MC90 Hardware Design

GSM/GPRS/GNSS Module Series

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About the Document

History

Revision	Date	Author	Description
1.0	2018-09-19	Andy ZHAO/ Kane ZHU	Initial

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1 Introduction

This document defines the MC90 module and describes its air interface and hardware interfaces which are connected with customers' applications.

This document can help customers quickly understand MC90 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 MC90 to design and set up mobile applications easily.

1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating MC90 module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals, clinics or other healthcare facilities.

	Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

2 Product Concept

2.1. General Description

MC90 is a quad-band full-featured GSM/GPRS/GNSS/Wi-Fi module. It supports GNSS+Cell ID+Wi-Fi hybrid positioning technology, which ensures position tracking under both indoor and outdoor environments. It also features compact form factor, great positioning performance, low power consumption and dual SIM single standby functions.

MC90 can work as **All-in-one** solution or **Stand-alone** solution according to customers' application demands. For detailed introduction on **All-in-one** solution and **Stand-alone** solution, please refer to ***Chapter 3.4***.

The quad-band GSM/GPRS engine can work at frequencies of GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz. MC90 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*** & ***C***.

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

The Wi-Fi interface of MC90 supports IEEE 802.11b/g/n protocol. Currently, the Wi-Fi function is mainly used for assisted positioning. By scanning hotspots near the device, information such as MAC address of the nearby hotspots can be obtained, and the device location information can be obtained through AT commands. For more details about the AT commands, please refer to ***document [15]***.

MC90 is an SMD type module with 60 LCC pads and 20 LGA pads which can be easily embedded into applications. With a compact profile of 25.6mm × 15.0mm × 2.3mm, the module can meet almost all the requirements for M2M applications, including vehicle and personal tracking, wearable devices, security systems, wireless POS, industrial PDA, smart metering, remote maintenance & control, etc.

Designed with power saving technique, the current consumption of MC90's GSM part is as low as 1.2mA in Sleep mode when DRX is 5 and the GNSS part is powered off. The GNSS engine also has many advanced power saving modes including standby and backup modes which can fit the requirement of low-power consumption in different scenes.

GSM part of MC90 is integrated with Internet service protocols such as TCP, UDP, PPP, HTTP and FTP. Extended AT commands have been developed for customers to use these Internet service protocols easily.

The GNSS part of MC90 is embedded with EASY™, EPO™, and QuecFastFix Online technology. EASY™ and EPO™ technology enable GNSS to achieve fast first-time positioning during hot or warm start. QuecFastFix Online technology reduces GNSS positioning time in cold start mode. For more details, please refer to ***Chapter 3.17***, ***3.18*** and ***3.19***.

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

2.2. Key Features

The following table describes the detailed features of MC90.

Table 1: Key Features (GMS/GPRS Part of MC90)

Features	Implementation
Power Supply	Single supply voltage: 3.3V~4.3V Typical supply voltage: 4.0V
Power Saving	Typical power consumption in Sleep mode (GNSS is powered off): 1.2mA @DRX=5 0.8mA @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 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 the protocol PAP (Password Authentication Protocol) usually

	used for PPP connection ● Internet service protocols: TCP, UDP, FTP, HTTP, PPP, SSL and MQTT, etc. ● Support Packet Broadcast Control Channel (PBCCH) ● Support Unstructured Supplementary Service Data (USSD)
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
Wi-Fi Interface	● Support IEEE 802.11b/g/n ● Used for assisted positioning
(U)SIM Interfaces	● Support (U)SIM: 1.8V, 3.0V ● Support Dual SIM Single Standby
SMS	● Text and PDU mode ● SMS storage: (U)SIM card
Audio Features	Speech codec modes: ● Half Rate (ETS 06.20) ● Full Rate (ETS 06.10) ● Enhanced Full Rate (ETS 06.50/06.60/06.80) ● Adaptive Multi-Rate (AMR) ● Echo Suppression ● Noise Reduction ● Embedded one amplifier of class AB with maximum driving power up to 800mW
UART Interfaces	Main UART port: ● Seven lines on main UART port interface ● Used for AT command communication and GPRS data transmission ● Used for PMTK command and NMEA output in **All-in-one** solution ● Multiplexing function ● Support autobauding from 4800bps to 115200bps Debug UART port: ● Two lines on debug port interface DBG_TXD and DBG_RXD ● Debug port only used for firmware debugging Auxiliary UART port: ● Two lines on auxiliary port interface: AUX_TXD and AUX_RXD ● Used for communication with the GNSS part in **All-in-one** solution
USB Interface	● Support USB 1.1 protocol specification ● Maximum transfer rate of 12Mbps ● Can be used for firmware upgrade
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

Physical Characteristics	Size: (25.6±0.15)mm × (15±0.15)mm × (2.3±0.2)mm Package: LCC+LGA Weight: Approx. 1.4g
Firmware Upgrade	Firmware upgrade via main UART port or USB port
Antenna Interfaces	● GSM antenna interface, GNSS antenna interface and Wi-Fi antenna interface ● Antenna impedance: 50Ω

NOTES

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

Table 2: Coding Schemes and Maximum Net Data Rates over Air Interface

Coding Scheme	1 Timeslot	2 Timeslot	4 Timeslot
CS-1	9.05kbps	18.1kbps	36.2kbps
CS-2	13.4kbps	26.8kbps	53.6kbps
CS-3	15.6kbps	31.2kbps	62.4kbps
CS-4	21.4kbps	42.8kbps	85.6kbps

Table 3: Key Features (GNSS Part of MC90)

Features	Implementation
GNSS	● GPS+GLONASS
Power Supply	● Supply voltage: 2.8V~4.3V ● Typical Supply voltage: 3.3V
Power Consumption	● Acquisition: 25mA @-130dBm (GPS) ● Tracking: 19mA @-130dBm (GPS) ● Acquisition: 29mA @-130dBm (GPS+GLONASS) ● Tracking: 22mA @-130dBm (GPS+GLONASS) ● Standby: 300uA @VCC=3.3V

	● Backup: 14uA @V_BCKP=3.3V
Receiver Type	● GPS L1 1575.42MHz C/A Code ● GLONASS L1 1598.0625~1605.375MHz C/A Code
Sensitivity GPS+GLONASS	● Acquisition: -149dBm ● Reacquisition: -161dBm ● Tracking: -167dBm
Time-to-First-Fix (EASY™ Enabled) 1)	● Cold Start: <15s average @-130dBm ● Warm Start: <5s average @-130dBm ● Hot Start: 1s @-130dBm
Time-to-First-Fix (EASY™ Disabled)	● Cold Start (Autonomous): <35s average @-130dBm ● Warm Start (Autonomous): <30s average @-130dBm ● Hot Start (Autonomous): 1s @-130dBm
Horizontal Position Accuracy (Autonomous)	● <2.5m CEP @-130dBm
Update Rate	● Up to 10Hz, 1Hz by default
Accuracy of 1PPS Signal	● Typical accuracy <10ns ● Time pulse width: 100ms
Velocity Accuracy	● Without aid: 0.1m/s
Acceleration Accuracy	● Without aid: 0.1m/s²
Dynamic Performance	● Maximum Altitude: 18000m ● Maximum Velocity: 515m/s ● Acceleration: 4G
GNSS UART Port	● GNSS UART port: GNSS_TXD and GNSS_RXD ● Support baud rates from 4800bps to 115200bps; 115200bps by default ● Communicate with the GSM Part in **All-in-one** solution ● Communicate with the MCU in **Stand-alone** solution

NOTE

1) In this mode, GNSS part's backup domain should be valid.

Table 4: Protocols Supported by the Module

Protocol	Type
NMEA	Output, ASCII, 0183, 3.01
PMTK	Input/output, MTK proprietary protocol

NOTE

Please refer to ***document [16]*** for details of NMEA standard protocol and MTK proprietary protocol.

2.3. Functional Diagram

The following figure shows a block diagram of MC90 and illustrates the major functional parts.

- Radio frequency
- Power management
- Memory
- Peripheral interfaces
  - Power supply
  - PWRKEY
  - UART interfaces
  - USB interface
  - Audio interfaces
  - PCM interface
  - (U)SIM interfaces
  - ADC interface
  - RF interfaces
  - Wi-Fi interface

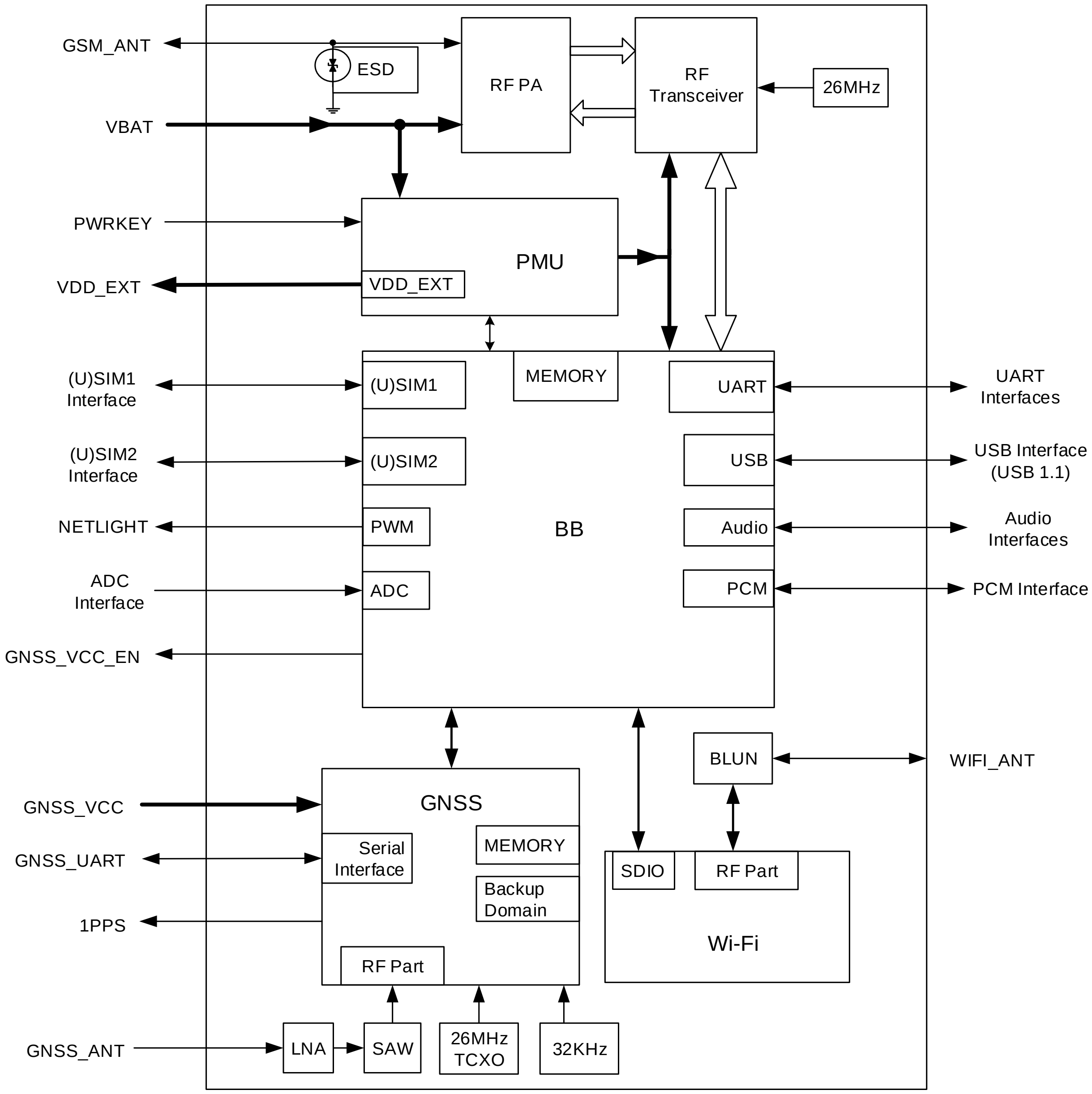

Figure 1: Module Functional Diagram

2.4. Development Board

Quectel provides a complete set of development tools to facilitate the use and testing of MC90 module. The development tool kit includes the evaluation board (EVB), TE-A board, RS-232 to USB cable, power adapter, earphone, GSM antenna, GNSS antenna and other peripherals. For details, please refer to ***document [11]*** and ***document [17]***.

3 Application Interfaces

3.1. General Description

MC90 is an SMD type module with 60 LCC pads and 20 LGA pads. The subsequent chapters will provide detailed descriptions of the following functions/pins/interfaces:

- Power supply
- Backup domain of GNSS
- Operating modes
- Power-on/off
- Power saving
- UART interfaces
- USB interface
- Audio interfaces
- PCM interface
- (U)SIM interfaces
- ADC interface
- Behaviors of the RI
- Network status indication
- EASY^{TM} autonomous AGPS technology
- EPO^{TM} offline AGPS technology
- QuecFastFix Online technology
- Multi-tone AIC
- LOCUS
- PPS VS. NMEA
- Wi-Fi interface

3.2. Pin Assignment

The following figure shows the pin assignment of MC90.

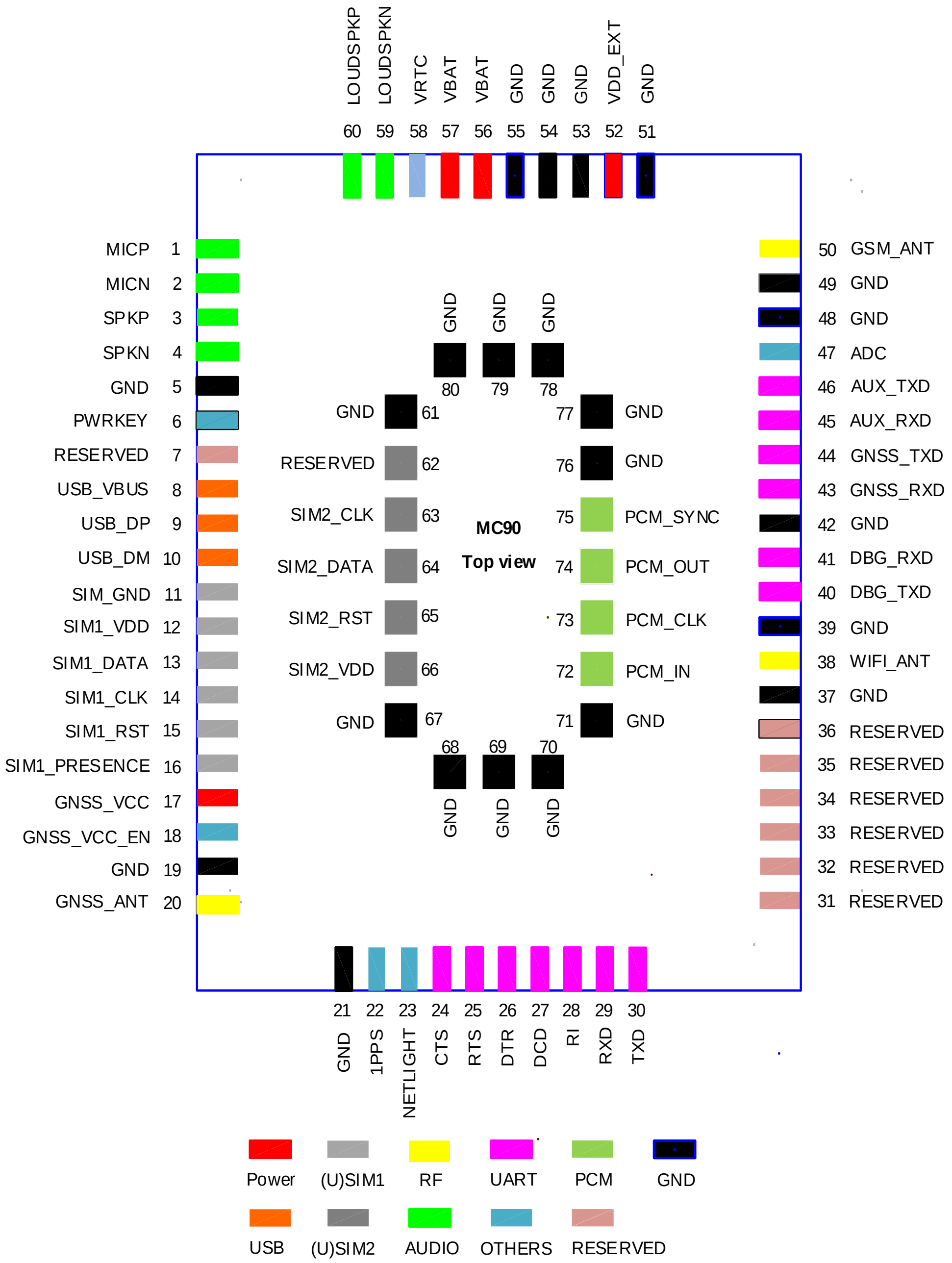

Figure 2: Pin Assignment

NOTE

Please keep all reserved pins open.

3.3. Pin Description

Table 5: 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
HO	High level output
LO	Low level output

Table 6: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT	56, 57	PI	Power supply of GSM/GPRS part: VBAT=3.3V~4.3V	$V_I$max=4.3V $V_I$min=3.3V $V_I$norm=4.0V	It must be able to provide sufficient current up to 1.6A in a transmitting burst.
GNSS_VCC	17	PI	Power supply of GNSS part: GNSS_VCC=2.8V~4.3V	$V_I$max=4.3V $V_I$min=2.8V $V_I$norm=3.3V	Assure load current no less than 150mA.
VRTC	58	IO	Power supply for GNSS's backup domain. Charging for backup battery or golden capacitor when the VBAT is applied.	VImax=3.3V VImin=1.5V VInorm=2.8V VOmax=2.8V VOmin=2.1V VOnorm=2.6V IOmax=2mA	Refer to ***Chapter 3.5.5***

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
				Iin≈14uA	
VDD_EXT	52	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 2.2uF~4.7uF bypass capacitor, when using this pin for power supply.
GND	5, 19, 21, 37, 39, 42, 48, 49, 51, 53~55, 61, 67~71, 76~80		Ground		
PWRKEY					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	6	DI	Turn-on/off key. PWRKEY should be pulled down for a moment to turn on or turn off the system.	V_{IL}max= 0.1 × VBAT 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	1, 2	AI	Positive and negative voice input	Refer to ***Chapter 3.11.6***	If unused, keep these pins open
SPKP, SPKN	3, 4	AO	Channel 1 positive and negative voice output		1. If unused, keep these pins open 2. Support both

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
					voice and ringtone output
LOUDSPKP, LOUDSPKN	60, 59	AO	Channel 2 positive and negative voice output		1. If unused, keep these pins open 2. Integrate a Class-AB amplifier internally. 3. Support both voice and ringtone output

Network Status Indicator

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
NETLIGHT	23	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	30	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	29	DI	Receive data		
DTR	26	DI	Data terminal ready		
RI	28	DO	Ring indication		
DCD	27	DO	Data carrier detection		
CTS	24	DO	Clear to send		
RTS	25	DI	Request to send		

Debug UART Port

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
DBG_TXD	40	DO	Transmit data	V_{IL}min=0V V_{IL}max= 0.25 × VDD_EXT	If unused, keep these pins open
DBG_RXD	41	DI	Receive data		

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
				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	
Auxiliary UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
AUX_TXD	46	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	Refer to ***Chapter 3.9.3***
AUX_RXD	45	DI	Receive data		
GNSS UART Port					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GNSS_TXD	44	DO	Transmit data	V_{OL}max=0.42V V_{OH}min=2.4V V_{OH}nom=2.8V V_{IL}min=-0.3V V_{IL}max=0.7V V_{IH}min=2.1V V_{IH}max=3.1V	Refer to ***Chapter 3.9.3***
GNSS_RXD	43	DI	Receive data		
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	8	PI	5V power supply	+5V	Support USB 1.1 protocol specification. If unused, keep these pins open.
USB_DP	9	IO	USB differential signal line (+)	90Ω characteristic impedance	
USB_DM	10	IO	USB differential signal line (-)	90Ω characteristic impedance	
(U)SIM Interfaces					

Pin Name	Pin No.	I/O	Description	DC Characteristics	Comment
SIM1_VDD, SIM2_VDD	12, 66	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 interfaces should be protected against ESD with a TVS diode array; Maximum trace length is 200mm from the module pad to (U)SIM card connector.
SIM1_CLK, SIM2_CLK	14, 63	DO	Clock signal of (U)SIM card	V_{OL}max= 0.15 × SIM_VDD V_{OH}min= 0.85 × SIM_VDD	
SIM1_DATA, SIM2_DATA	13, 64	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	
SIM1_RST, SIM2_RST	15, 65	DO	Reset signal of (U)SIM card	V_{OL}max= 0.15 × SIM_VDD V_{OH}min= 0.85 × SIM_VDD	
SIM_GND	11		Specified ground for (U)SIM card		
SIM1_ PRESENCE	16	DI	(U)SIM1 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	
ADC					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC	47	AI	General purpose analog to digital converter	Voltage range: 0V to 2.8V	If unused, keep this pin open.
Digital Audio Interface (PCM)					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_CLK	73	DO	PCM clock	V_{IL}min= 0V V_{IL}max= 0.25 × VDD_EXT	If unused, keep these pins open.
PCM_OUT	74	DO	PCM data output		

PCM_SYNC	75	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	
PCM_IN	72	DI	PCM data input		
Antenna Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GSM_ANT	50	IO	GSM antenna pad	Impedance of 50Ω	If unused, keep these pins open.
WIFI_ANT	38	IO	Wi-Fi antenna pad	Impedance of 50Ω	
GNSS_ANT	20	AI	GNSS signal input	Impedance of 50Ω	
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
GNSS_ VCC_EN	18	DO	GNSS power enabled	V_{OH}min= 0.85 × VDD_EXT V_{OL}max= 0.15 × VDD_EXT	1. Refer to ***Chapter 3.5.3.2*** in **All-in-one** solution. 2. Keep this pin open in **Stand-alone** solution.
1PPS	22	DO	One pulse per second	V_{OL}max=0.42V V_{OH}min=2.4V V_{OH}nom=2.8V	1. Synchronized at rising edge, and the pulse width is 100ms. 2. If unused, keep this pin open.
RESERVED	7, 31, 32, 33, 34, 35, 36, 62				Keep these pins open.

3.4. Application Mode Introduction

MC90 integrates both GSM and GNSS engines which can work as a whole (**All-in-one** solution) unit or work independently (**Stand-alone** solution) according to customers' demands.

In **All-in-one** solution, the MC90 works as a whole unit. The GNSS part can be regarded as a peripheral of the GSM Part. This allows for convenient communication between GSM and GNSS parts, such as AT command sending for GNSS control, GNSS part firmware upgrading, and EPO data download.

In **Stand-alone** solution, GSM and GNSS parts work independently, and thus have to be controlled separately.

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

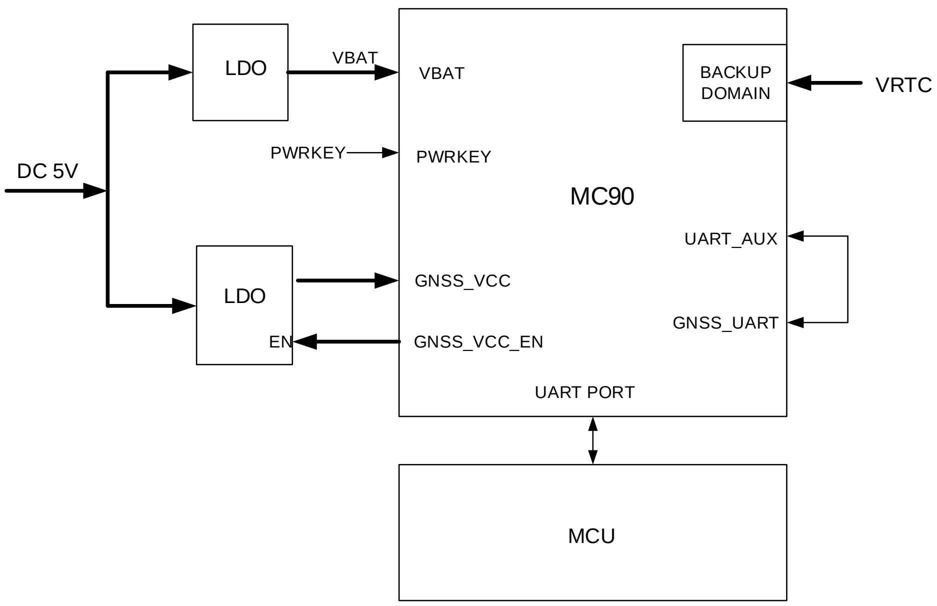

Figure 3: All-in-one Solution Schematic Diagram

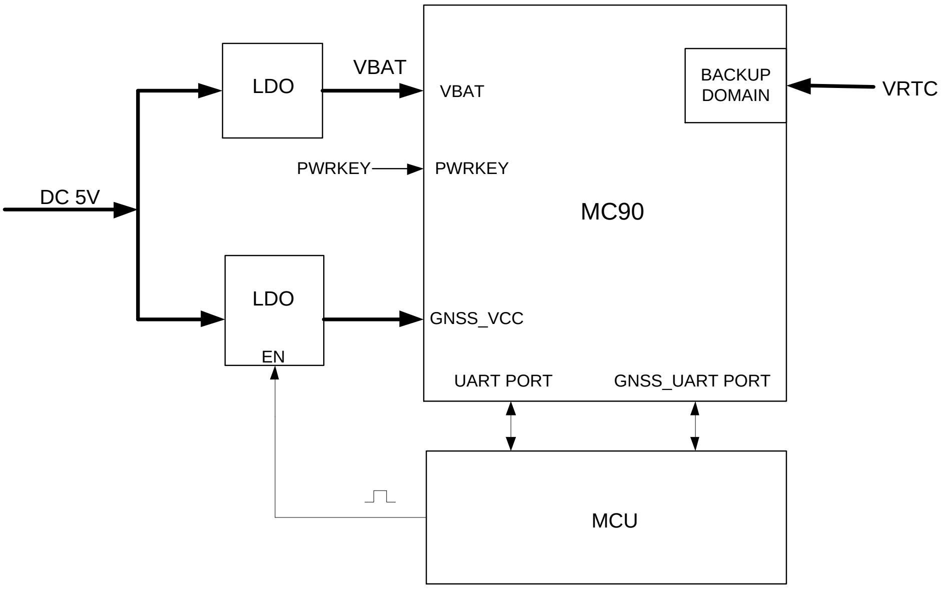

Figure 4: Stand-alone Solution Schematic Diagram

Table 7: Comparison between All-in-one and Stand-alone Solution

	All-in-one	Stand-alone	Remarks
Firmware upgrade	Firmware upgrade via main UART port or USB port (GSM and GNSS parts share the same firmware package)	Firmware upgrade via main UART port or USB port (GSM and GNSS parts share the same firmware package)	Refer to ***Chapter 3.9.1.3*** for details
Data transmission	Both GSM and GNSS data are transmitted through the main UART port	GSM data is transmitted through the main UART port. GNSS data is transmitted through the GNSS UART port.	
GNSS turn-on/off	By AT command through main UART port	Through the external switch of MCU	Refer to ***Chapter 3.7*** and ***3.8*** for details
GNSS's EPO data download	EPO data is downloaded directly through the GSM part.	MCU receives the EPO data which is downloaded through the GSM part, and then transmit it to the GNSS part.	Refer to ***Chapter 3.18*** for details

3.5. Power Supply

3.5.1. Power Features

3.5.1.1. Power Features of GSM Part

The power supply of the GSM part is one of the key issues in MC90 design. Due to the 577us radio burst in GSM part every 4.615ms, the power supply must be able to deliver high current peaks in a burst period. During these peaks, drops on the supply voltage must not exceed the minimum working voltage of the GSM part.

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

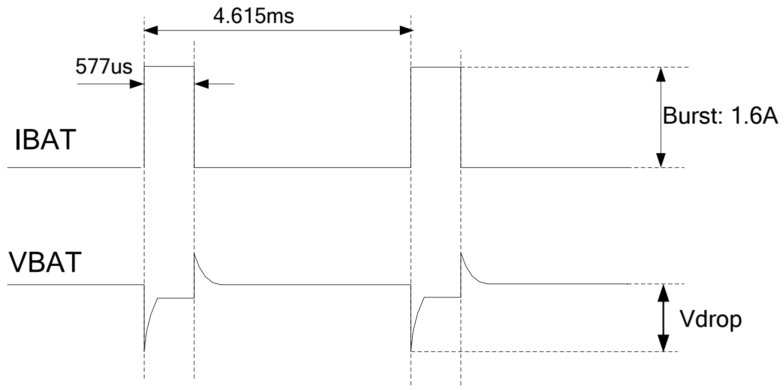

Figure 5: Voltage Ripple during Transmitting (GSM Part)

3.5.1.2. Power Features of GNSS Part

In **All-in-one** solution, the power supply of GNSS part is controlled by the GSM part through the GNSS_VCC_EN pin. In **Stand-alone** solution, the power supply of GNSS part is controlled independently via an external switch of MCU.

3.5.2. Decrease Supply Voltage Drop

3.5.2.1. Decrease Supply Voltage Drop for GSM Part

Power supply range of the GSM part is from 3.3V to 4.3V. 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 ceramic capacitors 100nF, 33pF and 10pF near the VBAT pin. A reference circuit is illustrated in the following figure.

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

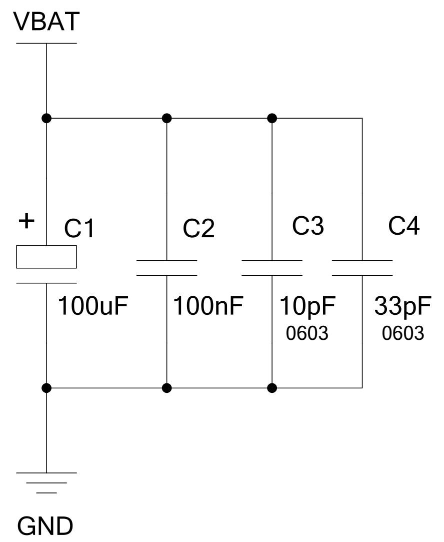

Figure 6: Reference Circuit for VBAT Input (GSM Part)

3.5.2.2. Decrease Supply Voltage Drop for GNSS Part

Power supply range of GNSS part is from 2.8 to 4.3V. GNSS_VCC's maximum average current is 40mA during GNSS acquisition after power up. So it is important to supply sufficient current and make the power clean and stable. The decouple combination of 10uF and 100nF capacitor is recommended nearby GNSS_VCC pin. A reference circuit is illustrated in the following figure.

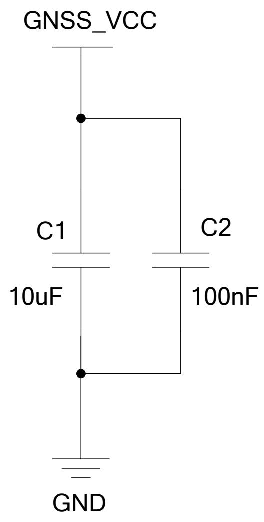

Figure 7: Reference Circuit for GNSS_VCC Input

3.5.3. Reference Design for Power Supply

3.5.3.1. Reference Design for Power Supply of GSM Part

In **All-in-one** solution, the GSM part controls the power supply of the GNSS part. Therefore, the GSM part share the same power circuit design in both **All-in-one** and **Stand-alone** solutions.

The power supply of GSM part is capable of providing sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is suggested to use a LDO as the GSM part's power supply. If there is a big voltage difference between the input source and the desired output (VBAT), a switcher power converter is recommended to be used as the power supply.

The following figure shows a reference design for +5V input power source for GSM part. The designed output for the power supply is 4.0V and the maximum load current is 3.0A. In addition, in order to get a stable output voltage, a zener diode is placed close to the pins of VBAT. As to the zener diode, it is suggested to use a zener diode whose reverse zener voltage is 5.1V and dissipation power is more than 1W.

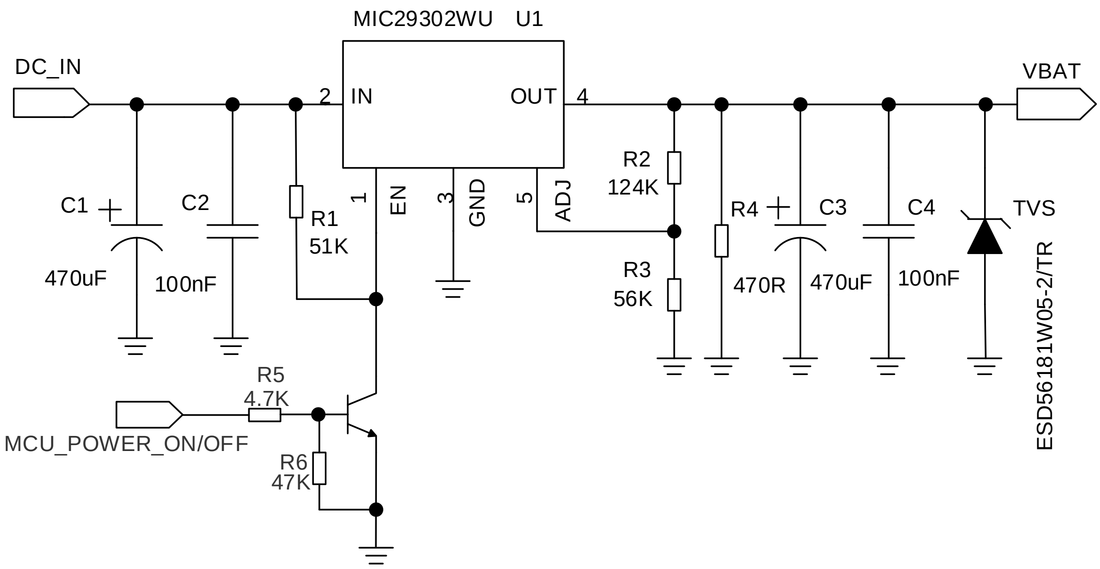

Figure 8: Reference Circuit for Power Supply of the GSM Part

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.

3.5.3.2. Reference Design for Power Supply of GNSS Part in All-in-one Solution

In **All-in-one** solution, the power supply of GNSS part is controlled by the GSM part through the GNSS_VCC_EN pin. A reference circuit for the GNSS part power supply is given below. Please pay attention to the electrical characteristics of GNSS_VCC_EN to match LDO's EN pin. Please refer to ***document [1]*** for details about the AT commands for GNSS control.

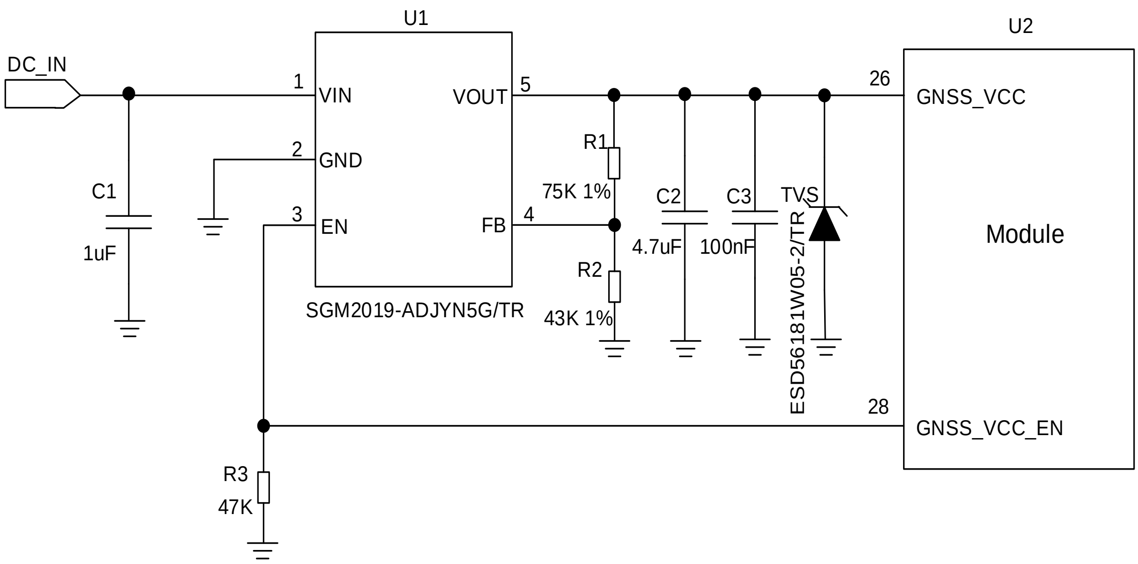

Figure 9: Reference Circuit Design for GNSS Part in All-in-one Solution

3.5.3.3. Reference Design for Power Supply of GNSS Part in Stand-alone Solution

In **Stand-alone** solution, GNSS is independent to the GSM part, and the power supply of the GNSS part is controlled by MCU. A reference circuit for the power supply of GNSS part is given below.

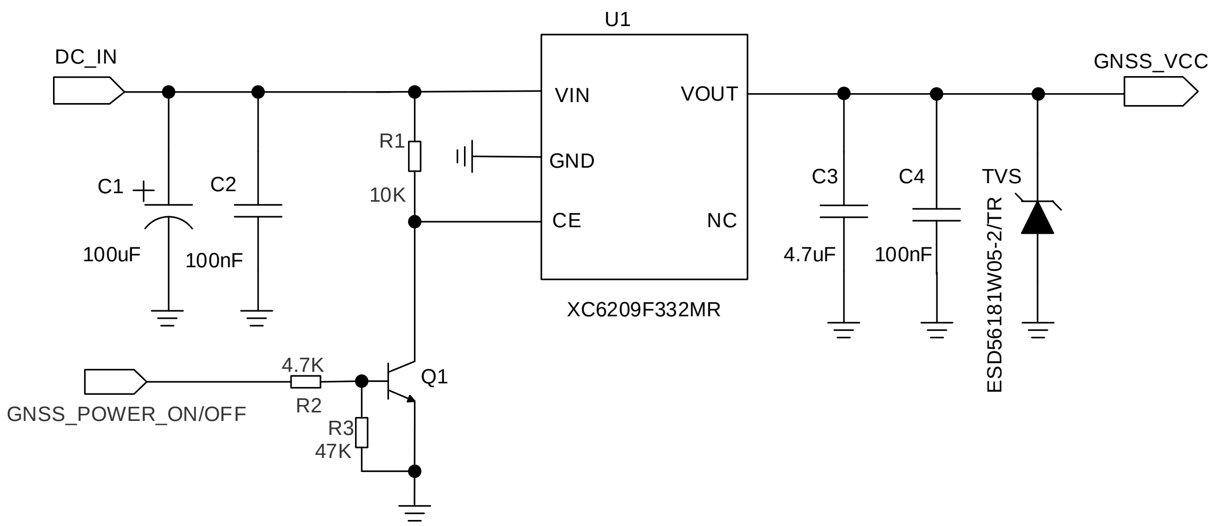

Figure 10: Reference Circuit Design for GNSS Part in Stand-alone Solution

3.5.4. Monitor Power Supply

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

3.5.5. Backup Domain of GNSS

The GNSS part of MC90 features a backup domain which contains all the necessary GNSS information for quick start-up and a small amount of user configuration variables. In GNSS's backup mode, the backup domain is still alive. As long as the backup domain is alive, EASY^{TM} technology will be available.

3.5.5.1. Use VBAT as the Backup Power Source of GNSS

In either **All-in-one** or **Stand-alone** solution, GNSS's backup mode will be active as long as the main power supply (VBAT) is remained, even when the module is turned off and GNSS_VCC is powered off; as the GNSS's backup domain is powered by VBAT. In this case, the VRTC pin can be kept floating, and the current consumption is only about 220uA.

When powered by VBAT, the reference schematic diagrams in **All-in-one** and **Stand-alone** solutions are shown below.

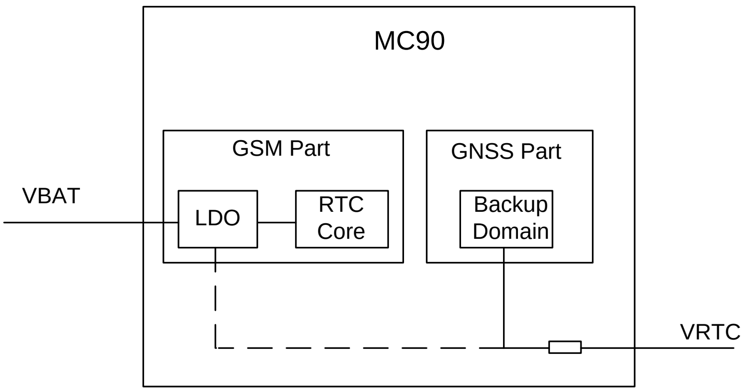

Figure 11: Internal GNSS's Backup Domain Power Construction

3.5.5.2. Use VRTC as Backup Power of GNSS

In either **All-in-one** or **Stand-alone** solution, when the main power supply (VBAT) is removed after the module is turned off, and GNSS_VCC is also powered off, a backup 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 GNSS in backup mode. In this case, the current consumption is as low as 14uA approximately.

When powered by VRTC, the reference schematic diagrams in **All-in-one** and **Stand-alone** solutions are shown below.

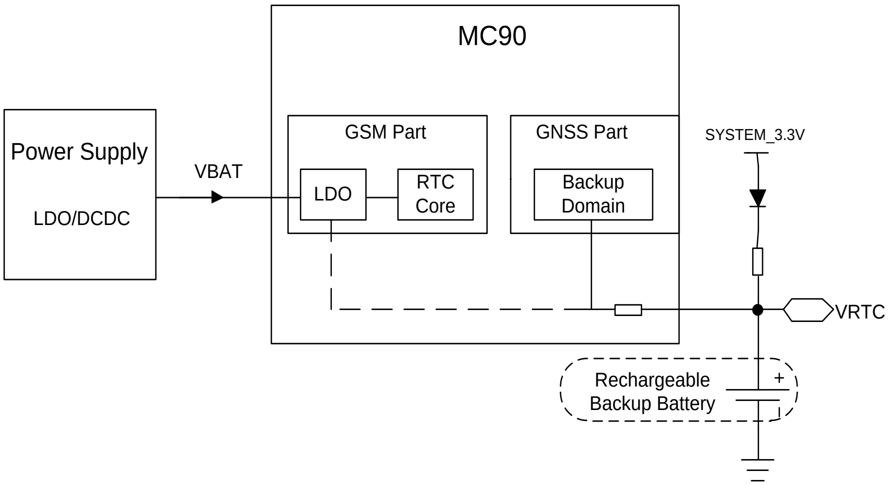

Figure 12: VRTC is Powered by a Rechargeable Battery

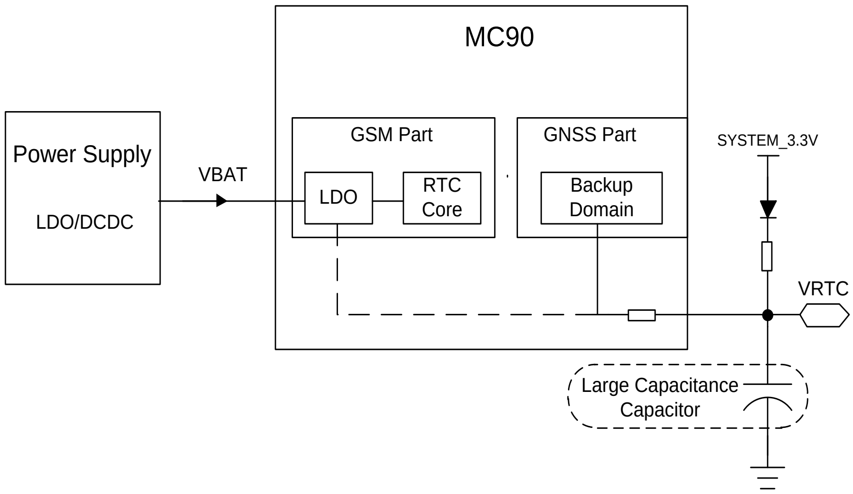

Figure 13: VRTC is Powered by a Capacitor

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

As SYSTEM_3.3V is used for battery charging, it is recommended to keep it powered for the longest time in all system power supplies.

3.6. Operating Modes

3.6.1. Operating Modes of GSM Part

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

Table 8: Operating Modes Overview of GSM Part

Modes	Function	
GSM Normal Operation	GSM/GPRS Sleep	After enabling Sleep mode by **AT+QSCLK=1**, the GSM part 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 main UART port). In this case, the current consumption of the GSM part will reduce to the minimal level. During Sleep mode, the GSM part can still receive paging message and SMS from the system normally.
	GSM IDLE	Software is active. The GSM part has registered on GSM network, and it is ready to send and receive GSM data.
	GSM TALK	GSM connection is ongoing. In this mode, the power consumption is decided by the configuration of Power Control Level (PCL), dynamic DTX control and the working RF band.
	GPRS IDLE	The GSM part is not registered on GPRS network. It is not reachable through GPRS channel.
	GPRS STANDBY	The GSM part 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 GSM part 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 GSM part. Software is not active. The UART interfaces are not accessible. Operating voltage (connected to VBAT) remains applied.	
Minimum Functionality Mode (without removing	**AT+CFUN** command can set the GSM part to a minimum functionality mode without removing the power supply. In this case, the RF part of the GSM part will not work or the (U)SIM card will not be accessible, or both RF part and (U)SIM	

power supply)	card will be disabled; but the main UART port is still accessible. The power consumption in this case is very low.

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

3.6.1.1. Minimum Functionality Mode

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

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

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

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

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

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

3.6.1.2. 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 GSM part cannot enter Sleep mode.

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

3.6.1.3. Wake up GSM Part from Sleep Mode

When the GSM part is in the Sleep mode, it can be woken up through the following methods:

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

NOTE

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

3.6.2. Operating Modes of GNSS Part

3.6.2.1. Full on Mode

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

When the GNSS_VCC is valid, the GNSS part will enter into full on mode automatically. The following table describes the default configuration of full on mode.

Table 9: Default Configuration of Full on Mode (GNSS Part)

Item	Configuration	Comment
Baud Rate	115200bps	
Protocol	NMEA	RMC, VTG, GGA, GSA, GSV and GLL
Update Rate	1Hz	
SBAS	Enable	
AIC	Enable	
LOCUS	Disable	

EASY^{TM} Technology	Enable	EASY^{TM} will be disabled automatically when update rate exceeds 1Hz.
GNSS	GPS+GLONASS	

In full on mode, the consumption complies with the following regulations:

When the GNSS part is powered on, the average current will rush to 40mA and last for a few seconds; then the consumption will be decreased to the acquisition current marked in ***Table 3*** and Quectel defined this state as acquisition state, and also it will last for several minutes until it switches to tracking state automatically. The consumption in tracking state is less than that in acquisition state. The value is also listed in ***Table 3***.

Sending PMTK commands allows for switching among multiple positioning systems:

- $PMTK353,0,1,0,0,0*2A: search GLONASS satellites only
- $PMTK353,1,0,0,0,0*2A: search GPS satellites only
- $PMTK353,1,1*37: search GLONASS and GPS satellites

NOTE

In **All-in-one** solution, make sure the GNSS part is powered on before sending these PMTK commands.

3.6.2.2. Standby Mode

Standby mode is a low-power consumption mode. In standby mode, the internal core and I/O power domain are still active; but RF and TCXO are powered off, and the GNSS part stops satellites search and navigation. The way to enter into standby mode is using PMTK commands.

When the GNSS part exits from standby mode, it will use all internal aiding information like GNSS time, ephemeris, last position, etc., to ensure the fastest possible TTFF in either Hot or Warm start. The typical current consumption is about 300uA @GNSS_VCC=3.3V in standby mode.

Sending the following PMTK command can make GNSS part enter into standby mode:

- $PMTK161,0*28: send this command in **Stand-alone** solution.

The following methods will make GNSS part exit from standby mode:

- Sending any data via GNSS_UART will make GNSS part exit from standby mode in **Stand-alone** solution.

- Sending any PMTK command data about the GNSS through the main UART port will make GNSS part exit the standby mode in **All-in-one** solution.

3.6.2.3. Backup Mode

Backup mode requires lower power consumption than standby mode. In this mode, the GNSS part stops acquiring and tracking satellites, but the backed-up memory in backup domain which contains all the necessary GNSS information for quick start-up and a small amount of user configuration variables is alive. Due to the backed-up memory, EASY^{TM} technology is available. The current consumption in this mode is about 14uA.

The following method will make GNSS part enter into backup mode:

- Cutting off GNSS_VCC and keeping VBAT/VRTC powered will make GNSS part enter into back mode from full on mode.

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

- As long as the GNSS_VCC is powered, the GNSS part will exit from backup mode and enter full on mode immediately.

3.6.2.4. Periodic Mode

Periodic mode can control the full on mode and standby/backup mode periodically to reduce power consumption. It contains periodic standby mode and periodic backup mode.

The format of the command, which enables the module's GNSS part to enter into periodic mode, is shown below:

Table 10: Format of the PMTK Command Enabling Periodic Mode

Format: $PMTK225,<Type>,<Run_time>,<Sleep_time>,<2nd_run_time>,<2nd_sleep_time>*<checksum><CR><LF>			
Parameter	**Format**	**Description**	**Range (ms)**
Type	Decimal	**Type=1**: Periodic backup mode **Type=2**: Periodic standby mode	/
Run_time	Decimal	**Run_time**=Full on mode period (ms)	1000~518400000
Sleep_time	Decimal	**Sleep_time**=Standby/Backup mode period (ms)	1000~518400000

2nd_run_time	Decimal	**2nd_run_time**=Full on mode period (ms) for extended acquisition in case module's acquisition fails during the **Run_time**	0 or 1000~518400000
2nd_sleep_time	Decimal	**2nd_sleep_time**=Standby/Backup mode period (ms) for extended sleep in case module's acquisition fails during the **Run_time**	0 or 1000~518400000
Checksum	Hexadecimal	Hexadecimal checksum	

Example

```
$PMTK225,2,3000,12000,18000,72000*15<CR><LF>
$PMTK225,1,3000,12000,18000,72000*15<CR><LF>
```

In periodic standby mode, sending "$PMTK225,0*2B" in any time can make the GNSS part enter into full on mode.

In periodic backup mode, sending "$PMTK225,0*2B" during the **Run_time** or **2nd_run_time** period can also make the GNSS part enter into full on mode. But this is hard to operate and thus is not recommended.

The following figure has shown the operation mechanism of periodic mode. When customers send PMTK command, the GNSS part will be in full on mode first. Several minutes later, the GNSS part will enter into periodic mode according to the parameters set. When the GNSS part fails to fix the position during **Run_time**, it will switch to **2nd_run_time** and **2nd_sleep_time** automatically. As long as the GNSS part fixes the position again successfully, it will return to **Run_time** and **Sleep_time**.

Before entering into periodic mode, please make sure the GNSS part is in tracking mode; otherwise it may have a risk of failure in satellite tracking. If module is located in weak signal areas, it is better to set a longer **2nd_run_time** to ensure the success of reacquisition.

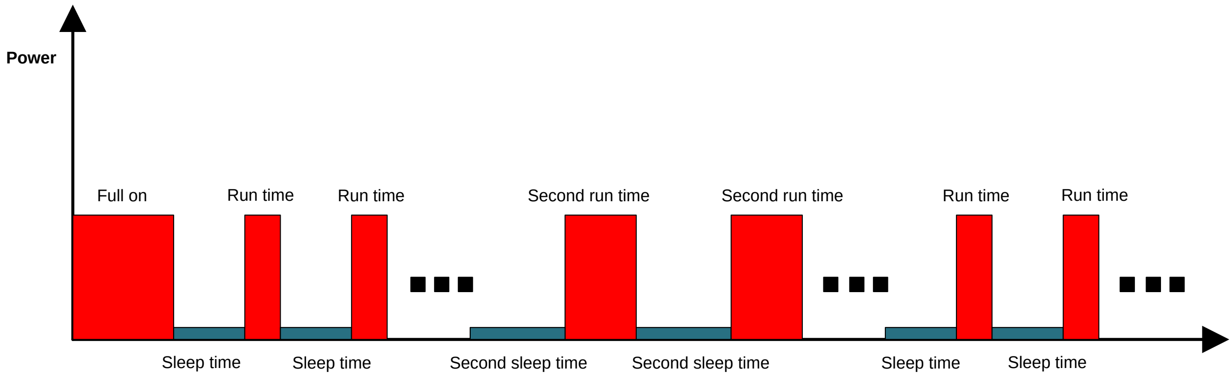

Figure 14: Operation Mechanism of Periodic Mode

The average current consumption in periodic mode can be calculated based on the following formula:

$I_{periodic} = (I_{tracking} * T1 + I_{standby/backup} * T2)/(T1+T2)$ T1: Run_time, T2: Sleep_time

Example

PMTK225,2,3000,12000,18000,72000*15 for periodic mode means 3s in tracking mode and 12s in standby mode based on GPS&GLONASS. The average current consumption is calculated below:
$I_{periodic} = (I_{tracking} * T1 + I_{standby} * T2)/(T1+T2) = (22mA*3s+0.5mA*12s)/(3s+12s) \approx 4.8(mA)$

PMTK225,1,3000,12000,18000,72000*15 for periodic mode means 3s in tracking mode and 12s in backup mode based on GPS&GLONASS. The average current consumption is calculated below:
$I_{periodic} = (I_{tracking} * T1 + I_{backup} * T2)/(T1+T2) = (22mA*3s+0.007mA*12s)/(3s+12s) \approx 4.4(mA)$

3.6.2.5. AlwaysLocate™ Mode

AlwaysLocate™ is an intelligent power saving mode. It contains AlwaysLocate™ backup mode and AlwaysLocate™ standby mode.

AlwaysLocate™ standby mode allows the GNSS part to switch automatically between full on mode and standby mode. According to the environmental and motion conditions, the GNSS part can adaptively adjust the full on time and standby time to achieve the balance between positioning accuracy and power consumption. Sending “$PMTK225,8*23” and the module returning “$PMTK001,225,3*35” mean that the GNSS part has entered AlwaysLocate™ standby mode successfully, which greatly saves power consumption. Sending “$PMTK225,0*2B” in any time will make the GNSS part back to full on mode.

AlwaysLocate™ backup mode is similar to AlwaysLocate™ standby mode. The difference is that the AlwaysLocate™ backup mode allows the GNSS part to switch automatically between full on mode and backup mode. Sending “$PMTK225,9*22” command will make the GNSS part enter into AlwaysLocate™

backup mode. During the "Full on mode" period in AlwaysLocate^{TM} backup mode, sending "$PMTK225,0*2B" will make the GNSS part back to full on mode.

The positioning accuracy in AlwaysLocate^{TM} mode may be decreased, especially in high speed movement. The following figure shows the power consumption of the module in different scenarios.

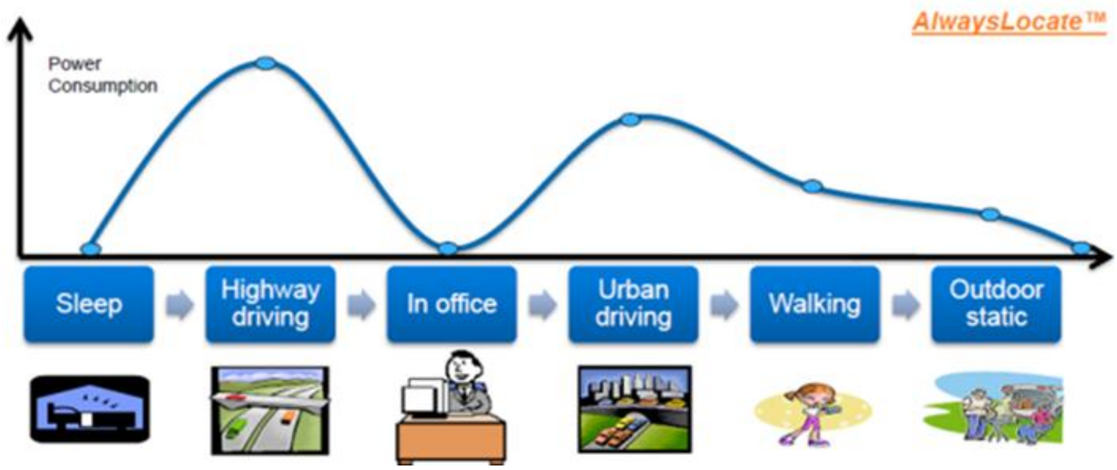

Figure 15: Power Consumption in Different Scenarios (AlwaysLocate^{TM} Mode)

When located in outdoors in static and equipped with an active antenna, the GNSS part has an average current consumption of approx. 2.7mA after tracking satellites in AlwaysLocate^{TM} standby mode and 2.6mA in AlwaysLocate^{TM} backup mode based on GPS&GLONASS.

3.6.2.6. GLP Mode

GLP (GNSS low power) mode is an optimized solution for wearable fitness and tracking devices. It can reduce power consumption by closing high accuracy positioning.

In GLP mode, the GNSS part can also provide good positioning performance in walking and running scenarios, and supports automatic dynamic duty operation switch for balance on performance and power consumption. It will come back to normal mode in difficult environments to keep good accuracy, thus realizing maximum performance with the lowest power consumption.

The average current consumption in GLP mode is down to 8.9mA in static scenario, which is only 40% of that in normal mode. It may increase a little bit in dynamic scenario. The average current consumption in different outdoor scenarios in GLP mode and normal mode is shown in the table below.

Table 11: Average Current Consumption in GLP Mode and Normal Mode

Scenario	In GLP Mode (mA)	In Normal Mode (mA)
Static	8.9	22
Walking	11.2	22
Running	11.5	22
Driving	21.5	22

Customers can use the following commands to make the GNSS part enter into or exit from the GLP mode:

- $PQGLP,W,1,1*21: The command is used to set the GNSS part into GLP mode. When "$PQGLP,W,OK*09" is returned, it means the part has entered into GLP mode successfully.
- $PQGLP,W,0,1*20: The command is used to make the GNSS part exit from GLP mode. When "$PQGLP,W,OK*09" is returned, it means the part has exited from GLP mode successfully.

NOTES

1. It is recommended to set all the necessary commands before the GNSS part enters into GLP mode. If customers need to send commands, please exit from GLP mode first.
2. When the GNSS part enters into GLP mode, 1PPS function will be disabled.
3. When the GLP mode is enabled, the SBAS will be affected.
4. In high dynamic scenario, the module will have slightly decreased positioning accuracy in GLP mode.
5. The module supports 4800bps~115200bps baud rates and 1Hz~10Hz frequency. It is recommended that 115200bps baud rate and 1Hz frequency are set before the GNSS part enters into GLP mode in **Stand-alone** solution.
6. The GNSS part will automatically come back to the normal mode in complex environments to keep good positioning accuracy.

3.6.3. Summary of GSM and GNSS Parts' State in All-in-one Solution

Table 12: Combination States of GSM and GNSS Parts in All-in-one Solution

GNSS Part Modes	GSM Part Modes		
	Normal	Sleep	Minimum Functionality
Full on	✓	✓	✓
Backup	✓	✓	✓

Periodic	✓	✓	✓
AlwaysLocate™	✓	✓	✓
GLP	✓	✓	✓

3.6.4. Summary of GSM and GNSS Parts' State in Stand-alone Solution

Table 13: Combination States of GSM and GNSS Parts in Stand-alone Solution

GNSS Part Modes	GSM Part Modes		
	Normal	Sleep	Minimum Functionality
Full on	✓	✓	✓
Standby	✓	✓	✓
Backup	✓	✓	✓
Periodic	✓	✓	✓
AlwaysLocate™	✓	✓	✓
GLP	✓	✓	✓

NOTES

1. The mark "✓" means that the Part supports this mode.
2. In **All-in-one** solution, all PMTK commands used for the GNSS part should be sent through the GSM UART after the GNSS part is powered on. Make sure the main UART port is accessible.
3. In **All-in-one** solution, when the GSM part is in Sleep mode, the GNSS part can work in either standby or full on mode. However, if NMEA GPS data is needed, the GSM part should be woken up first and then send the corresponding AT command to get. For detailed AT command information, please refer to ***document [1]***.
4. In **Stand-alone** solution, all PMTK commands used for the GNSS part can be sent through GNSS UART in any mode of GSM part.

3.7. Power-on/off Scenarios in All-in-one Solution

In **All-in-one** solution, GNSS function is turned on or off by the AT command sent from GSM part.

3.7.1. Power-on

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

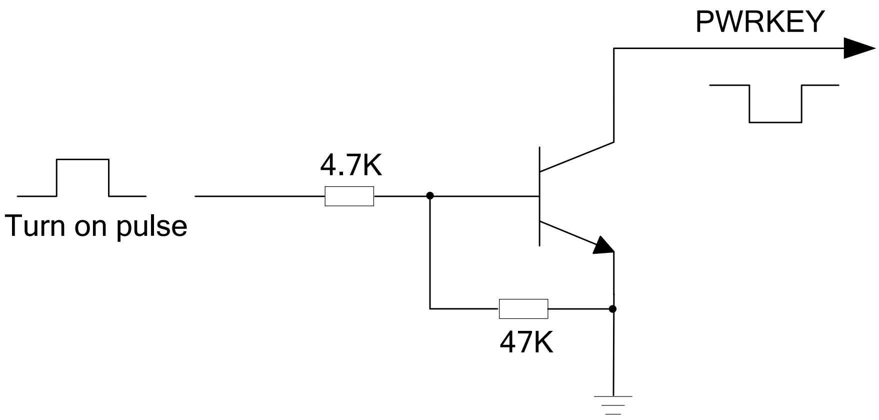

Figure 16: Turn on the Module through an Open-collector Driver

NOTES

1. MC90 is set to autobauding mode (**AT+IPR=0**) by default. In autobauding mode, URC **RDY** is not reported to the host controller after the module is powered on. When the module is powered on after a delay of 4s~5s, it can receive AT commands. Host controller should first send an **AT** string in order that the module can detect baud rate of host controller, and it should continue to send the next **AT** string until receiving **OK** string from the module. Then enter **AT+IPR=x;&W** to set a fixed baud rate for the module and save the configuration to flash memory of the module. After these configurations, the URC **RDY** would be received from the main UART port of the module every time when the module is powered on. For more details, refer to the section **AT+IPR** in ***document [1]***.
2. When AT command is responded, it indicates the module is turned on successfully; or else the module fails to be turned on.

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

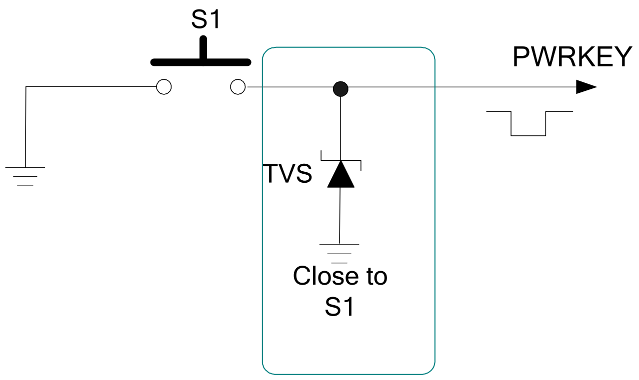

Figure 17: Turn on the Module through a Button

Command **AT+QGNSSC=1** should be sent to enable the GNSS power supply after the GSM part is running. When the GNSS_VCC is valid, the GNSS will enter into full on mode automatically. The power-on scenario is illustrated in the following figure.

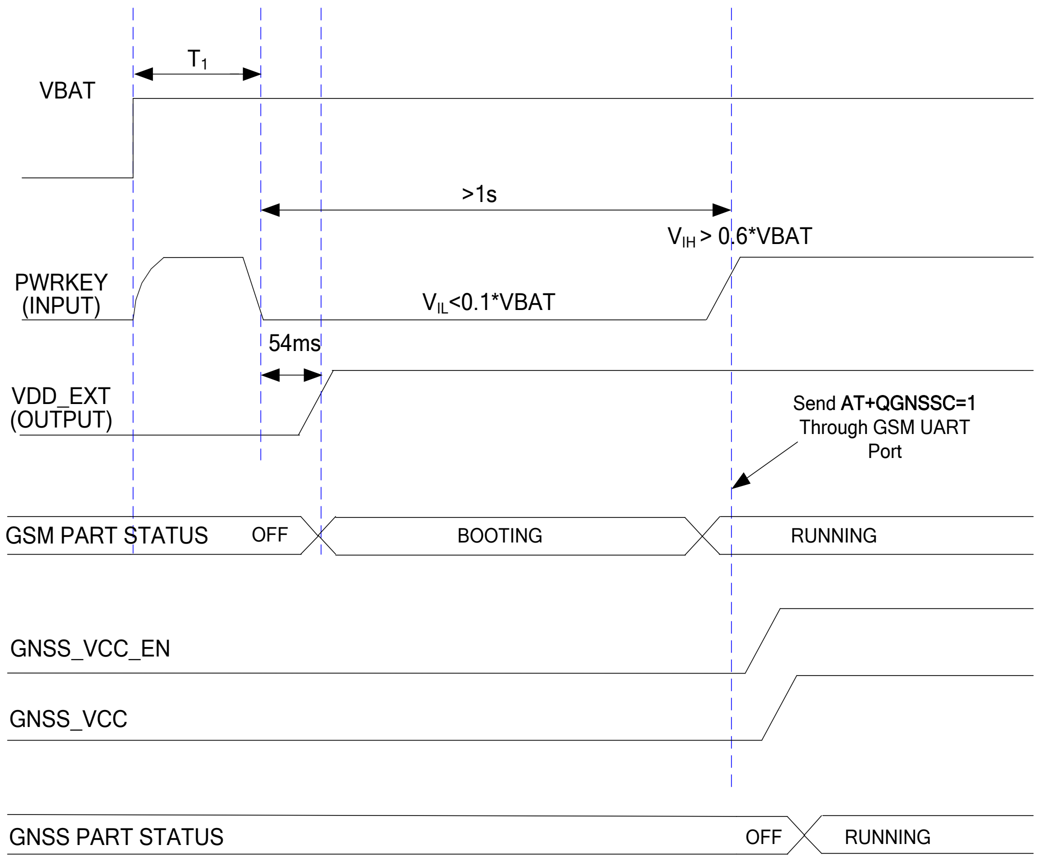

Figure 18: Power-on Scenario

NOTE

Make sure that VBAT is stable before pulling down PWRKEY pin. The time of T1 is recommended to be 100ms.

3.7.2. Power-off

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

- Normal turn-off procedure: turn off module using the PWRKEY pin
- Normal turn-off procedure: turn off module using command **AT+QPOWD**
- Under-voltage automatic shutdown: take effect when under-voltage is detected.

3.7.2.1. Turn off Module Using PWRKEY Pin

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

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

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

NORMAL POWER DOWN

NOTES

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

After that moment, no further AT commands can be executed. Then the module enters the power-down mode.

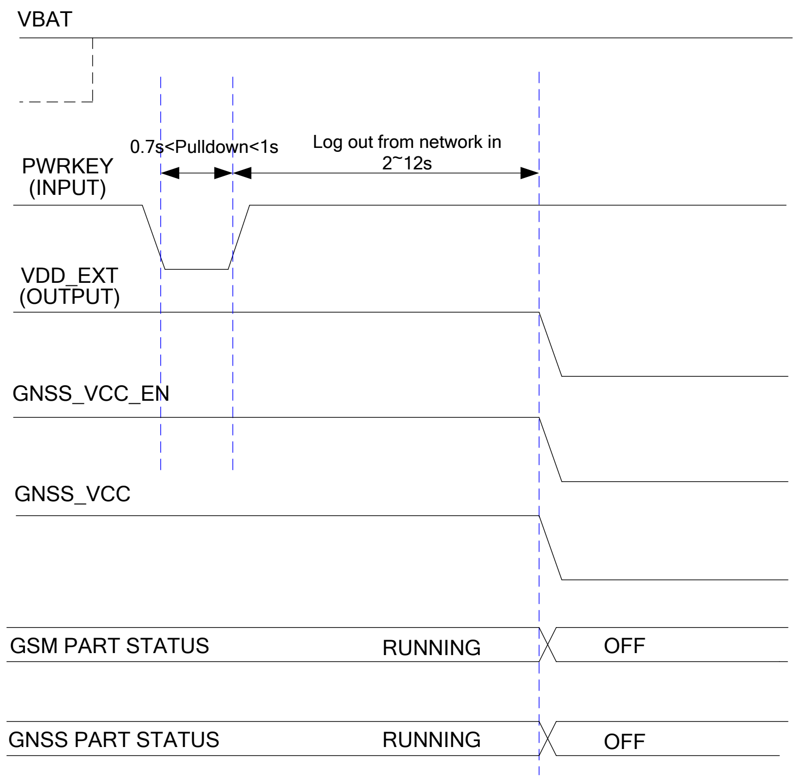

Figure 19: Power-off Scenario by Using PWRKEY Pin

3.7.2.2. Turn off Module Using AT Command

It is also a safe way to turn off the module via command **AT+QPOWD=1**. This command will let the module log off from the network and allow the firmware to save important data before completely disconnecting the power supply.

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

NORMAL POWER DOWN

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

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

3.7.2.3. Turn off GNSS Part Alone Using AT Command

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

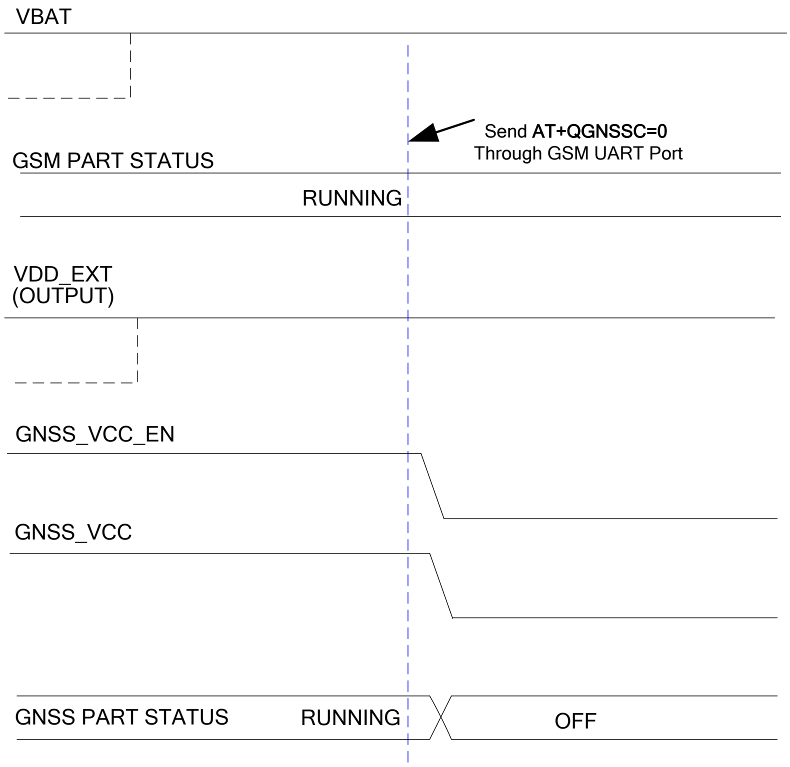

Figure 20: Power-off Scenario of GNSS Part by Using AT Command

3.7.2.4. 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 4.3V. If the voltage is <3.3V, the module will automatically shut down.

NOTE

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

3.8. Power-on/off Scenarios in Stand-alone Solution

In **Stand-alone** solution, GSM and GNSS parts are controlled separately, and thus the power-on and power-down control of them are independent from each other as well. The GSM part can be turned on/off or restarted via PWRKEY pin control, which is the same as that in **All-in-one** solution. The GNSS part is turned on/off via an external switch of MCU.

3.8.1. Turn on GSM Part

The GSM part can be turned on by driving the pin PWRKEY to a low level voltage. An open collector driver circuit is suggested to control the PWRKEY. A simple reference circuit is illustrated in ***Figure 16***.

NOTES

1. The GSM module is set to autobauding mode (**AT+IPR=0**) by default. In the autobauding mode, URC **RDY** is not reported to the host controller after the module is powered on. When the GSM module is powered on after a delay of 4 or 5 seconds, it can receive AT command. Host controller should first send an **AT** string in order that the GSM module can detect baud rate of host controller, and it should continue to send the next **AT** string until receiving **OK** string from the module. Then enter **AT+IPR=x;&W** to set a fixed baud rate for the module and save the configuration to flash memory of the module. After these configurations, the URC **RDY** would be received from the main UART port of the GSM module every time when the module is powered on. For more details, refer to the section **AT+IPR** in ***document [1]***.
2. When AT command is responded, it indicates the GSM module is turned on successfully; or else the module fails to be turned on.

The other way to control the PWRKEY is through a button directly. While pressing the key, electrostatic strike may generate from the finger, and thus, a TVS component is indispensable to be placed nearby the button for ESD protection. For the best performance, the TVS component must be placed nearby the button. A reference circuit is shown in ***Figure 17***.

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

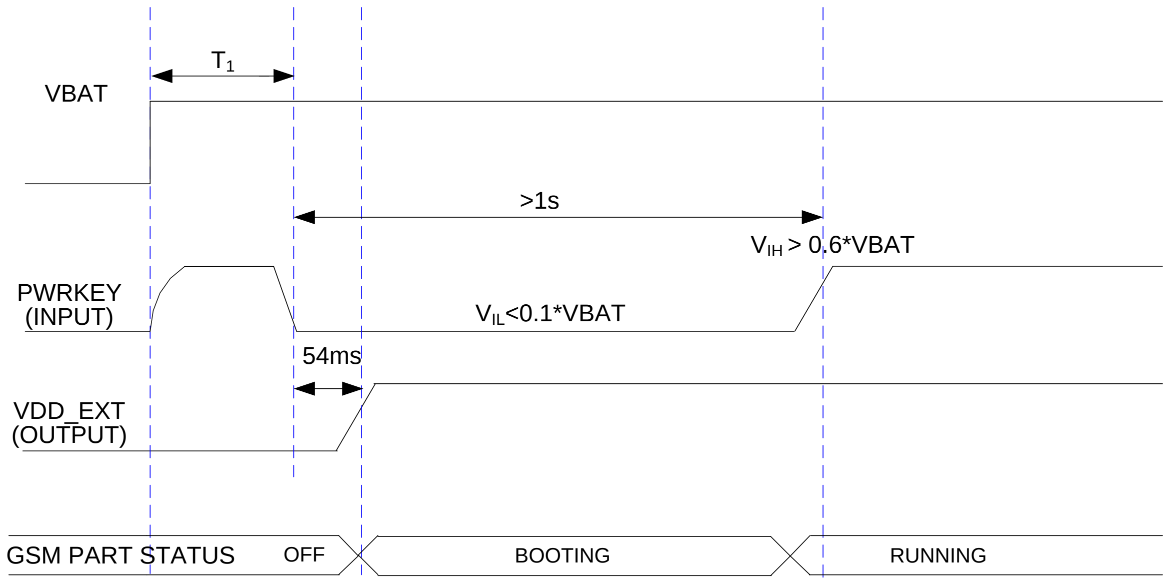

Figure 21: Power-on Scenario of GSM Part

NOTE

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

3.8.2. Turn off GSM Part

The following procedures can be used to turn off the GSM part:

- Normal power-off procedure: turn off GSM part using the PWRKEY pin
- Normal power-off procedure: turn off GSM part using command **AT+QPOWD**
- Under-voltage automatic shutdown: take effect when under-voltage is detected

3.8.2.1. Turn off GSM Part Using PWRKEY Pin

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

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

NORMAL POWER DOWN

NOTES

1. When unsolicited result codes do not appear when autobauding is active and DTE & DCE are not correctly synchronized after start-up, the GSM module is recommended to be set to a fixed baud rate.
2. As logout network time is related to the local mobile network, it is recommended to delay about 12 seconds before disconnecting the power supply or restarting the module.

After that moment, no further AT commands can be executed. Then the GSM module enters the power-down mode.

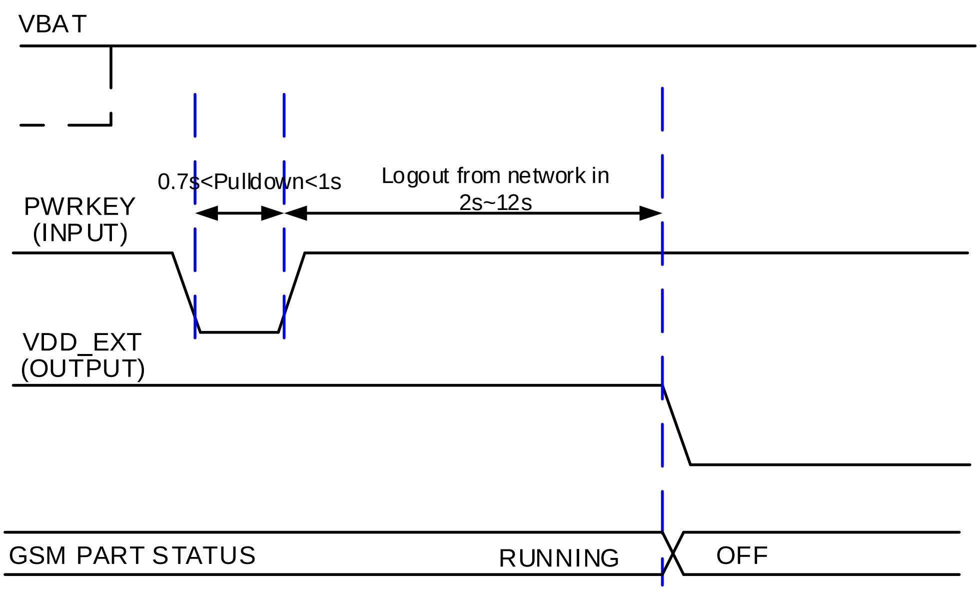

Figure 22: Power-off Scenario of GSM Part by Using PWRKEY Pin

3.8.2.2. Turn off GSM Part Using AT Command

It is also a safe way to turn off the GSM module via AT command **AT+QPOWD=1**. This command will let the GSM module log off from the network and allow the firmware to save important data before completely disconnecting the power supply.

Before the completion of the power-off procedure, the GSM module sends out the result code shown below:

NORMAL POWER DOWN

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

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

3.9. UART Interfaces

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

The Main UART Port:

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

The Debug UART Port:

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

The Auxiliary UART Port:

- In **All-in-one** solution:
  AUX_TXD: Send data to the GNSS part.
  AUX_RXD: Receive data from the GNSS part.

- In **Stand-alone** solution:
  AUX_TXD: Keep open
  AUX_RXD: Keep open

The GNSS UART Port:

- In **All-in-one** solution:
  GNSS_TXD: Send data to the GSM part.

GNSS_RXD: Receive data from the GSM part.

- In **Stand-alone** solution:
  GNSS_TXD: Send GNSS data to the COM port of peripheral.
  GNSS_RXD: Receive GNSS data from the COM port of peripheral.

The logic levels are described in the following table.

Table 14: 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 15: Pin Definition of UART Interfaces

Interface	Pin Name	Pin No.	I/O	Description
Main UART Port	TXD	30	DO	Transmit data
	RXD	29	DI	Receive data
	DTR	26	DI	Data terminal ready
	RI	28	DO	Ring indication
	DCD	27	DO	Data carrier detection
	CTS	24	DO	Clear to send
	RTS	25	DI	Request to send
Debug UART Port	DBG_RXD	41	DI	Receive data
	DBG_TXD	40	DO	Transmit data
Auxiliary UART Port 1)	AUX_RXD 1)	45	DI	Receive data
	AUX_TXD 1)	46	DO	Transmit data

GNSS UART Port	GNSS_RXD	43	DI	Receive data
	GNSS_TXD	44	DO	Transmit data

NOTE

1) It is recommended to keep these pins open in **Stand-alone** solution.

3.9.1. Main UART Port

3.9.1.1. Features of Main UART Port

- Seven-wire UART interfaces
- 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, GPRS data, etc. Multiplexing function is supported on the main UART Port. NMEA output and PMTK command can be supported in **All-in-one** solution.
- Support the following communication baud rates: 300bps, 600bps, 1200bps, 2400bps, 4800bps, 9600bps, 14400bps, 19200bps, 28800bps, 38400bps, 57600bps, 115200bps.
- The default setting is autobauding mode. Support the following baud rates for autobauding function: 4800bps, 9600bps, 19200bps, 38400bps, 57600bps, 115200bps.
- Hardware flow control is disabled by default. When hardware flow control is required, RTS and CTS should be connected to the host. AT command **AT+IFC=2,2** is used to enable hardware flow control. AT command **AT+IFC=0,0** is used to disable the hardware flow control. For more details, please refer to ***document [1]***.

After setting a fixed baud rate or autobauding, please send **AT** string at that rate. The main 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) is powered 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 main 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 a new baud rate.
- It is not recommended to switch to autobauding from a fixed baud rate.
- If autobauding is active, it is not recommended to switch to multiplex mode.

NOTE

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

3.9.1.2. The Connection of UART

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

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

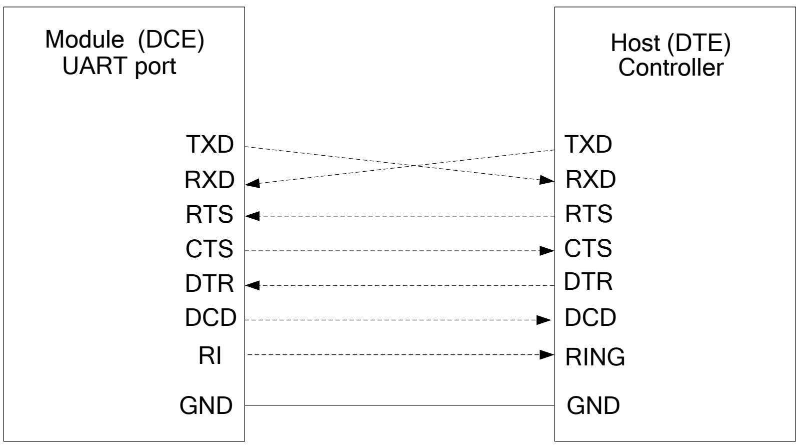

Figure 23: Reference Design for Full-Function UART

Three-wire connection is shown as below.

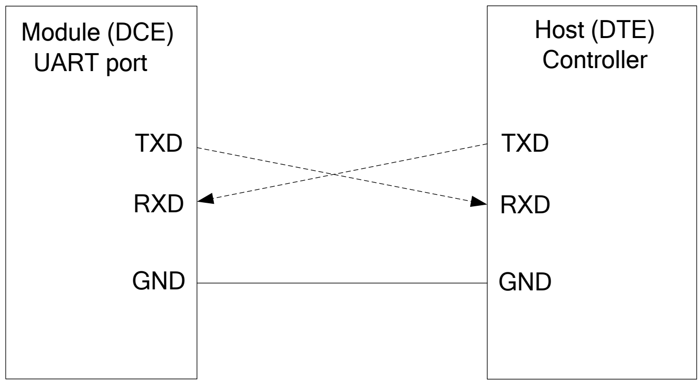

Figure 24: Reference Design for Main UART Port (Three-wire Connection)

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

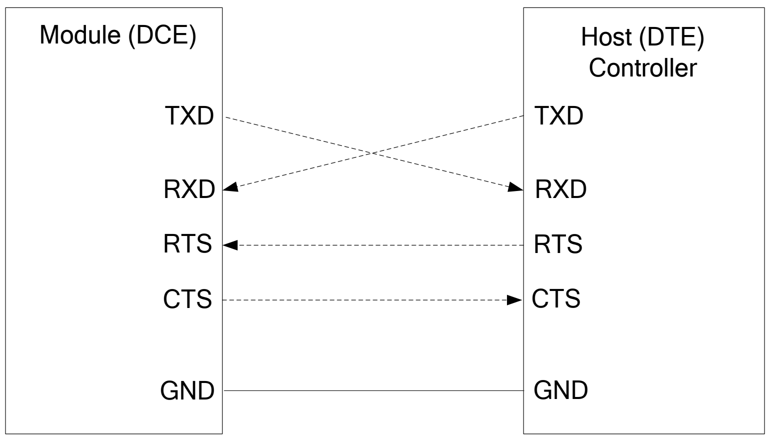

Figure 25: Reference Design for UART Port with Hardware Flow Control

3.9.1.3. Firmware Upgrade

The main UART port and USB port can be used for firmware upgrade in both **All-in-one** solution and **Stand-alone** solution. The PWRKEY pin must be pulled down before firmware upgrade. The following cautions must be taken into account.

- VBAT voltage must be stable
- PWRKEY pin must be set to low

A reference circuit for firmware upgrade via main UART port is shown as below:

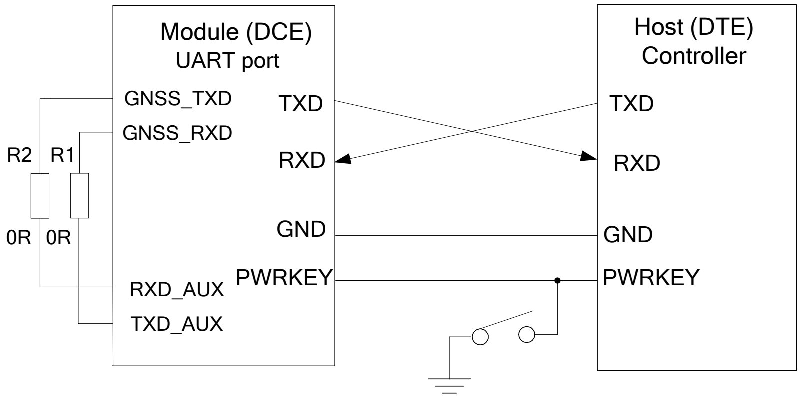

Figure 26: Reference Design for Firmware Upgrade via Main UART Port

NOTES

1. In **Stand-alone** solution, make sure the auxiliary UART port is connected to the GNSS UART port during firmware upgrade. Please refer to ***Chapter 3.9.3.2*** for details.
2. The firmware of module might need to be upgraded due to a certain of reasons. It is thus recommended to reserve these pins in the host board for firmware upgrade.
3. If firmware upgrade via USB port is needed, please contact Quectel for support.

3.9.2. Debug UART Port

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

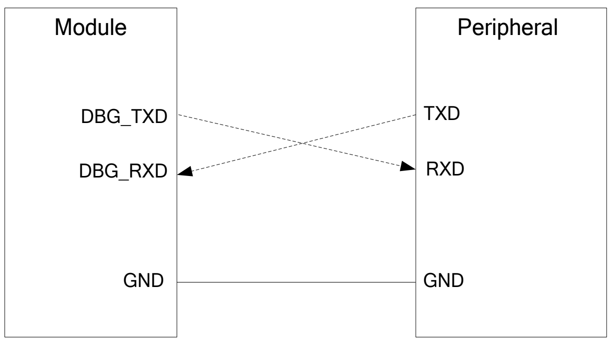

Figure 27: Reference Design for Debug Port

3.9.3. Auxiliary UART Port and GNSS UART Port

3.9.3.1. Connection in All-in-one Solution

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

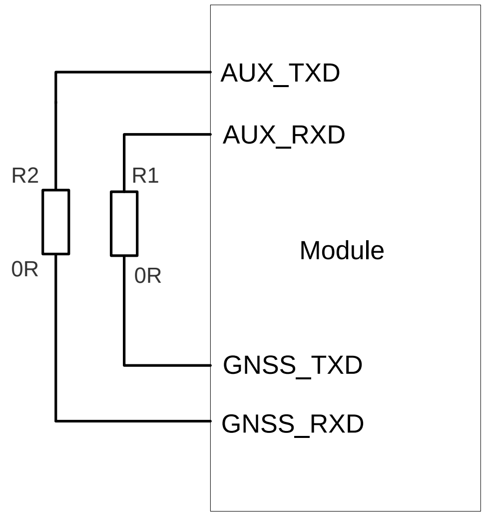

Figure 28: Auxiliary and GNSS UART Port Connection in All-in-one Solution

NOTE

As the GNSS part of MC90 outputs more data than a single GNSS system, the default output NMEA types running in 4800bps baud rate and 1Hz update rate will lose some data. The solution to avoid losing data in 4800bps baud rate and 1Hz update rate is to decrease the output NMEA types. 115200bps baud rate is enough to transmit GNSS NMEA in default settings and it is thus recommended.

3.9.3.2. Connection in Stand-alone Solution

In **Stand-alone** solution, the GNSS UART port is connected to the COM port of peripheral. During firmware upgrade, switch S1 should be kept closed. Otherwise, it should be kept open. A reference design is shown below.

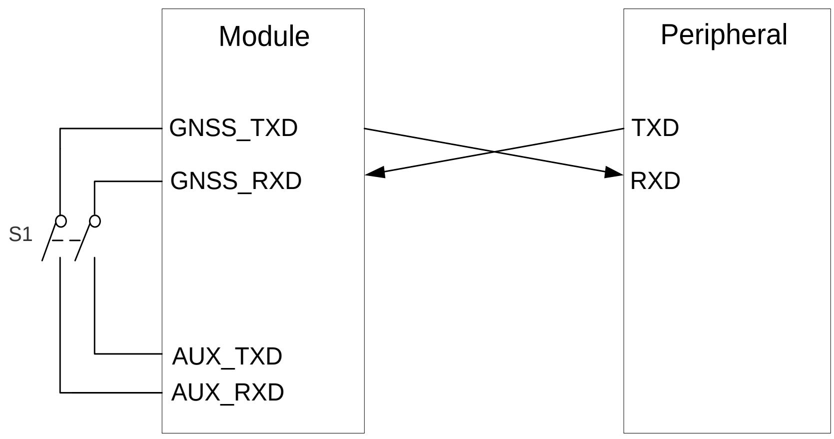

Figure 29: Auxiliary and GNSS UART Port Connection in Stand-alone Solution

3.9.4. UART Application

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

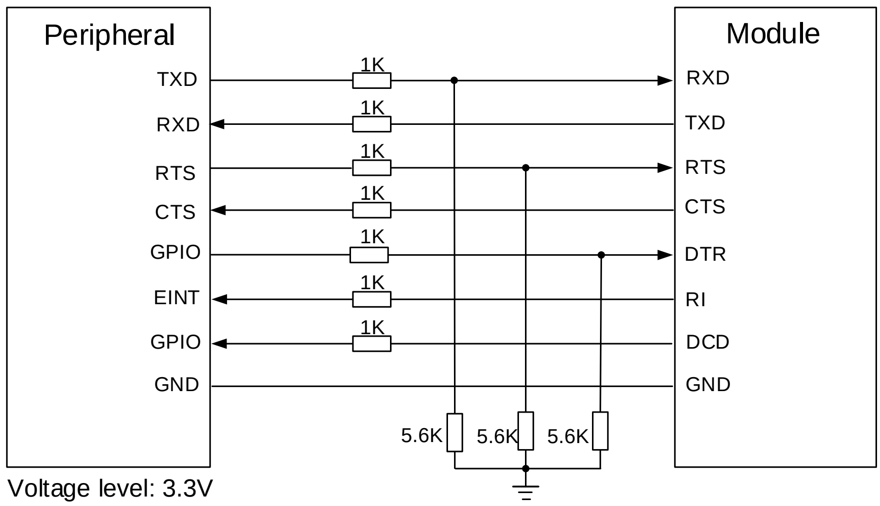

Figure 30: Level Match Design for 3.3V System

NOTE

It is highly recommended to add the resistor divider circuit on the UART signal lines when the host's level is 3V or 3.3V. For a higher voltage level system, a level shifter IC could be used between the host and the module. For more details about UART circuit design, please refer to ***document [13]***.

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

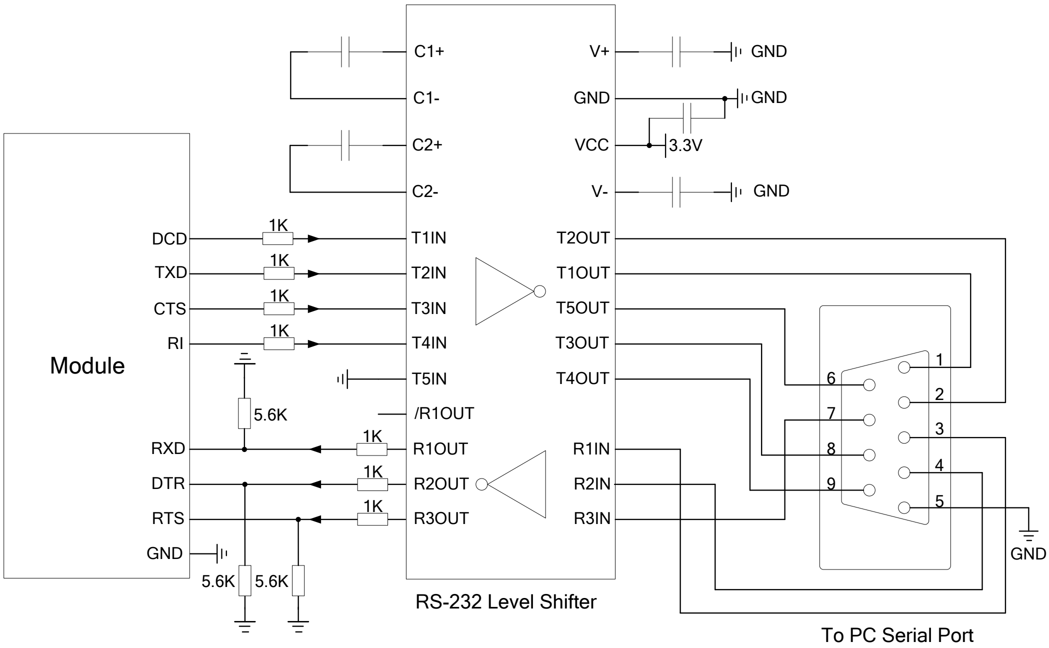

Figure 31: Sketch Map for RS-232 Interface Match

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

3.10. USB Interface

The USB interface of MC90 module supports USB 1.1 protocol specification with a maximum transfer rate of 12Mbps. It supports slave mode and can be used for firmware upgrade.

Table 16: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	DC Characteristics	Comment
USB_DM	10	IO	+5V	Support USB 1.1 protocol specification. If unused, keep these pins open.
USB_DP	9	IO	90Ω characteristic impedance	
USB_VBUS	8	PI	90Ω characteristic impedance	

3.11. Audio Interfaces

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

Table 17: Pin Definition of Audio Interfaces

Interface	Pin Name	Pin No.	I/O	Description
AIN/AOUT1	MICP	1	AI	Microphone positive input
	MICN	2		Microphone negative input
	SPKP	3	AO	Channel 1 Audio positive output
	SPKN	4		Channel 1 Audio negative output
AIN/AOUT2	MICP	1	AI	Microphone positive input
	MICN	2		Microphone negative input
	LOUDSPKP	60	AO	Channel 2 Audio positive output
	LOUDSPKN	59		Channel 2 Audio negative output

AIN can be used for input of microphone and line. 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 used for loudspeaker output as it is embedded with an amplifier of class AB whose maximum drive power is 800mW. AOUT2 is a differential channel.

AOUT2 also can be used for output of earphone, and can be used as a single-ended channel.

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

Use AT command **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.
- **AT+QAUDCH=2**: AIN/AOUT2, this channel is always used for loudspeaker.

For each channel, customers can use **AT+QMIC** to adjust the input gain level of microphone. Customers can also use **AT+CLVL** to adjust the output gain level of receiver and speaker. **AT+QSIDET** is used to set the side-tone gain level. For more details, please refer to ***document [1]***.

Table 18: AOUT2 Output Characteristics

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

3.11.1. Decrease TDD Noise and Other Noises

It is recommended to use the electret microphone with dual built-in capacitors (e.g. 10pF and 33pF) for filtering out RF interference, thus reducing TDD noise. The 33pF capacitor is applied for filtering out 900MHz RF interference when the module is transmitting at EGSM900MHz. Without placing this capacitor, TDD noise could be heard. The 10pF capacitor is used for filtering out 1800MHz RF interference. Please note that the resonant frequency point of a capacitor largely depends on the material and production technique. Therefore, customers would have to discuss with their capacitor vendors to choose most suitable capacitors for filtering out GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz separately.

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

The capacitor which is used for filtering out RF noise should be close to the audio interface, and the audio trace should be as short as possible.

In order to decrease radio or other signal interference, the position of RF antenna should be kept away from audio interface and audio trace. The power trace could not be parallel with the audio trace, and should be far away from it.

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

3.11.2. Microphone Interface Design

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

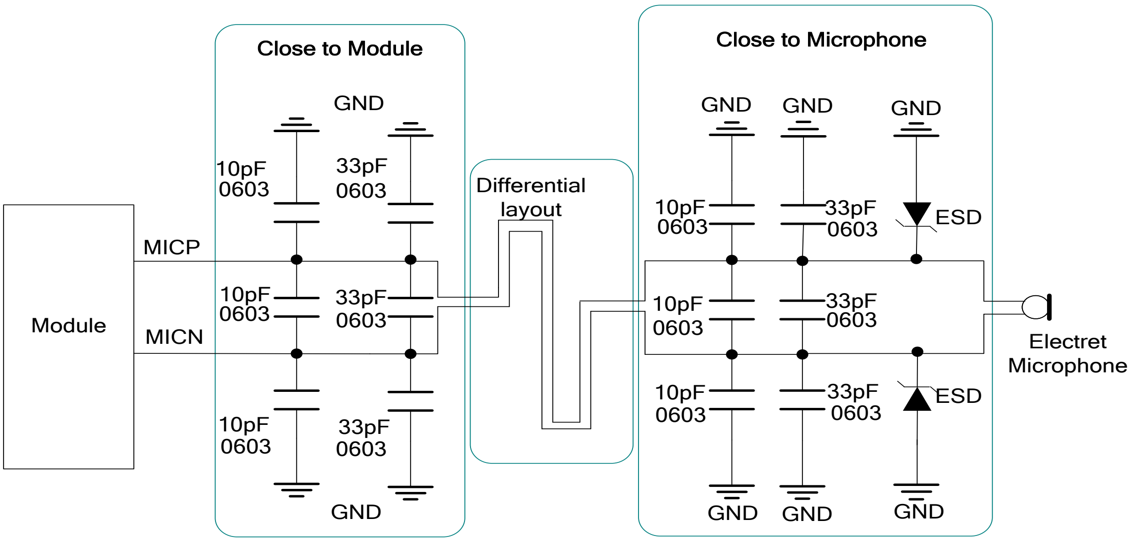

Figure 32: Reference Design for Microphone

3.11.3. Speaker Interface Design

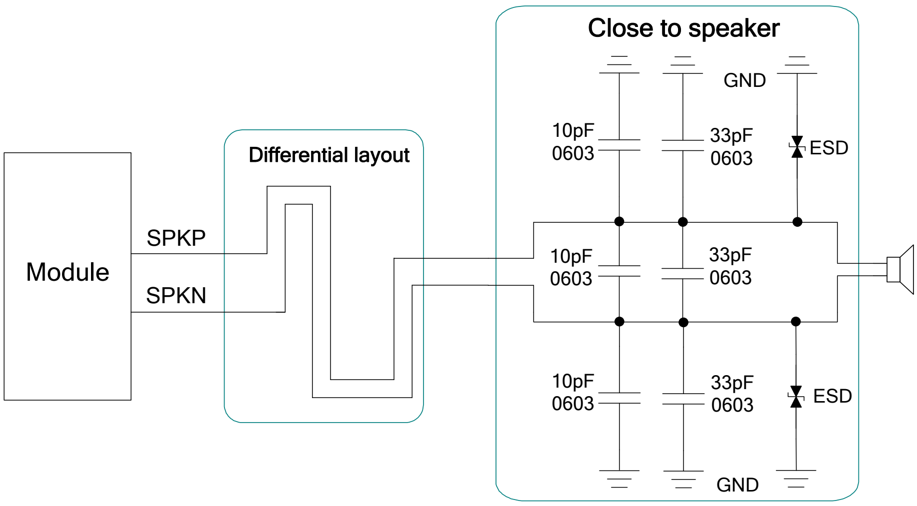

Figure 33: Reference Design for Speaker

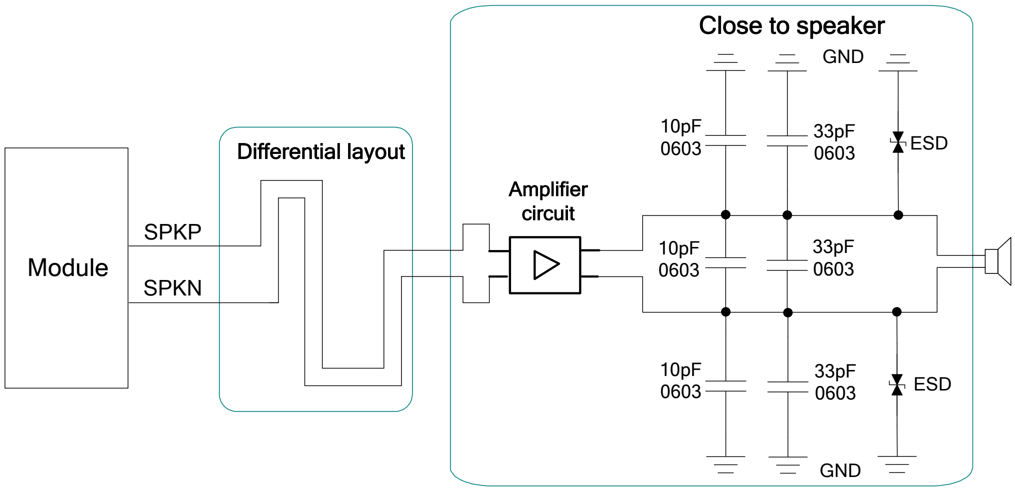

Figure 34: Reference Design for Speaker with an Amplifier

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

3.11.4. Earphone Interface Design

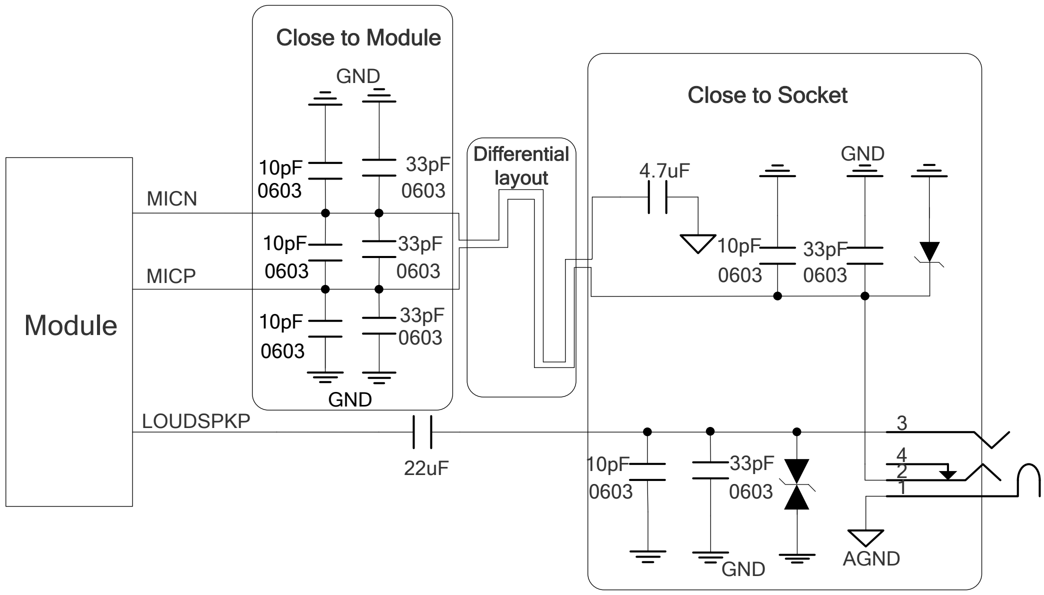

Figure 35: Reference Design for Earphone

3.11.5. Loud Speaker Interface Design

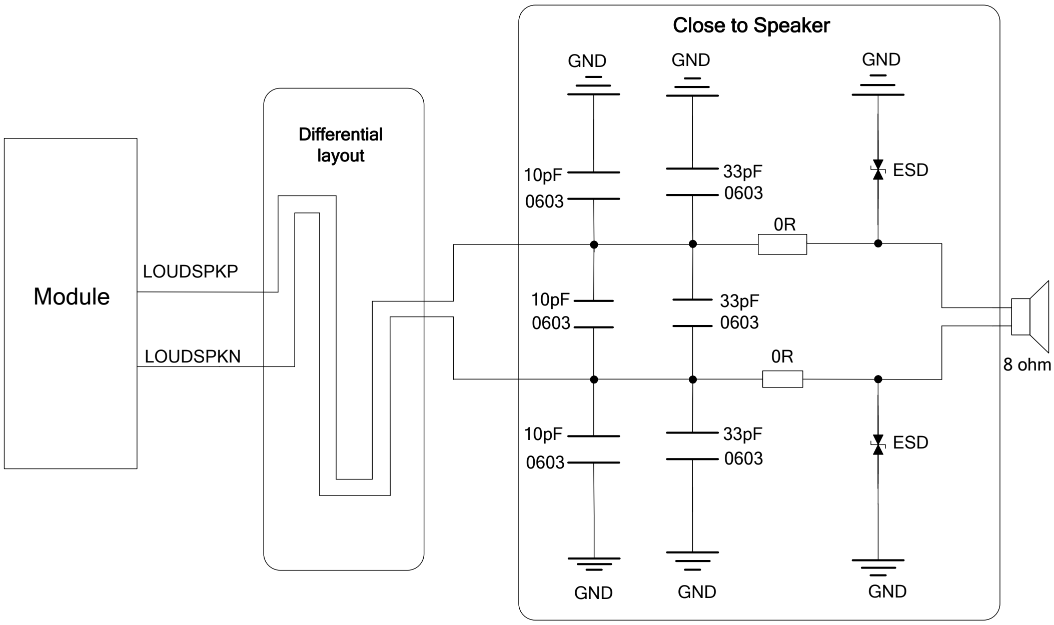

Figure 36: Reference Design for Loud Speaker

3.11.6. Audio Characteristics

Table 19: 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		Kohm

Table 20: 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	Differential	Load resistance		8		Ohm
		Reference level	0		2 × VBAT	Vpp
	Single-ended	Load resistance		8		Ohm
		Reference level	0		VBAT	Vpp

3.12. PCM Interface

MC90 provides a PCM interface. The interface is used for digital audio transmission between the module and the device. It 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 process of Pulse Code Modulation includes sampling, quantizing and encoding.

Table 21: Pin Definition of PCM Interface

Pin Name	Pin No.	I/O	Description	Comment
PCM_OUT	74	DO	PCM data output	2.8V power domain
PCM_IN	72	DI	PCM data input	
PCM_CLK	73	DO	PCM clock output	
PCM_SYNC	75	DO	PCM frame synchronization output	

3.12.1. Parameter Configuration

MC90 supports 16-bit linear code PCM format through software configuration. The sample rate is 8KHz and the clock source rate is 256KHz. 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 22: PCM Parameter Configuration

Parameter	Description
Interface Format	Linear
Data Length	Linear: 16bits
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

3.12.2. Timing Diagram

The sample rate of the PCM interface is 8KHz and the clock source rate is 256KHz. Every frame contains 32-bit data. 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.

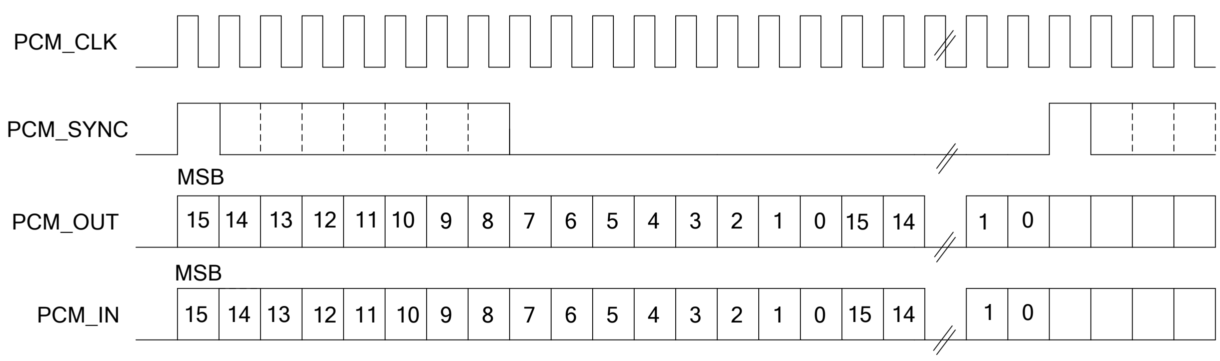

Figure 37: Timing Diagram for Long Frame Synchronization

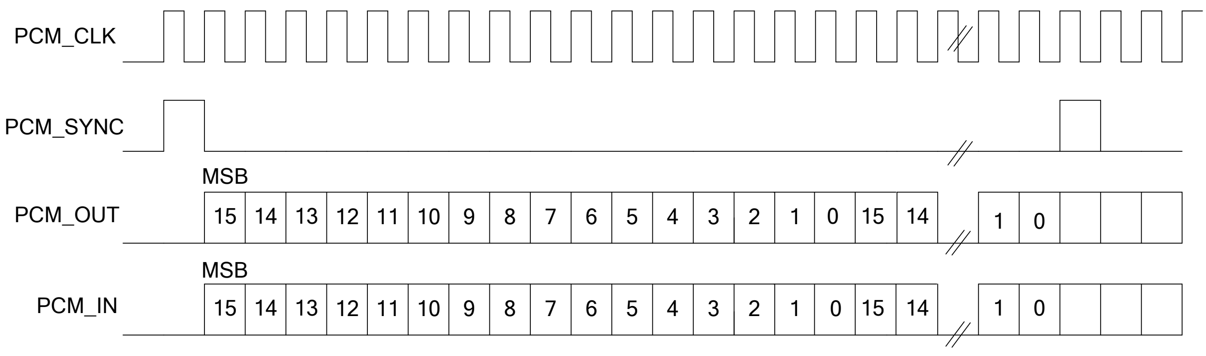

Figure 38: Timing Diagram for Short Frame Synchronization

3.12.3. Reference Design

MC90 can only work as a master, providing clock and synchronization source for PCM bus. A reference design for PCM is shown below.

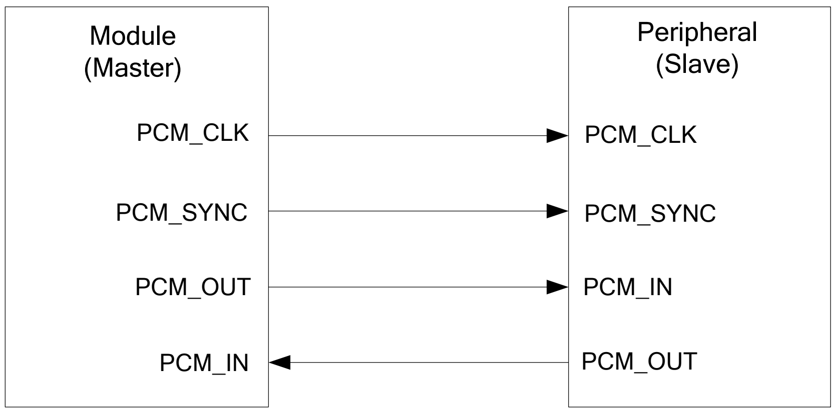

Figure 39: Reference Design for PCM

3.12.4. AT Command

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 23: AT+QPCMON Command Parameter Configuration

Parameter	Value Range	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 1bit to 8bits via software configuration in long frame synchronization format
Sign Extension	0~1	Not supported
MSB First	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 24: AT+QPCMVOL Command Parameter Configuration

Parameter	Value Range	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.

3.13. (U)SIM Interfaces

(U)SIM interfaces circuitry meet GSM Phase 1 and GSM Phase 2+ specifications, and supports FAST 64kbps (U)SIM card (intended for use with a (U)SIM application tool-kit).

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

Table 25: Pin Definition of (U)SIM Interfaces

Pin Name	Pin No.	I/O	Description
SIM1_VDD	12	PO	Supply power for (U)SIM1 card. Automatic detection of (U)SIM1 card voltage.

			Voltage accuracy: 3.0V±5% and 1.8V±5%. Maximum supply current is around 10mA.
SIM1_CLK	14	DO	Clock signal of (U)SIM1 card
SIM1_DATA	13	IO	Data signal of (U)SIM1 card
SIM1_RST	15	DO	Reset signal of (U)SIM1 card
SIM1_PRESENCE	16	DI	(U)SIM1 card insertion detection
SIM_GND	11		Specified ground for (U)SIM card
SIM2_VDD	66	PO	Supply power for (U)SIM2 card. Automatic detection of (U)SIM2 card voltage. Voltage accuracy: 3.0V±5% and 1.8V±5%. Maximum supply current is around 10mA.
SIM2_CLK	63	DO	Clock signal of (U)SIM2 card
SIM2_DATA	64	IO	Data signal of (U)SIM2 card
SIM2_RST	65	DO	Reset signal of (U)SIM2 card

The following figure shows a reference design for (U)SIM1 interface with an 8-pin (U)SIM card connector.

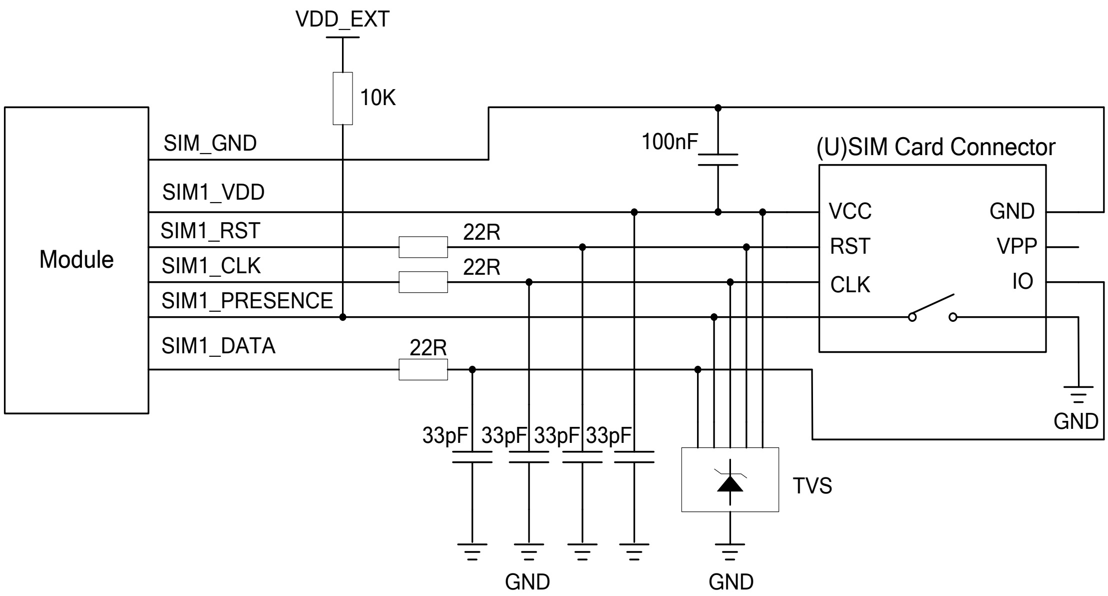

Figure 40: Reference Circuit for (U)SIM1 Interface with an 8-Pin (U)SIM Card Connector

If (U)SIM1 card insertion detection function is not used, keep pin SIM1_PRESENCE unconnected. A reference circuit for (U)SIM1 interface with a 6-pin (U)SIM card connector is illustrated in the following figure.

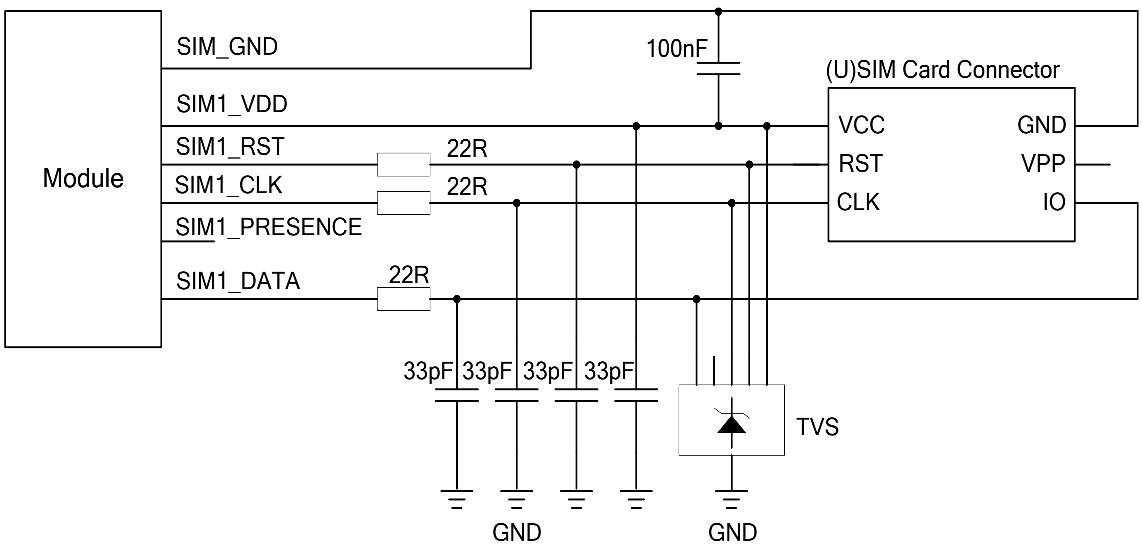

Figure 41: Reference Circuit for (U)SIM1 Interface with a 6-Pin (U)SIM Card Connector

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

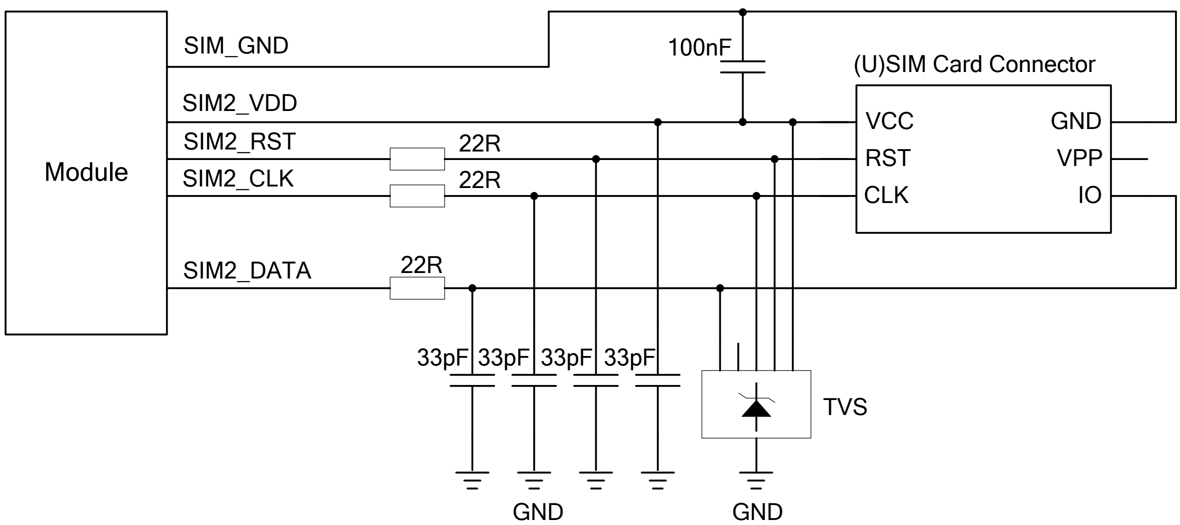

Figure 42: Reference Circuit for (U)SIM2 Interface with a 6-Pin (U)SIM Card Connector

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

- Keep the placement of (U)SIM card connector as close as possible to the module. Keep the trace length as less than 200mm as possible.
- Keep (U)SIM card signals away from RF and VBAT traces.
- 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

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 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 first from (U)SIM card connector and then to the module. The 22Ω resistors should be connected in series between the module and the (U)SIM card connector so as to suppress EMI spurious transmission and enhance ESD protection. Please note that the (U)SIM peripheral circuit should be close to the (U)SIM card connector.
- The pull-up resistor on SIM_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion are applied, and should be placed close to the (U)SIM card connector.

3.14. ADC

The module provides an ADC channel to measure the value of voltage. Please give priority to the use of ADC channel. Command **AT+QADC** can read the voltage value applied on ADC 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 26: Pin Definition of ADC Interface

Pin Name	Pin No.	I/O	Description
ADC	47	AI	Analog-to-digital converter

Table 27: Characteristics of ADC

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

3.15. Behaviors of RI

Table 28: Behaviors of RI

State	RI Response
Standby	HIGH
Voice Call	Change to LOW, and then: ● Change to HIGH when call is established. ● Change to HIGH when use ATH to hang up the call. ● Change to HIGH first when 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, and then changes to HIGH.
URC	Certain URCs can trigger 120ms low level on RI.

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

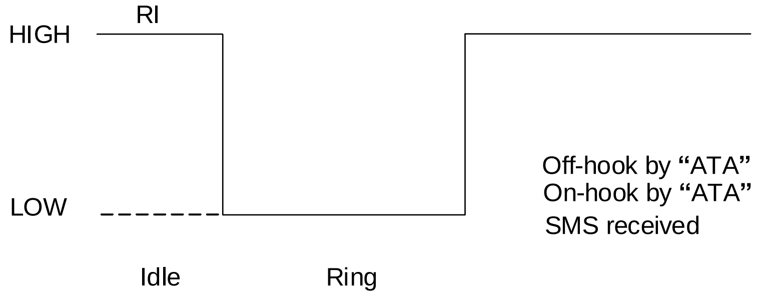

Figure 43: RI Behavior as a Receiver When Voice Calling

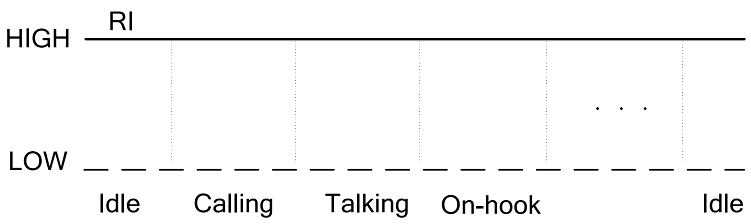

Figure 44: RI Behavior as a Caller

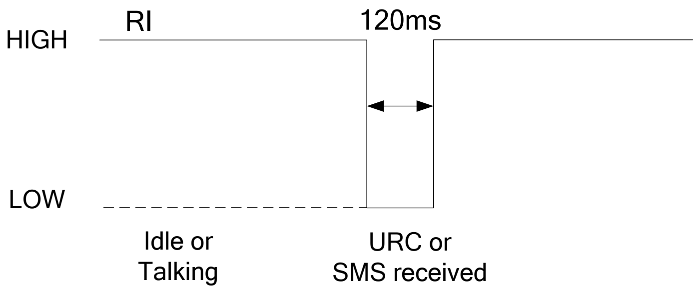

Figure 45: RI Behavior When URC or SMS Received

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 29: 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 after dialing the PPP connection.

A reference circuit is shown as below.

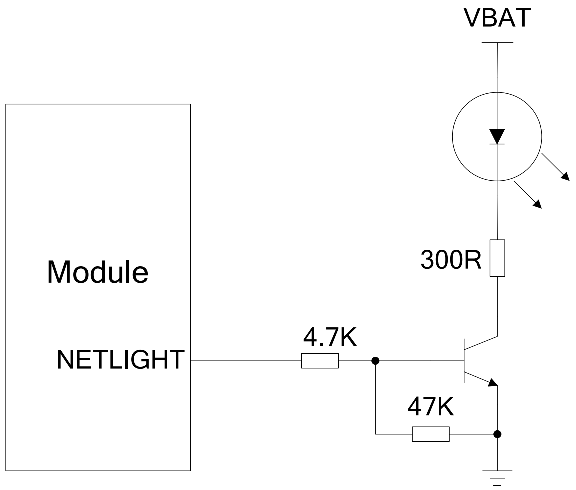

Figure 46: Reference Design for NETLIGHT

3.17. EASY™ Autonomous AGPS Technology

Supplying aiding information like ephemeris, almanac, rough last position, time and satellite status, can help improve the acquisition sensitivity and the TTFF for a module. This is called as EASY™ technology and MC90's GNSS part supports it.

EASY™ technology works as embedded software which can accelerate TTFF by predicting satellite navigation messages from received ephemeris. The GNSS part will calculate and predict orbit information automatically up to 3 days after first receiving the broadcast ephemeris, and save the predicted information into the internal memory. GNSS part of MC90 will use the information for positioning if no enough information from satellites, so the function is helpful for positioning and TTFF improvement.

The EASY™ function can reduce TTFF to 5s in warm start. In this case, GNSS's backup domain should be valid. In order to gain enough broadcast ephemeris information from GNSS satellites; the GNSS part should receive the information for at least 5 minutes in good signal conditions after it fixes the position.

EASY™ function is enabled by default. Command "$PMTK869,1,0*34" can be used to disable EASY™ function. For more details, please refer to ***document [16]***.

NOTE

In **All-in-one** solution, make sure the GNSS part is powered on before sending the PMTK command.

3.18. EPO^{TM} Offline AGPS Technology

MC90 features a function called EPO^{TM} (Extended Prediction Orbit) which is a world leading technology. When MC90 is powered on, EPO^{TM} function can be enabled via AT command **AT+QGNSSEPO=1**. When the GSM part detected that the EPO data has expired, the EPO data will be automatically downloaded to the GSM part's FS from MTK server via GSM/GPRS network; and the GNSS part will get the EPO data via build-in GNSS command from GSM's FS when it detected that the local EPO data has expired. When there is no local EPO data or when the data has expired, MC90 will download the data (4KB) for 6 hours' orbit predictions in order to achieve cold start in the shortest time, and then continue to download the EPO data (96KB) for 6 days (3 days+3 days). The technology allows the module to realize fast positioning. Command **AT+QGNSSEPO=0** can be used to turn off the EPO^{TM} function. For more details, please refer to ***document [14]***.

NOTE

Make sure the EPO^{TM} function is enabled if customers need to download the EPO data.

3.19. QuecFastFix Online Technology

QuecFastFix Online function can be used in combination with EPO^{TM} technology to further improve TTFF and acquisition sensitivity in cold start. Based on the latest EPO data, QuecFastFix Online additionally offers adding information such as reference-location and NITZ/NTP time, which shortens TTFF to only several seconds (approx. 4.5s) in cold start. The function makes the cold start TTFF comparable to that in hot start. For more details, please refer to ***document [14]***.

3.20. Multi-tone AIC

MC90 has a function called multi-tone AIC (Active Interference Cancellation) to decease harmonic of RF noise from Wi-Fi, GSM, 3G and 4G.

Up to 12 multi-tone AIC embedded in the module can provide effective narrow-band interference and jamming elimination. The GNSS signal could be demodulated from the jammed signal, which can ensure better navigation quality. AIC function is enabled by default. Enabling AIC function will increase current consumption by about 1mA @VCC=3.3V. The following commands can be used to set AIC function.

Enable AIC function: $PMTK 286,1*23
Disable AIC function: $PMTK 286,0*22

NOTE

In **All-in-one** solution, make sure the GNSS part is powered on before sending these PMTK commands.

3.21. LOCUS

MC90 supports the embedded logger function called LOCUS. When enabled by PMTK command "$PMTK185, 0*22", the function allows the module to log GNSS data to internal flash memory automatically without the need to wake up host, and thus, the module can enter into Sleep mode to save power consumption, and does not need to receive NMEA information all the time. MC90 provides a log capacity of more than 16 hours.

The detail procedures of this function are illustrated below:

- The module has fixed the position (only effective in 3D_fixed scenario).
- Sending PMTK command "$PMTK184,1*22" to erase internal flash.
- Sending PMTK command "$PMTK185,0*22" to start logging.
- The module logs the basic information (UTC time, latitude, longitude and height) every 15 seconds to internal flash memory.
- Stop logging the information by sending PMTK command "$PMTK185,1*23".
- MCU can get the data by sending PMTK command "$PMTK622,1*29" to the module.

PMTK Command "$PMTK183*38" can be used to query the state of LOCUS.

The raw data which MCU gets has to be parsed via LOCUS parser code provided by Quectel. For more details, please contact Quectel technical supports.

3.22. PPS VS. NMEA

Pulse per Second (PPS) VS. NMEA can be used for time service. The latency range of the beginning of UART Tx is between 465ms and 485ms, and after the rising edge of PPS.

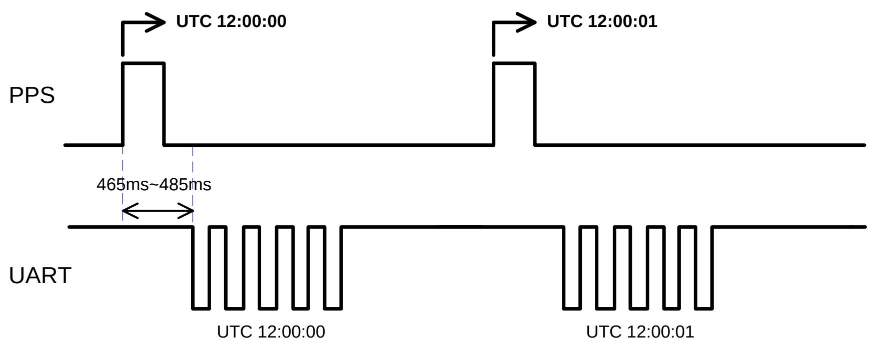

Figure 47: PPS VS. NMEA Timing

The feature only supports 1Hz NMEA output and baud rate at 14400bps~115200bps. When the baud rate is 9600bps or 4800bps, it only supports RMC NMEA sentence output. Because at low baud rates, per second transmission may exceed one second if there are many NMEA sentences output. Customers can enable this function by sending "$PMTK255,1*2D", and disable the function by sending "$PMTK255,0*2C".

NOTE

In **All-in-one** solution, the GNSS UART port has a fixed baud rate, and it is 115200bps by default.

3.23. Wi-Fi Interface

The Wi-Fi interface of MC90 supports IEEE 802.11b/g/n protocol. Currently, the Wi-Fi function is mainly used for assisted positioning. By scanning hotspots near the device, information such as MAC address of the nearby hotspots can be obtained, and the device location information can be obtained through AT commands. For more details about the AT commands, please refer to ***document [15]***.

4 Antenna Interfaces

MC90 has three antenna interfaces which are used for GSM antenna, GNSS antenna and Wi-Fi antenna, respectively. The pin 50 is the GSM antenna pad; the pin 20 is the GNSS antenna pad; and pin 38 is the Wi-Fi antenna pad. The RF interface of the three antenna pads has an impedance of 50Ω.

4.1. GSM Antenna Interface

There is a GSM antenna pad named GSM_ANT for MC90, and the pin definition is as following table.

Table 30: Pin Definition of GSM_ANT

Pin Name	Pin No.	I/O	Description
GSM_ANT	50	IO	GSM antenna pad
GND	49		Ground

4.1.1. Reference Design

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

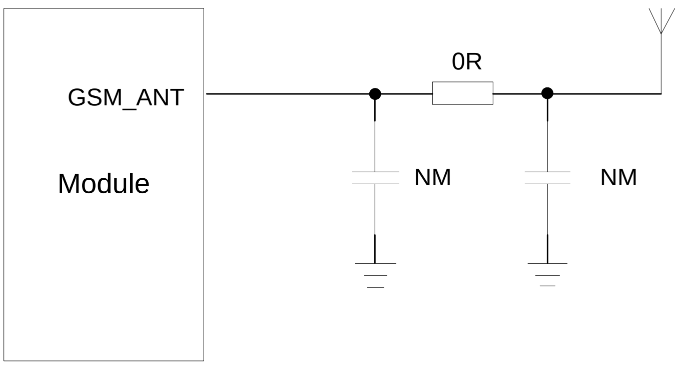

Figure 48: Reference Design for GSM Antenna

MC90 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. MC90 comes with grounding pads which are next to the antenna pad in order to give a better grounding. Besides, a π type matching circuit is suggested to be used to adjust the RF performance.

To minimize the loss on RF trace and RF cable, please pay attention to the design. The following table shows the requirements on GSM antenna.

Table 31: Antenna Cable Requirements

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

Table 32: Antenna Requirements

Type	Requirements
Frequency Range	Low frequency band: 820MHz~960MHz Medium frequency band: 1710MHz~1990MHz
VSWR	≤2
Gain (dBi)	1
Max. Input Power (W)	50
Input Impedance (Ω)	50
Polarization Type	Linear

4.1.2. RF Output Power

Table 33: 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 34: RF Receiving Sensitivity

Frequency	Receive Sensitivity
GSM850	< -109.5dBm
EGSM900	< -109.5dBm
DCS1800	< -109dBm
PCS1900	< -109dBm

4.1.4. Operating Frequencies

Table 35: Operating Frequencies

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

4.1.5. RF Cable Soldering

Soldering the RF cable to RF pad of module correctly will reduce the loss on the path of RF. Please refer to the following example of RF cable soldering.

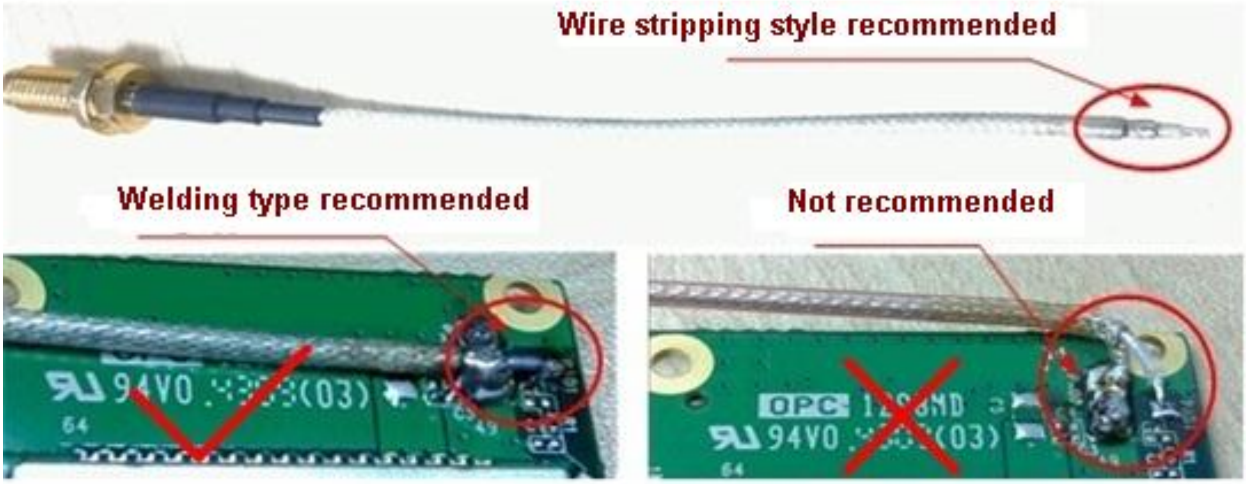

Figure 49: RF Cable Soldering Sample

4.2. GNSS Antenna Interface

The GNSS part of MC90 supports both GPS and GLONASS systems. The RF signal is obtained from the GNSS_ANT pin. The impedance of RF trace should be controlled as 50Ω, and the trace length should be kept as short as possible.

4.2.1. Antenna Specifications

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

Table 36: Recommended Antenna Specifications

Antenna Type	Specifications
GNSSGNS	Frequency band: 1559MHz~1609MHz Polarization: RHCP or Linear VSWR: < 2 (Typ.) Passive antenna gain: > 0dBi

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

4.2.2. Active Antenna

The following figure is a typical reference design with active antenna. In this mode, the antenna is powered by GNSS_VCC.

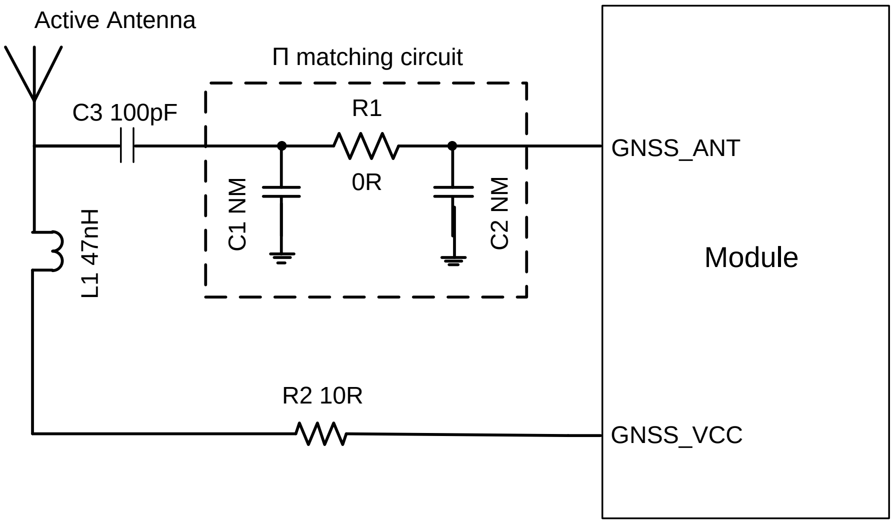

Figure 50: Reference Design with Active Antenna

C1, R1 and C2 are reserved matching circuit for antenna impedance modification. By default, C1 and C2 are not mounted; R1 is 0Ω.

The external active antenna is powered by GNSS_VCC. The voltage ranges from 2.8V to 4.3V, and the typical value is 3.3V. If the voltage does not meet the requirements for powering the active antenna, an external LDO should be used.

The inductor L1 is used to prevent the RF signal from leaking into the GNSS_VCC pin and route the bias supply to the active antenna, and the recommended value of L1 is no less than 47nH. R2 can protect the whole circuit in case the active antenna is shorted to ground.

NOTE

In **All-in-one** solution, please note that the power supply of GNSS_VCC is controlled by the GSM part via AT command.

4.2.3. Passive Antenna

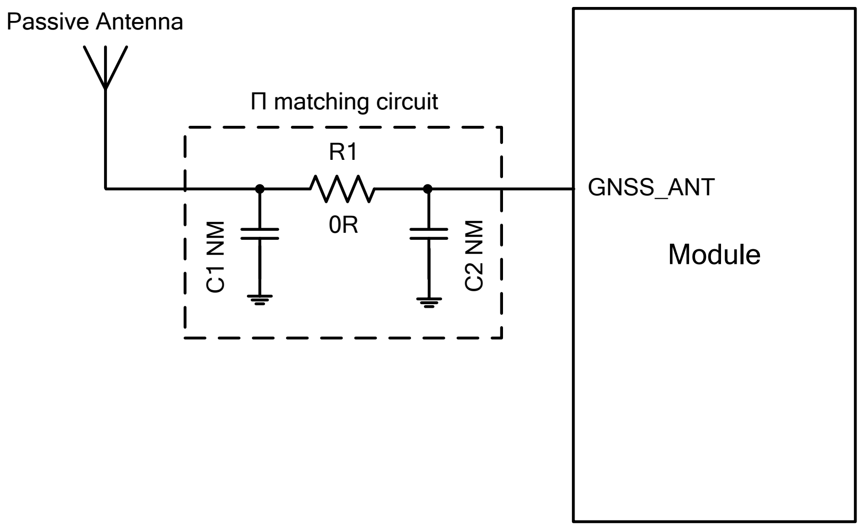

Figure 51: Reference Design with Passive Antenna

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

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

4.3. Wi-Fi Antenna Interface

There is a Wi-Fi antenna pad named WIFI_ANT for MC90, and the pin definition is as following figure.

Table 37: Pin Definition of WIFI_ANT

Pin Name	Pin No.	I/O	Description
WIFI_ANT	38	IO	Wi-Fi antenna pad
GND	37, 39		Ground

The external antenna must be matched properly to achieve the best performance. Therefore, it is recommended to reserve a matching circuit. The antenna connection reference circuit is shown below.

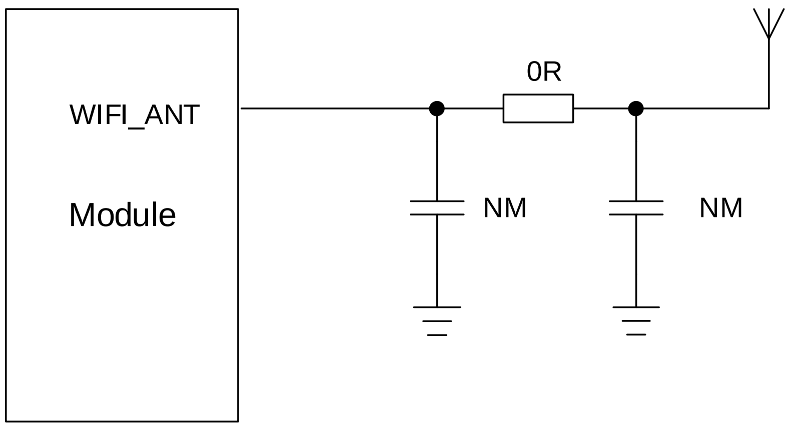

Figure 52: Reference Design for Wi-Fi Antenna

There are some suggestions for component placement and RF trace layout for RF traces:

- The antenna matching circuit should be as close as possible to the antenna;
- The impedance of RF traces between WIFI_ANT and antenna should be controlled as 50Ω, and the traces should be kept far away from the high-speed signal lines and strong interference sources to avoid crossing or paralleling any signal lines in adjacent layers.

4.3.1. Recommended Antenna

Wi-Fi antenna of ACA-5036-A2-CC-S type manufactured by INPAQ is recommended by Quectel. The antenna features low cost, high efficiency and small size. The main specifications of the antenna are listed in following table:

Table 38: Recommended Wi-Fi Antenna Specifications

Specifications
Frequency band: 2.04GHz~2.5GHz VSWR: < 2.5 Polarization: Linear Gain: 3dBi (Typ.) (Layout A) 2.1dBi (Typ.) (Layout B) Efficiency: 80% (Typ.) (Layout A) 74% (Typ.) (Layout B) Impedance: 50Ω (Typ.)

Layout A and Layout B are two different layouts. The component placement and trace layout need to be operated strictly in accordance with the specifications. And detailed specifications can be obtained by contacting Quectel or INPAQ.

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 39: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT	-0.3	+4.73	V
GNSS_VCC	-0.3	+4.5	V
Peak Current of Power Supply (VBAT)	0	2	A
RMS Current of Power Supply (VBAT, during one TDMA-frame)	0	0.7	A
Voltage at Digital Pins	-0.3	3.08	V
Voltage at Analog Pins	-0.3	3.08	V
Voltage at Digital/analog Pins in Power Down Mode	-0.25	0.25	V

5.2. Operation and Storage Temperatures

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

Table 40: Operation Temperature

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range [1)]	-35	+25	+75	ºC
Extended Temperature Range [2)]	-40		+85	ºC
Storage Temperature Range	-40		+90	ºC

NOTES

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

5.3. Power Supply Ratings

Table 41: Power Supply Ratings of GSM Part (GNSS is Powered off)

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VBAT	Supply voltage	The actual input voltages must stay between the minimum and maximum values.	3.3	4.0	4.3	V
	Voltage drop during transmitting burst	Maximum power control level on GSM850 and EGSM900.			400	mV
I_{VBAT}	Average supply current	Power down mode Sleep mode @DRX=5		220 1.2		uA mA

		Minimum functionality mode			
		AT+CFUN=0			
		IDLE mode	13		mA
		Sleep mode	0.68		mA
		AT+CFUN=4			
		IDLE mode	13		mA
		Sleep mode	0.73		mA
		TALK mode			
		GSM850/EGSM900 [1)]	199/213		mA
		DCS1800/PCS1900 [2)]	135/144		mA
		DATA mode, GPRS (3Rx, 2Tx)			
		GSM850/EGSM900 [1)]	361/387		mA
		DCS1800/PCS1900 [2)]	241/253		mA
		DATA mode, GPRS (2 Rx, 3Tx)			
		GSM850/EGSM900 [1)]	414/447		mA
		DCS1800/PCS1900 [2)]	324/342		mA
		DATA mode, GPRS (4 Rx, 1Tx)			
		GSM850/EGSM900 [1)]	216/228		mA
		DCS1800/PCS1900 [2)]	157/164		mA
		DATA mode, GPRS (1Rx, 4Tx)			
		GSM850/EGSM900 [1)]	473/516 [3)]		mA
		DCS1800/PCS1900 [2)]	406/431		mA
	Peak supply current (during transmission slot)	Maximum power control level on GSM850 and EGSM900.	1.6	2	A

NOTES

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

Table 42: Power Supply Ratings of GNSS Part

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
GNSS_ VCC	Supply voltage	The actual input voltages must stay between the minimum and maximum values.	2.8	3.3	4.3	V

I_{VCCP} 1)	Peak supply current	VCC=3.3V			150	mA
VRTC	Backup domain voltage supply		1.5	2.8	3.3	V

NOTE

1) This figure can be used to determine the maximum current capability of power supply.

5.4. Current Consumption

Table 43: Current Consumption of GSM Part (GNSS is Powered off)

Condition	Current Consumption
Voice Call	
GSM850	@power level #5 <300mA, typical 199mA @power level #12, typical 81mA @power level #19, typical 61mA
EGSM900	@power level #5 <300mA, typical 213mA @power level #12, typical 84mA @power level #19, typical 61mA
DCS1800	@power level #0 <250mA, typical 135mA @power level #7, typical 71mA @power level #15, typical 58mA
PCS1900	@power level #0 <250mA, typical 144mA @power level #7, typical 72mA @power level #15, typical 58mA
GPRS Data	
DATA Mode, GPRS (3 Rx, 2Tx) CLASS 12	
GSM850	@power level #5 <550mA, typical 361mA
EGSM900	@power level #5 <550mA, typical 387mA
DCS1800	@power level #0 <450mA, typical 241mA
PCS1900	@power level #0 <450mA, typical 253mA

DATA Mode, GPRS (2 Rx, 3Tx) CLASS 12	
GSM850	@power level #5 <640mA, typical 414mA
EGSM900	@power level #5 <600mA, typical 447mA
DCS1800	@power level #0 <490mA, typical 324mA
PCS1900	@power level #0 <480mA, typical 342mA
DATA Mode, GPRS (4 Rx, 1Tx) CLASS 12	
GSM850	@power level #5 <350mA, typical 216mA
EGSM900	@power level #5 <350mA, typical 228mA
DCS1800	@power level #0 <300mA, typical 157mA
PCS1900	@power level #0 <300mA, typical 164mA
DATA Mode, GPRS (1 Rx, 4Tx) CLASS 12	
GSM850	@power level #5 <600mA, typical 473mA
EGSM900	@power level #5 <600mA, typical 516mA
DCS1800	@power level #0 <500mA, typical 406mA
PCS1900	@power level #0 <500mA, typical 431mA

NOTE

GPRS Class 12 is the default setting. The GSM 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 GSM module.

Table 44: Current Consumption of GNSS Part

Parameter	Conditions	Typ.	Unit
I_{VCC} @Acquisition	@VCC=3.3V (GPS)	25	mA
I_{VCC} @Tracking	@VCC=3.3V (GPS)	19	mA
I_{VCC} @Acquisition	@VCC=3.3V (GPS+GLONASS)	29	mA
I_{VCC} @Tracking	@VCC=3.3V (GPS+GLONASS)	22	mA

I_{VCC} @Standby	@VCC=3.3V	0.3	mA
I_{BCKP} @backup	@V_BCKP=3.3V	14	uA

NOTE

The tracking current is tested in following conditions:

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

Table 45: Wi-Fi Current Consumption

RF State	GSM State	Wi-Fi State	Current Consumption
Minimum function (**AT+CFUN=0**)	SLEEP	OFF	0.69mA
		ON	1.08mA
Disable from both transmitting and receiving RF signals (**AT+CFUN=4**)	SLEEP	OFF	0.79mA
		ON	1.15mA

NOTES

1. The power consumption of Wi-Fi function is independent of the state of GSM and GNSS.
2. When the Wi-Fi function is enabled, the overall increased current consumption of the module is no more than 0.4mA.

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

Test Point	Contact Discharge	Air Discharge
VBAT, GND	+/-5KV	+/-10KV
GSM_ANT	+/-5KV	+/-10KV
TXD, RXD	+/-2KV	+/-4KV
GNSS_TXD GNSS_RXD	+/-2KV	+/-4KV
Others	+/-0.5KV	+/-1KV

6 Mechanical Dimensions

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

6.1. Mechanical Dimensions of Module

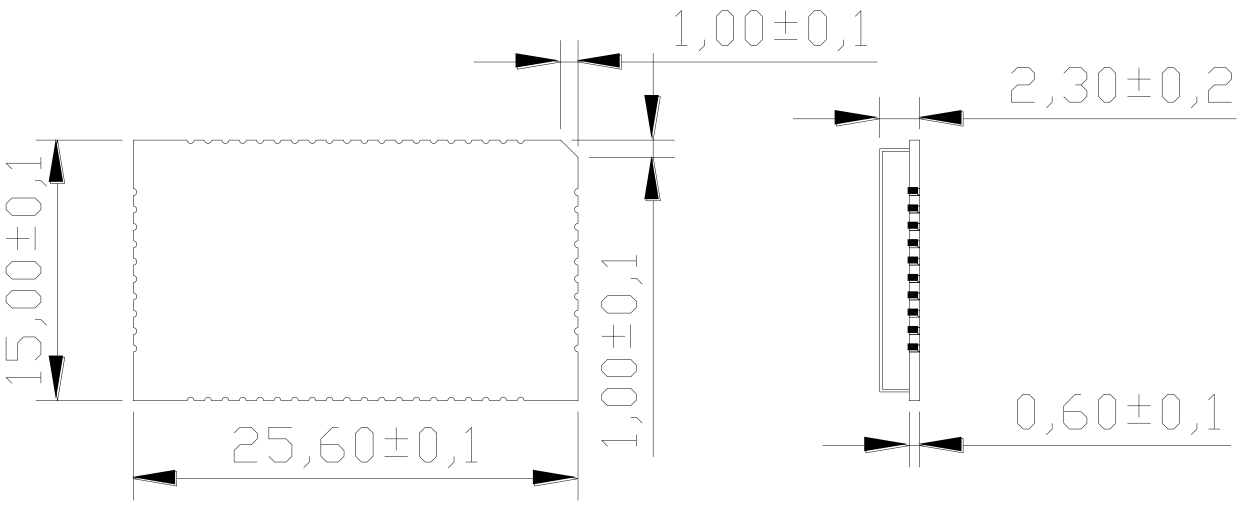

Figure 53: Top and Side Dimensions (Unit: mm)

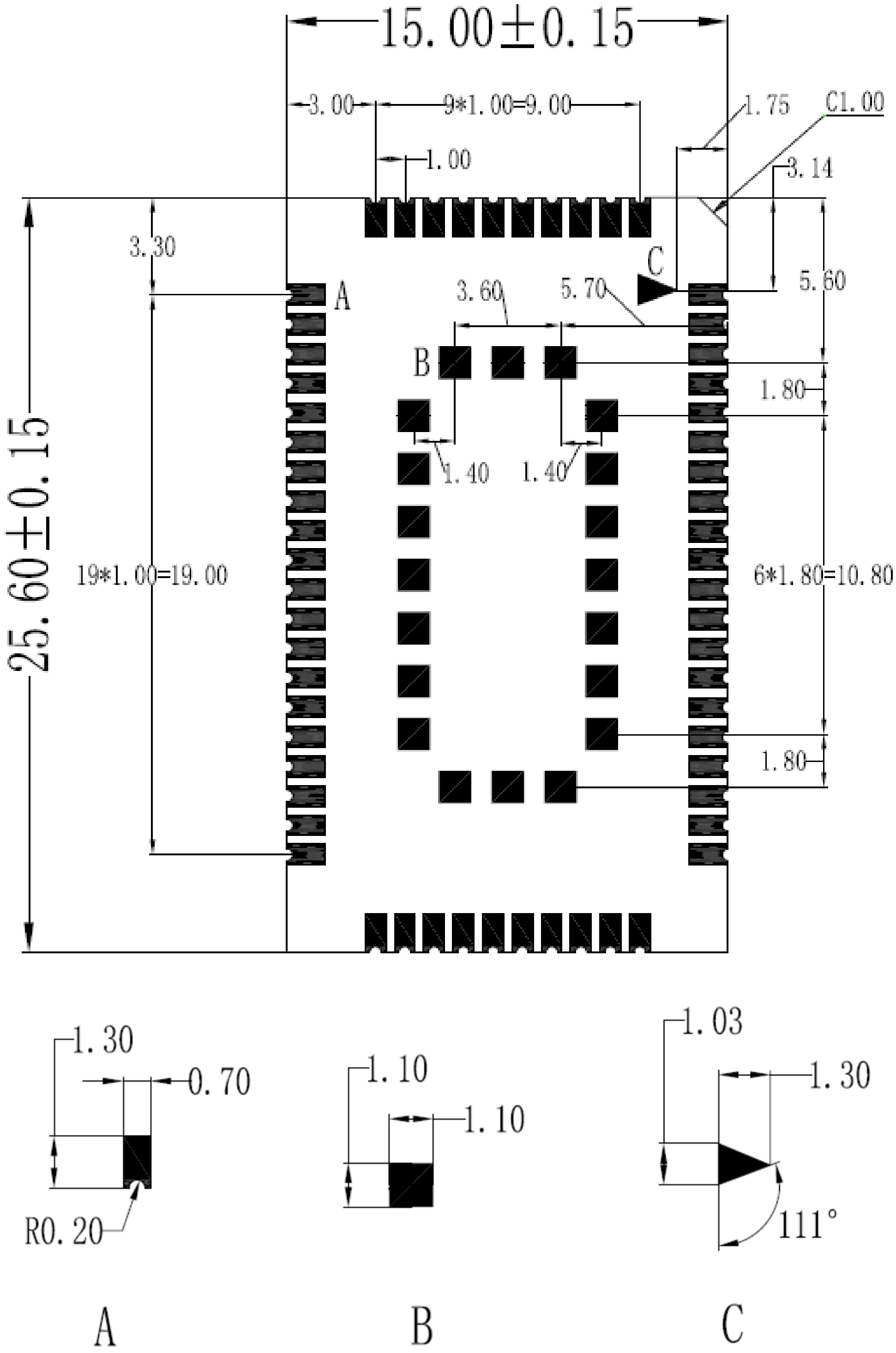

Figure 54: Bottom Dimensions (Bottom View) (Unit: mm)

6.2. Recommended Footprint

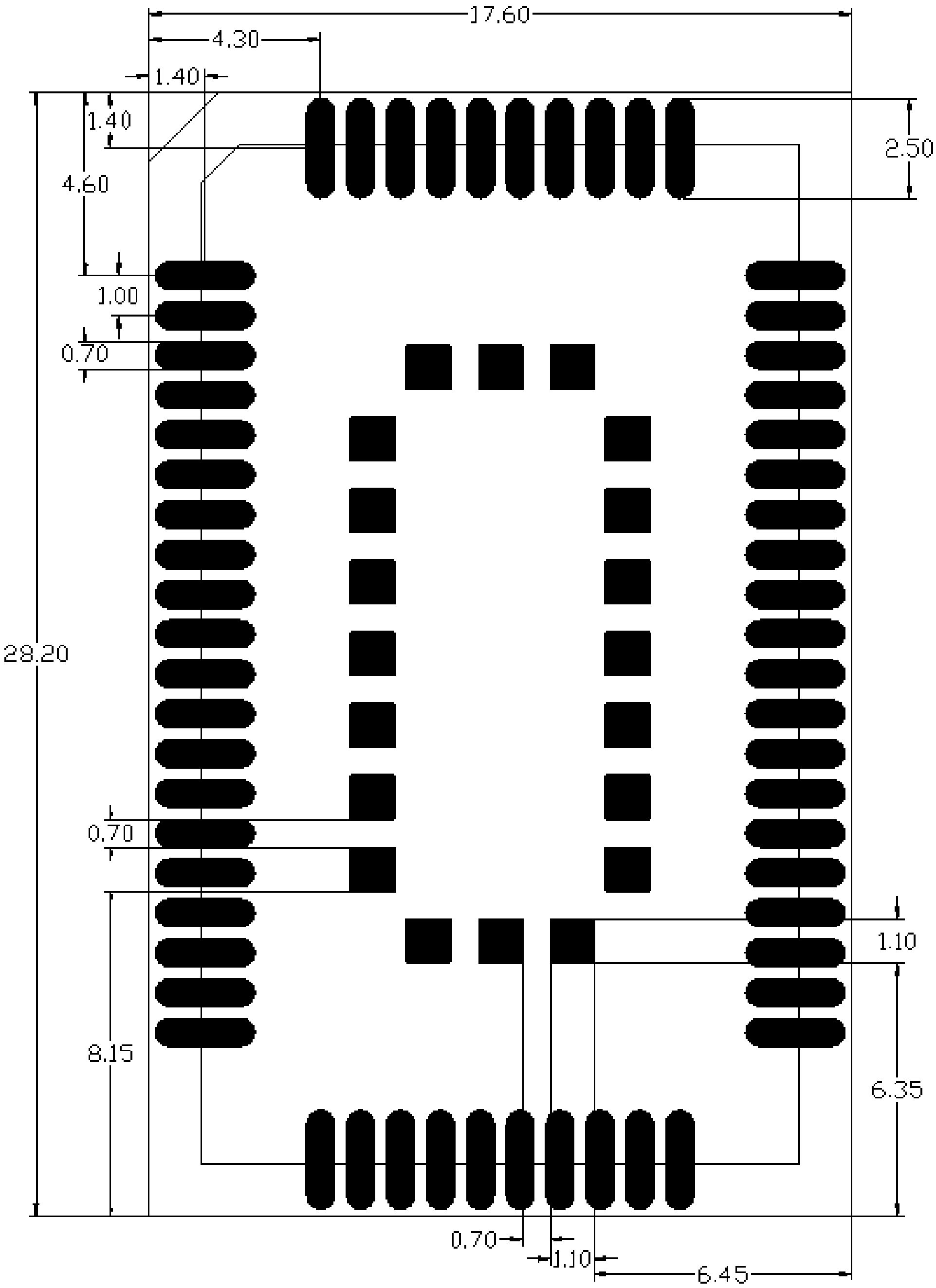

Figure 55: Recommended Footprint (Unit: mm)

NOTE

The module should be kept about 3mm away from other components on the host PCB.

6.3. Top and Bottom Views of the Module

Figure 56: Top View of MC90

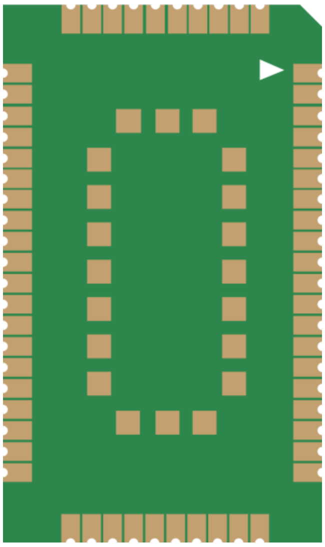

Figure 57: Bottom View of MC90

NOTE

These are renderings of MC90 module. For authentic dimension and appearance, please refer to the module that you receive from Quectel.

7 Storage, Manufacturing and Packaging

7.1. Storage

MC90 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 0.2mm. For more details, please refer to ***document [12]***.

It is suggested that the peak reflow temperature is 240ºC ~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.

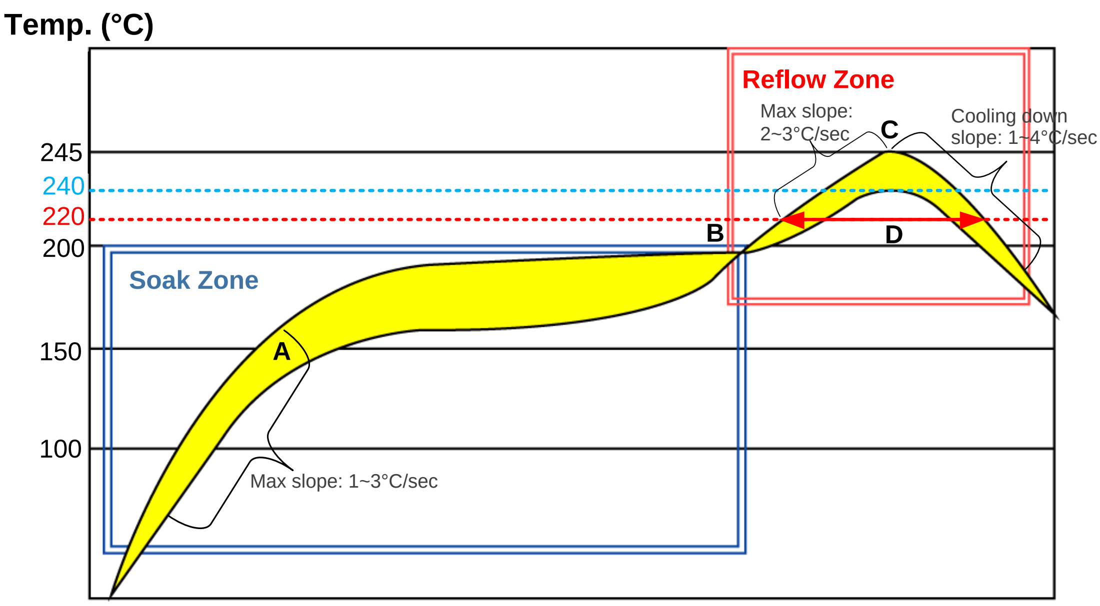

Figure 58: Reflow Soldering Thermal Profile

Table 47: 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	240°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

MC90 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.

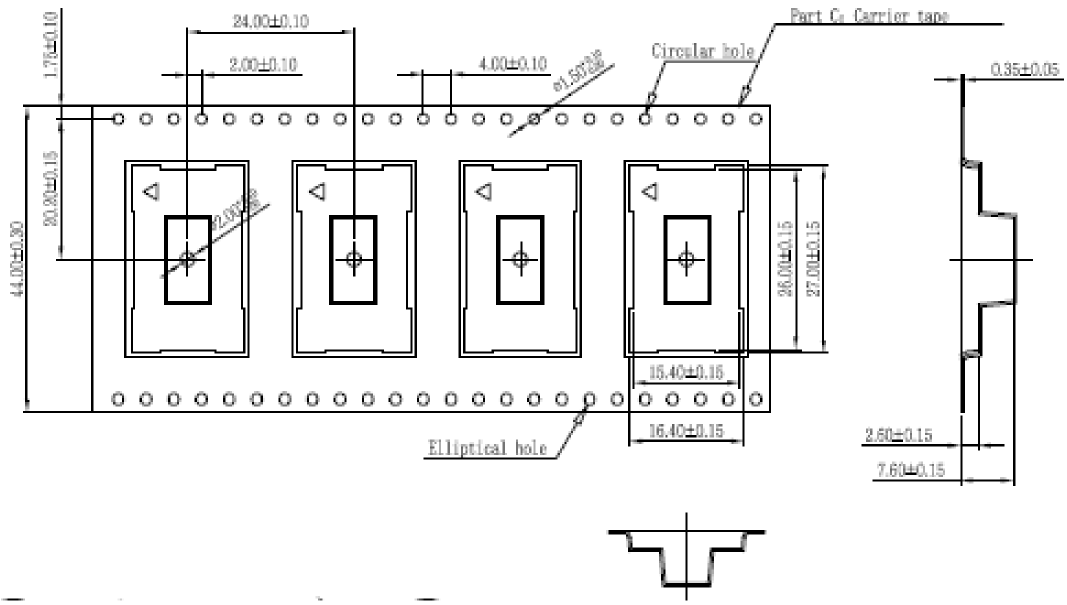

Figure 59: Tape Dimensions

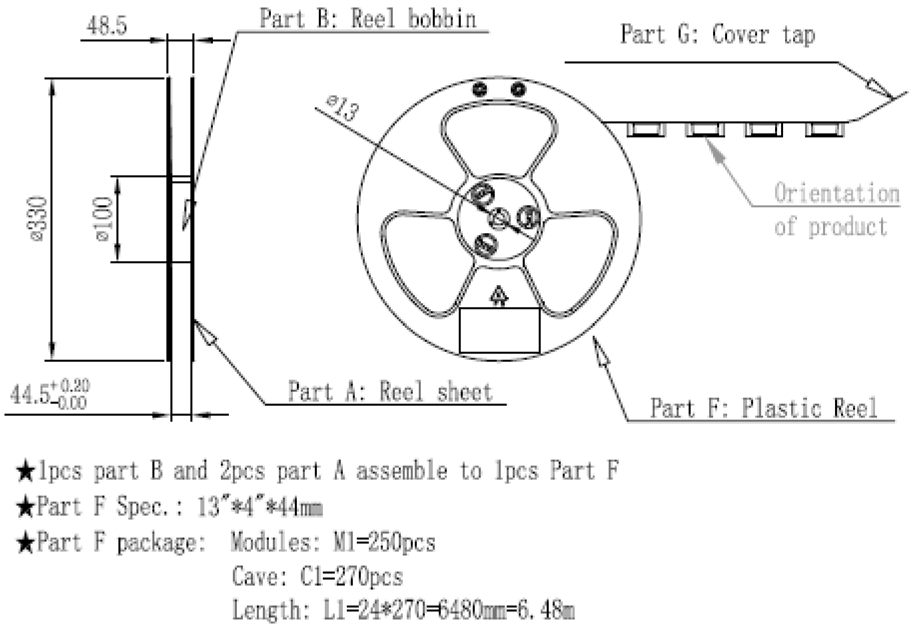

Figure 60: Reel Dimensions

Table 48: Reel Packaging

Model Name	MOQ for MP	Minimum Package: 250pcs	Minimum Package x 4=1000pcs
MC90	250pcs	Size: 370mm × 350mm × 56mm N.W: 0.4kg G.W: 0.9kg	Size: 380mm × 250mm × 365mm N.W: 1.3kg G.W: 4.8kg

8 Appendix A References

Table 49: Related Documents

SN	Document Name	Remarks
[1]	Quectel_MC60&MC90_AT_Commands_Manual	MC60&MC90 AT commands manual
[2]	ITU-T Draft New Recommendation V.25ter	Serial asynchronous automatic dialing and control
[3]	GSM 07.07	Digital cellular telecommunications (Phase 2+); AT command set for GSM Mobile Equipment (ME)
[4]	GSM 07.10	Support GSM 07.10 multiplexing protocol
[5]	GSM 07.05	Digital cellular telecommunications (Phase 2+); Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS)
[6]	GSM 11.14	Digital cellular telecommunications (Phase 2+); Specification of the (U)SIM Application Toolkit for the Subscriber Identity module – Mobile Equipment ((U)SIM – ME) interface
[7]	GSM 11.11	Digital cellular telecommunications (Phase 2+); Specification of the Subscriber Identity module – Mobile Equipment ((U)SIM – ME) interface
[8]	GSM 03.38	Digital cellular telecommunications (Phase 2+); Alphabets and language-specific information
[9]	GSM 11.10	Digital cellular telecommunications (Phase 2); Mobile Station (MS) conformance specification; Part 1: Conformance specification

[10]	Quectel_GSM_UART_Application_Note	UART port application note
[11]	Quectel_GSM_EVB_User_Guide	GSM EVB user guide
[12]	Quectel_Module_Secondary_SMT_User_Guide	Module secondary SMT user guide
[13]	Quectel_GSM_Module_Digital_IO_Application_Note	GSM module digital IO application note
[14]	Quectel_MC90_GNSS_AGPS_Application_Note	MC90 GNSS AGPS application note
[15]	Quectel_MC90_Wi-Fi_AT_Commands_Manual	MC90 Wi-Fi AT commands manual
[16]	Quectel_MC60&MC90_GNSS_Protocol_Specification	MC60&MC90 GNSS protocol_specification
[17]	Quectel_MC90-TE-A_User_Guide	MC90-TE-A user guide

Table 50: Terms and Abbreviations

Abbreviation	Description
ADC	Analog-to-Digital Converter
AG	Audio Gateway
AGPS	Assisted GPS
AIC	Active Interference Cancellation
AIN	Audio In
AMR	Adaptive Multi-Rate
ARP	Antenna Reference Point
ASIC	Application Specific Integrated Circuit
BER	Bit Error Rate
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear to Send
DGPS	Differential GPS

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
EASY™	Embedded Assist System
EFR	Enhanced Full Rate
EGSM	Enhanced GSM
EMC	Electromagnetic Compatibility
EPO™	Extended Prediction Orbit
ESD	Electrostatic Discharge
ETS	European Telecommunication Standard
FCC	Federal Communications Commission (U.S.)
FDMA	Frequency Division Multiple Access
FR	Full Rate
FS	File System
FTP	File Transfer Protocol
GAGAN	GPS Aided Geo Augmented Navigation
GGA	NMEA: Global Positioning System Fix Data
GLL	NMEA: Geographic Latitude and Longitude
GLONASS	Global Navigation Satellite System
GLP	GNSS Low Power
GMSK	Gaussian Minimum Shift Keying
GNSS	Global Navigation Satellite System

GPRS	General Packet Radio Service
GPS	Global Positioning System
GSA	NMEA: GPS DOP and Active Satellites
GSM	Global System for Mobile Communications
GSV	NMEA: GPS Satellites in View
G.W	Gross Weight
HFP	Hands-free Profile
HO	High Level Output
HR	Half Rate
HTTP	Hypertext Transfer Protocol
I/O	Input/Output
IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers
IMEI	International Mobile Equipment Identity
$I_{O}max$	Maximum Output Load Current
kbps	Kilo Bits Per Second
LCC	Leadless Chip Carriers
LED	Light Emitting Diode
LGA	Land Grid Array
Li-Ion	Lithium-Ion
LO	Low Level Output
MCU	Micro Control Unit
MMS	Microsoft Media Server
MQTT	Message Queuing Telemetry Transport
LNA	Low Noise Amplifier

MO	Mobile Originated
MOQ	Minimum Order Quantity
MP	Manufacture Product
MS	Mobile Station (GSM engine)
MSAS	Multi-Functional Satellite Augmentation System
MT	Mobile Terminated
NMEA	National Marine Electronics Association
NTP	Network Time Protocol
N.W	Net Weight
PAP	Password Authentication Protocol
PBCCH	Packet Switched Broadcast Control Channel
PCB	Printed Circuit Board
PCL	Power Control Level
PCM	Pulse Code Modulation
PD	Pull-down
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PING	Packet Internet Groper
PMOS	Positive Channel Metal Oxide Semiconductor
PMTK	MTK Proprietary Protocol
PMU	Power Management Unit
PPP	Point-to-Point Protocol
PPS	Pulse per Second
PU	Pull-up
QZSS	Quasi-Zenith Satellite System

RF	Radio Frequency
RMC	NMEA: Recommended Minimum Position Data
RMS	Root Mean Square (value)
RoHS	Restriction of Hazardous Substances
RTC	Real Time Clock
RX	Receive Direction
SBAS	Satellite-based Augmentation System
SIM	Subscriber Identification Module
SMD	Surface Mounted Devices
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SPI	Serial Peripheral Interface
SPP	Standard Parallel Port
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TE	Terminal Equipment
3GPP	3rd Generation Partnership Project
TTFF	Time to First Fix
TX	Transmitting Direction
UART	Universal Asynchronous Receiver & Transmitter
UDP	User Datagram Protocol
URC	Unsolicited Result Code
USIM	Universal Mobile Telecommunication System
USSD	Unstructured Supplementary Service Data

VSWR	Voltage Standing Wave Ratio
VTG	NMEA: Track Made Good and Ground Speed
V_{O}max	Maximum Output Voltage Value
V_{O}norm	Normal Output Voltage Value
V_{O}min	Minimum Output Voltage Value
V_{IH}max	Maximum Input High Level Voltage Value
V_{IH}min	Minimum Input High Level Voltage Value
V_{IL}max	Maximum Input Low Level Voltage Value
V_{IL}min	Minimum Input Low Level Voltage Value
V_{I}max	Absolute Maximum Input Voltage Value
V_{I}norm	Absolute Normal Input Voltage Value
V_{I}min	Absolute Minimum Input Voltage Value
V_{OH}max	Maximum Output High Level Voltage Value
V_{OH}min	Minimum Output High Level Voltage Value
V_{OL}max	Maximum Output Low Level Voltage Value
V_{OL}min	Minimum Output Low Level Voltage Value
WAAS	Wide Area Augmentation System
Phonebook Abbreviations	
LD	(U)SIM Last Dialing phonebook (list of numbers most recently dialed)
MC	Mobile Equipment list of unanswered MT Calls (missed calls)
ON	(U)SIM (or ME) Own Numbers (MSISDNs) list
RC	Mobile Equipment list of Received Calls
SM	(U)SIM phonebook

9 Appendix B GPRS Coding Schemes

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

Table 51: 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.

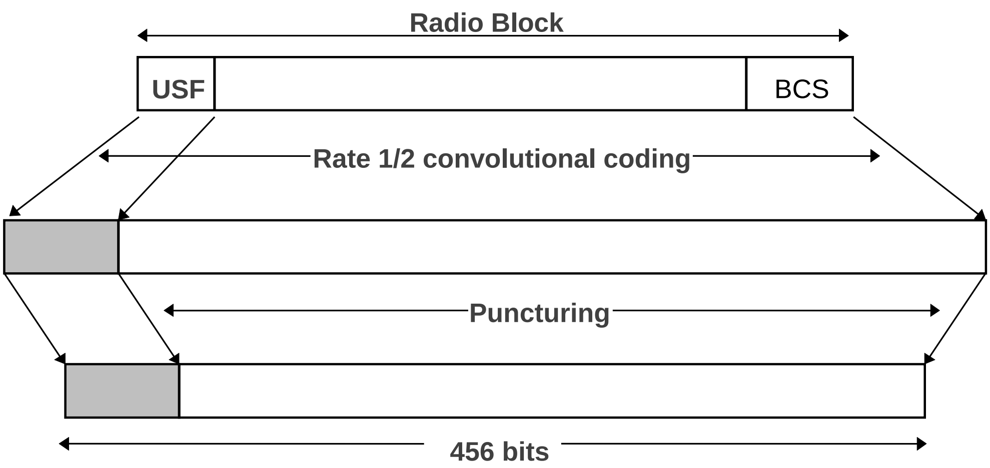

Figure 61: Radio Block Structure of CS-1, CS-2 and CS-3

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

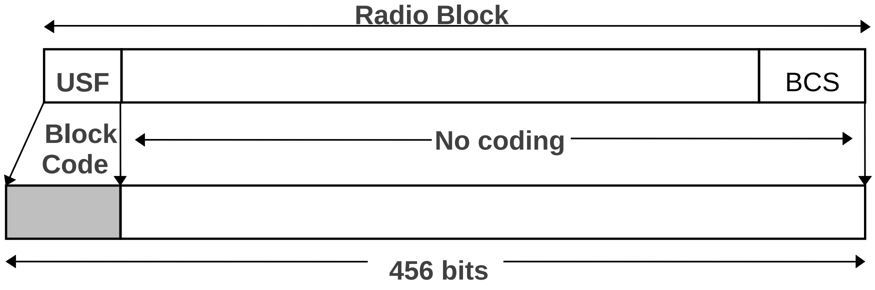

Figure 62: Radio Block Structure of CS-4

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 52: 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