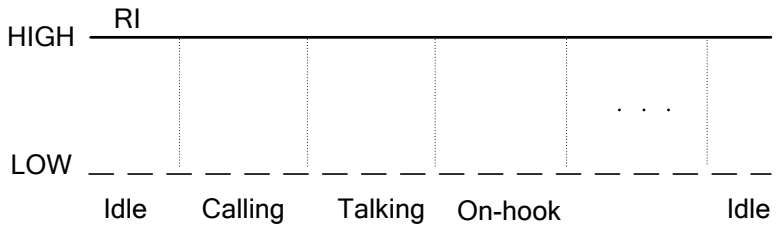

Figure 34: RI Behavior as a Caller

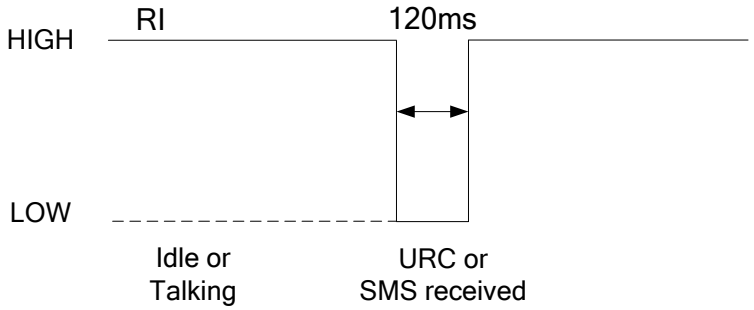

Figure 35: RI Behavior When URC or SMS Received

3.16. 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 23: Working State of NETLIGHT

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 after dialing the PPP connection.

A reference circuit is shown as below.

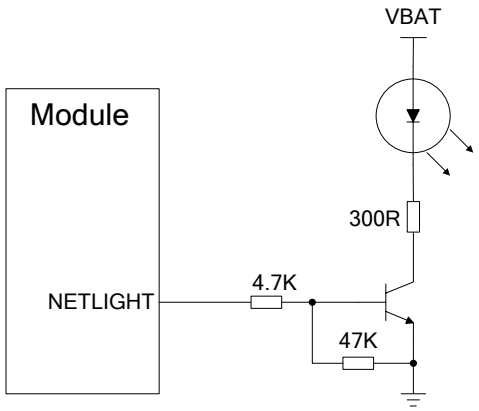

Figure 36: Reference Design for NETLIGHT

3.17. RF Transmission Signal Indication

M66 R2.0 provides a RFTXMON pin which will be at high level when the transmitter is active and returns to low level after the transmitter activity is completed.

Table 24: 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 transmission activity

In such case, RFTXMON pin is used to indicate the transmission burst. When it outputs a high level, 220us later there will be a transmission burst.

AT+QCFG="RFTXburst",1 can be used to enable the mode.

The timing of the RFTXMON signal is shown below.

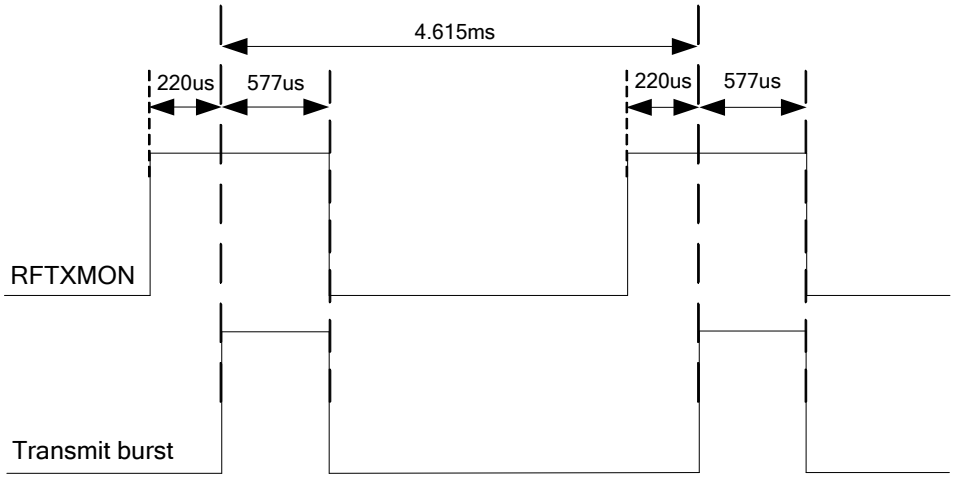

Figure 37: RFTXMON Signal during Burst Transmission

2) Active during a Call

RFTXMON will be at high level during a call and return to low after the call is hung up.

AT+QCFG="RFTXburst",2 command can be used to enable the mode.

The timing of the RFTXMON signal is shown below.

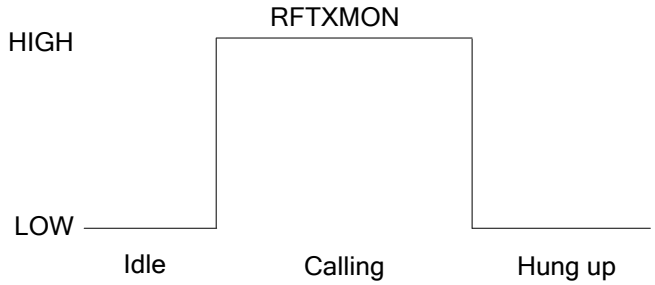

Figure 38: RFTXMON Signal during a Call

4 Antenna Interface

M66 R2.0 has a GSM antenna pad. The RF interface has an impedance of 50Ω.

4.1. GSM Antenna Interface

Table 25: 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 a matching circuit is necessary. A reference design for RF interface is shown as below.

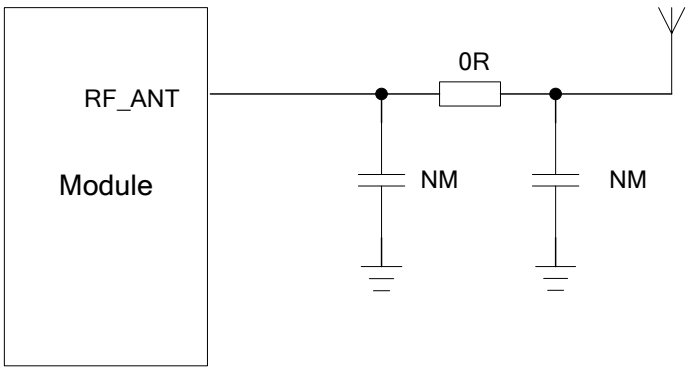

Figure 39: Reference Design for GSM Antenna Interface

M66 R2.0 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. M66 R2.0 comes with ground pads which are next to the antenna pad in order to give a better grounding. Additionally, a π type matching circuit is recommended 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 requirement on GSM antenna.

Table 26: Antenna Cable Requirements

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

Table 27: Antenna Requirements

Type	Requirements
Frequency Range	Depend on the frequency band(s) provided by the network operator
VSWR	≤ 2
Gain (dBi)	1
Max Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Vertical

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 2.5dB. This design conforms to the GSM specification as described in ***Chapter 13.16*** of ***3GPP TS 51.010-1***.

4.1.3. RF Receiving Sensitivity

Table 29: RF Receiving Sensitivity

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

4.1.4. Operating Frequencies

Table 30: Module Operating Frequencies

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

4.1.5. 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 for correct RF cable soldering.

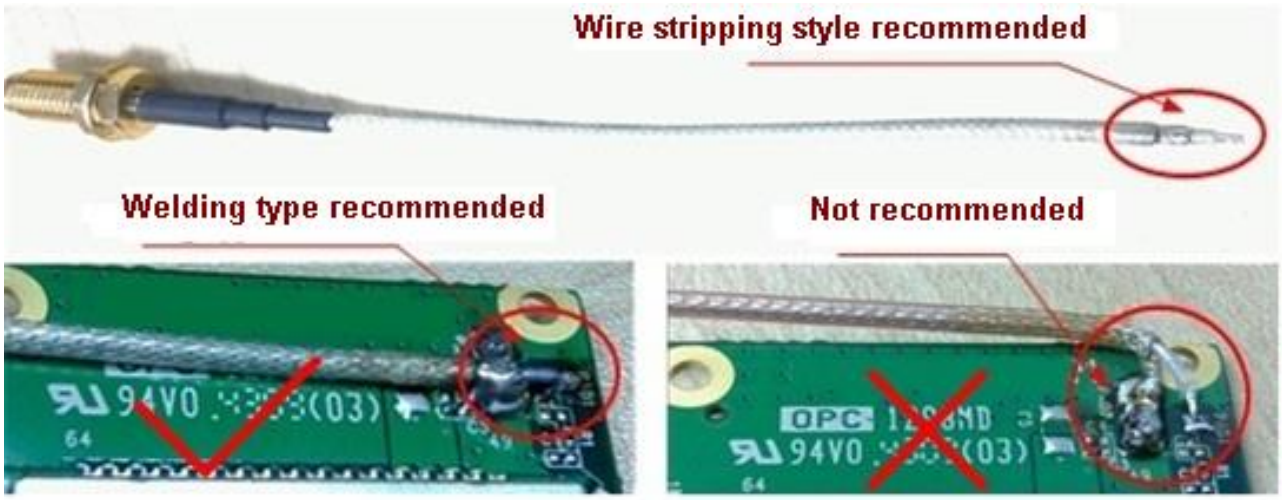

Figure 40: RF Cable Soldering Sample

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 the module are listed in the following table:

Table 31: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT	-0.3	+4.73	V
Peak Current of Power Supply	0	2	A
RMS Current of Power Supply (during one TDMA frame)	0	0.7	A
Voltage at Digital Pins	-0.3	3.08	V
Voltage at Analog Pins	-0.3	3.08	V
Voltage at Digital/analog Pins in Power down Mode	-0.25	0.25	V

5.2. Operation and Storage Temperatures

Table 32: Operation and Storage Temperatures

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

Storage temperature range	-40	+90	℃

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 33: 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.	3.3	4.0	4.6	V
	Voltage drop during transmitting burst	Maximum power control level on GSM850 and EGSM900.			400	mV
I_{VBAT}	Average supply current	Power down mode		150		uA
		Sleep mode @DRX=5		1.3		mA
		AT+CFUN=0				
		Idle mode		13		mA
		Sleep mode		0.98		mA
		AT+CFUN=4				
		Idle mode		13		mA
		Sleep mode		1.0		mA
		Talk mode				
		GSM850/EGSM900 [1)]		220/211		mA
		DCS1800/PCS1900 [2)]		173/162		mA
		Data mode, GPRS (3Rx, 2Tx)				
		GSM850/EGSM900 [1)]		363/393		mA
		DCS1800/PCS1900 [2)]		268/257		mA
		Data mode, GPRS (2 Rx, 3Tx)				
		GSM850/EGSM900 [1)]		506/546		mA
		DCS1800/PCS1900 [2)]		366/349		mA

		Data mode, GPRS (4 Rx, 1Tx) GSM850/EGSM900 [1)] DCS1800/PCS1900 [2)]	 237/224 190/178		 mA mA
		Data mode, GPRS (1Rx, 4Tx) GSM850/EGSM900 [1)] DCS1800/PCS1900 [2)]	 554/522 514/479		 mA mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM850 and EGSM900.	1.72	2	A

NOTES

1. [1)] Power control level (PCL)=5.
2. [2)] Power control level (PCL)=0.

5.4. Current Consumption

Table 34: Current Consumption

Condition	Current Consumption
Voice Call	
GSM850	@power level #5 <300mA, Typical 220mA @power level #12, Typical 90mA @power level #19, Typical 64mA
EGSM900	@power level #5 <300mA, Typical 211mA @power level #12, Typical 86mA @power level #19, Typical 64mA
DCS1800	@power level #0 <250mA, Typical 173mA @power level #7, Typical 80mA @power level #15, Typical 63mA
PCS1900	@power level #0 <250mA, Typical 162mA @power level #7, Typical 80mA @power level #15, Typical 63mA
GPRS Data	
Data Mode, GPRS (3 Rx, 2Tx) Class 12	
GSM850	@power level #5 <550mA, Typical 401mA @power level #12, Typical 131mA

	@power level #19, Typical 91mA
EGSM900	@power level #5 <550mA, Typical 374mA @power level #12, Typical 152mA @power level #19, Typical 98mA
DCS1800	@power level #0 <450mA, Typical 302mA @power level #7, Typical 128mA @power level #15, Typical 93mA
PCS1900	@power level #0 <450mA, Typical 278mA @power level #7, Typical 126mA @power level #15, Typical 92mA
Data Mode, GPRS (2 Rx, 3Tx) Class 12	
GSM850	@power level #5 <640mA, Typical 476mA @power level #12, Typical 159mA @power level #19, Typical 99mA
EGSM900	@power level #5 <600mA, Typical 443mA @power level #12, Typical 160mA @power level #19, Typical 101mA
DCS1800	@power level #0 <490mA, Typical 409mA @power level #7, Typical 131mA @power level #15, Typical 93mA
PCS1900	@power level #0 <480mA, Typical 374mA @power level #7, Typical 138mA @power level #15, Typical 94mA
Data Mode, GPRS (4 Rx,1Tx) Class 12	
GSM850	@power level #5 <350mA, Typical 237mA @power level #12, Typical 110mA @power level #19, Typical 83mA
EGSM900	@power level #5 <350mA, Typical 224mA @power level #12, Typical 104mA @power level #19, Typical 84mA
DCS1800	@power level #0 <300mA, Typical 190mA @power level #7, Typical 102mA @power level #15, Typical 85mA
PCS1900	@power level #0 <300mA, Typical 178mA @power level #7, Typical 104mA @power level #15, Typical 86mA
Data Mode, GPRS (1 Rx, 4Tx) Class 12	
GSM850	@power level #5 <660mA, Typical 554mA @power level #12, Typical 182mA @power level #19, Typical 106mA

EGSM900	@power level #5 <660mA, Typical 522mA @power level #12, Typical 187mA @power level #19, Typical 109mA
DCS1800	@power level #0 <530mA, Typical 512mA @power level #7, Typical 149mA @power level #15, Typical 97mA
PCS1900	@power level #0 <530mA, Typical 466mA @power level #7, Typical 159mA @power level #15, Typical 99mA

NOTE

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

5.5. Electrostatic Discharge

Although the module is generally protected against Electrostatic Discharge (ESD), ESD protection precautions should still be emphasized. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application using the module.

The measured ESD values of the module are shown in the following table.

Table 35: ESD Performance Parameter (Temperature: 25ºC, Humidity: 45%)

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

6 Mechanical Dimensions

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

6.1. Mechanical Dimensions of the Module

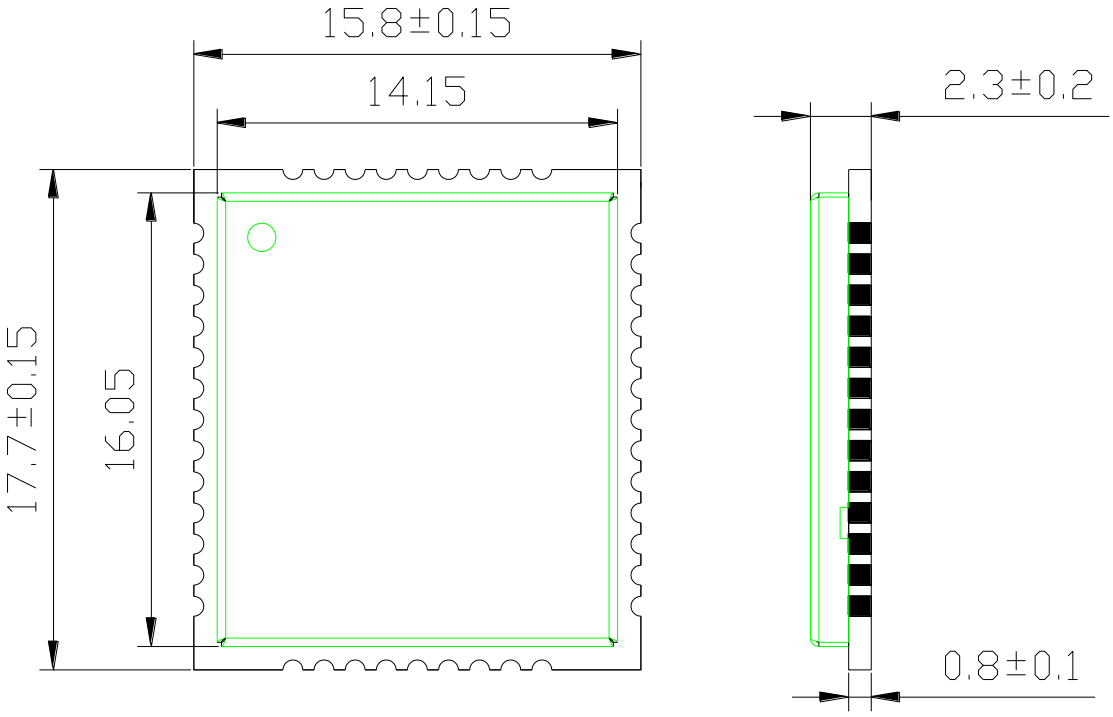

Figure 41: M66 R2.0 Module Top and Side Dimensions (Unit: mm)

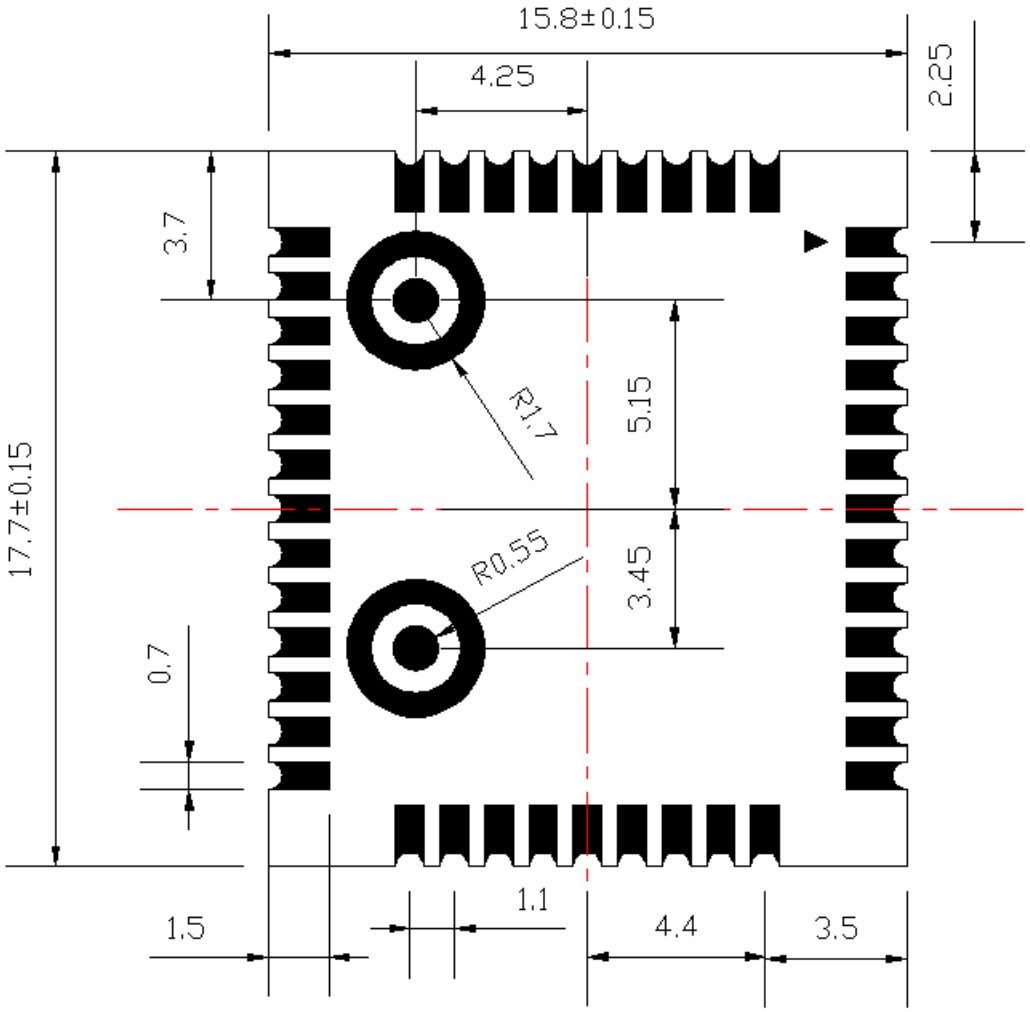

Figure 42: M66 R2.0 Module Bottom Dimensions (Unit: mm)

6.2. Recommended Footprint

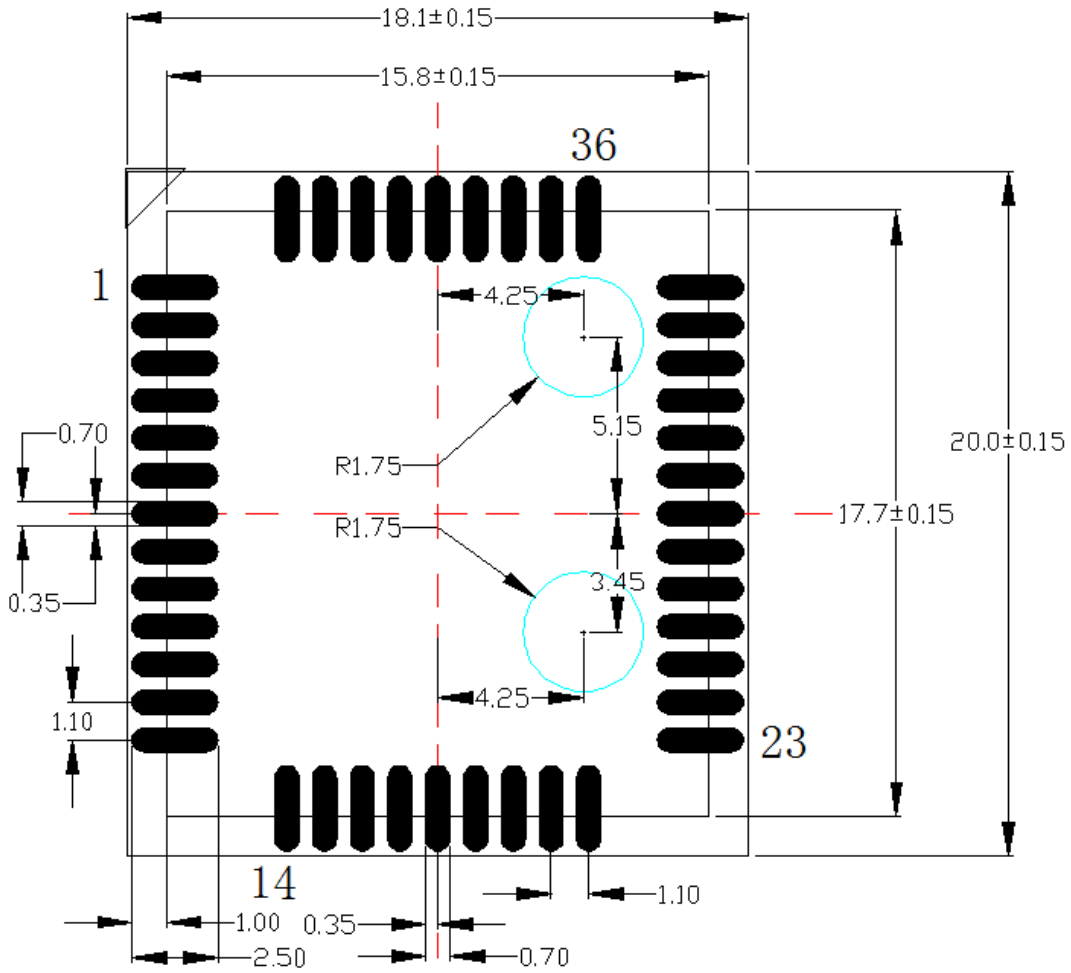

Figure 43: Recommended Footprint (Unit: mm)

NOTES

1. The module should be kept about 3mm away from other components in the host PCB.
2. The circular test points with a radius of 1.75mm in the above recommended footprint should be treated as keepout areas. ("keepout" means copper pouring on the motherboard is forbidden).

6.3. Top and Bottom Views of the Module

Figure 44: Top View of the Module

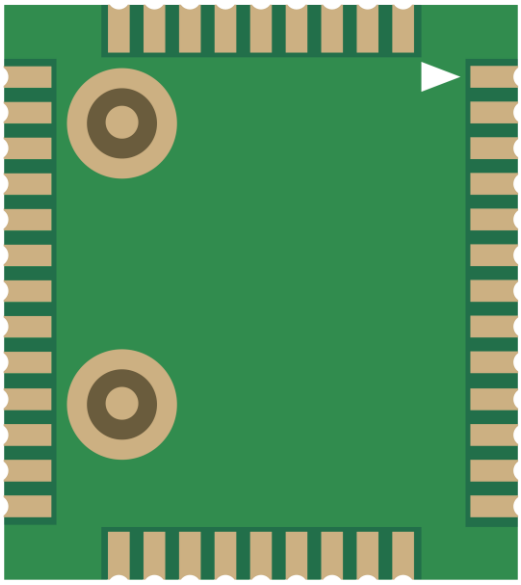

Figure 45: Bottom View of the Module

NOTE

These are design effect drawings of M66 R2.0 modules. For more accurate pictures, please refer to the module that customers get from Quectel.

7 Storage, Manufacturing and Packaging

7.1. Storage

M66 R2.0 module is stored in a vacuum-sealed bag. The storage restrictions are shown as below.

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

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

   - Mounted within 168 hours at the factory environment of ≤30ºC and <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 when the ambient temperature is <30ºC and the humidity is <60%.
   - Stored at >10% RH.

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

NOTE

As the plastic package cannot be subjected to high temperature, it should be removed from devices before high temperature (125ºC) 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 0.2mm. For more details, please refer to ***document [12]***.

It is suggested that peak reflow temperature is from 235ºC to 245ºC (for SnAg3.0Cu0.5 alloy). The absolute maximum reflow temperature is 260ºC. To avoid damage to the module caused by repeated heating, it is suggested that the module should be mounted after reflow soldering for the other side of PCB has been completed. Recommended reflow soldering thermal profile is shown below:

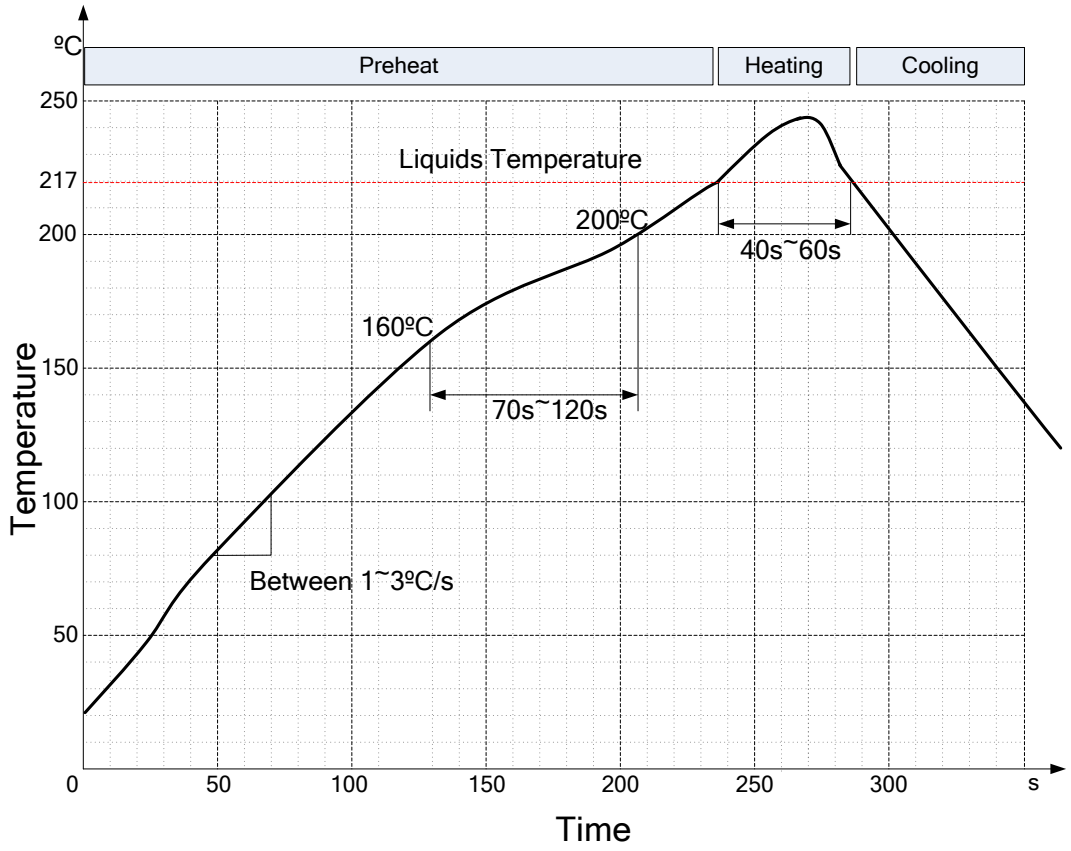

Figure 46: Reflow Soldering Thermal Profile

7.3. Packaging

The modules are stored 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.

7.3.1. Tape and Reel Packaging

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

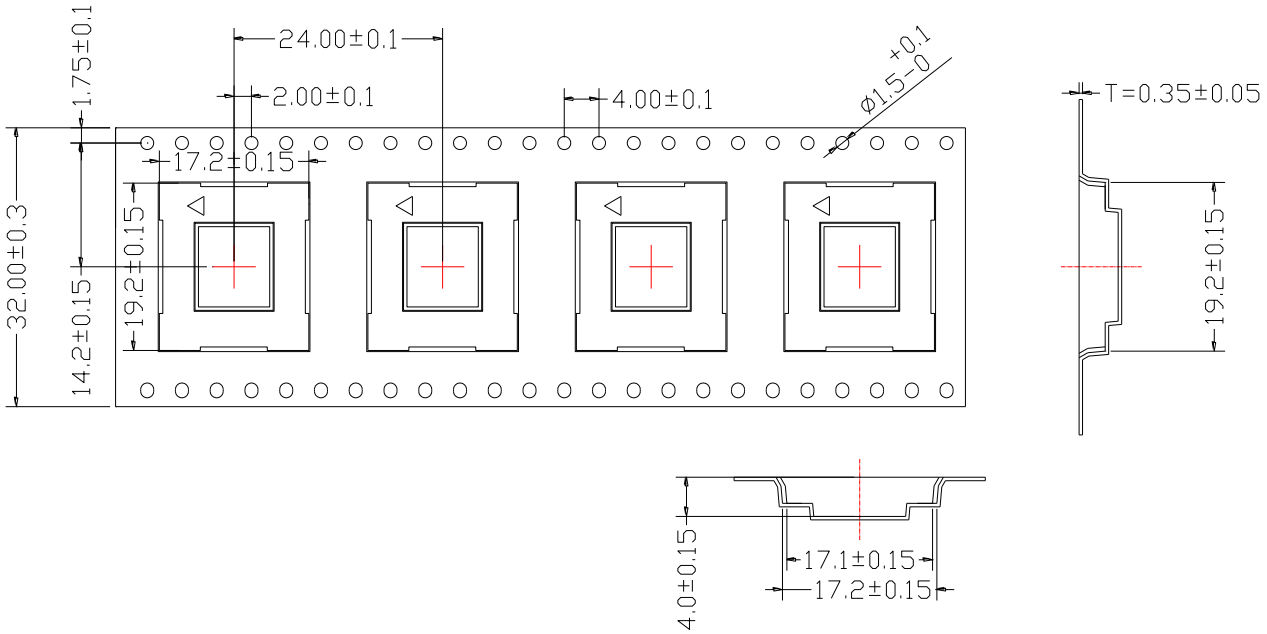

Figure 47: Tape Dimensions (Unit: mm)

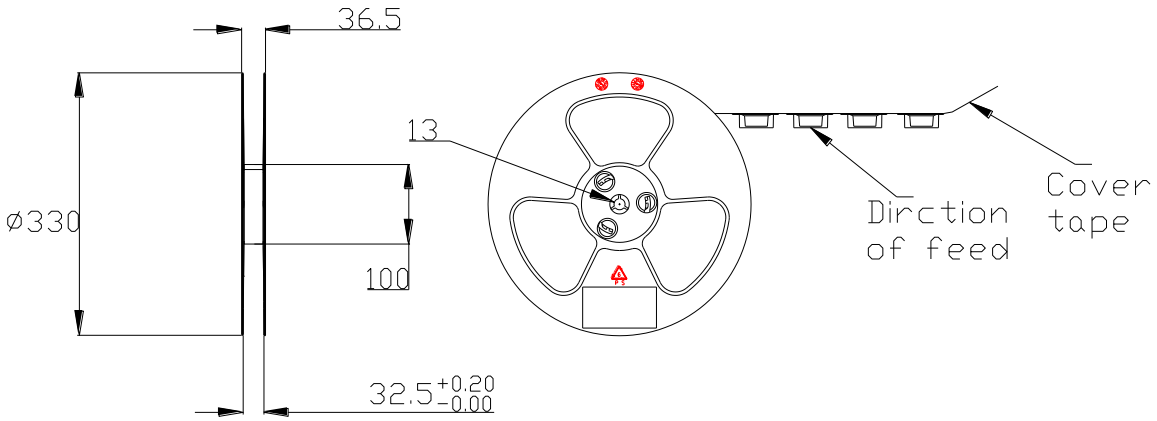

Figure 48: Reel Dimensions (Unit: mm)

8 Appendix A References

Table 36: Related Documents

SN	Document Name	Remark
[1]	Quectel_M66_Series_AT_Commands_Manual	AT commands manual for M66 series modules
[2]	ITU-T Draft new recommendation V.25ter	Serial asynchronous automatic dialing and control
[3]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[4]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[5]	GSM 07.05	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[6]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[7]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment (SIM – ME) interface
[8]	GSM 03.38	Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information
[9]	GSM 11.10	Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification

[10]	Quectel_GSM_UART_Application_Note	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

Table 37: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AMR	Adaptive Multi-Rate
ARP	Antenna Reference Point
ASIC	Application Specific Integrated Circuit
BER	Bit Error Rate
BOM	Bill of Material
BT	Bluetooth
BTS	Base Transceiver Station
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DAC	Digital-to-Analog Converter
DRX	Discontinuous Reception
DSP	Digital Signal Processor
DCE	Data Communications Equipment (typically module)
DTE	Data Terminal Equipment (typically computer, external controller)
DTR	Data Terminal Ready

DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communications
G.W	Gross Weight
HR	Half Rate
I/O	Input/Output
IC	Integrated Circuit
IMEI	International Mobile Equipment Identity
$I_O$max	Maximum Output Load Current
kbps	Kilo Bits Per Second
LED	Light Emitting Diode
Li-Ion	Lithium-Ion
MO	Mobile Originated
MOQ	Minimum Order Quantity
MP	Manufacture Product
MS	Mobile Station (GSM engine)

MT	Mobile Terminated
N.W	Net Weight
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
RF	Radio Frequency
RMS	Root Mean Square (value)
RTC	Real Time Clock
RX	Receive Direction
SMS	Short Message Service
TDMA	Time Division Multiple Access
TE	Terminal Equipment
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identification Module
USSD	Unstructured Supplementary Service Data
VSWR	Voltage Standing Wave Ratio
$V_O$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	SIM Last Dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT Calls (missed calls)
ON	SIM (or ME) Own Numbers (MSISDNs) list
RC	Mobile Equipment list of Received Calls
SM	SIM phonebook

9 Appendix B GPRS Coding Schemes

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

Table 38: 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.

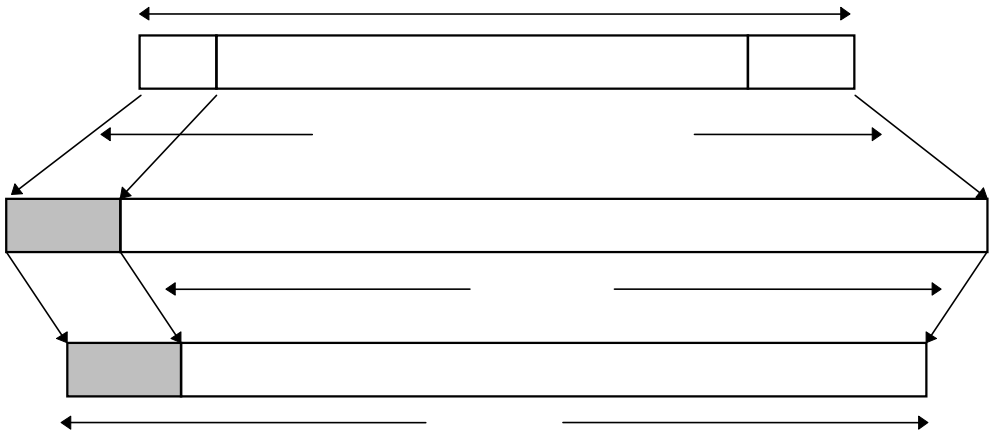

Figure 49: Radio Block Structure of CS-1, CS-2 and CS-3

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

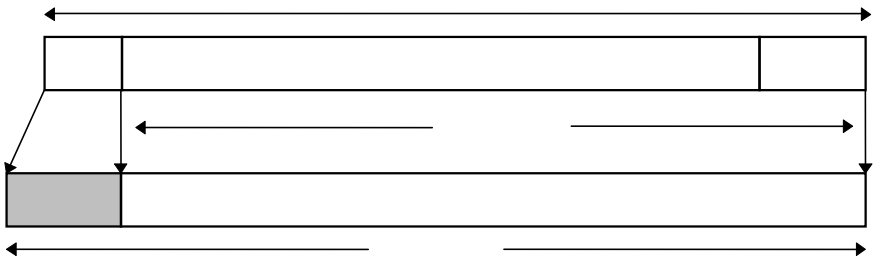

Figure 50: Radio Block Structure of CS-4

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 39: 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