SIM66MD
Hardware Design

GNSS Module

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1 Introduction

This document describes the hardware interface of the SIMCom module SIM66MD which can be used as a stand-alone or A-GPS（Assisted Global Positioning System）receiver. As a wide range of applications can be integrated in SIM66MD, all functional components of SIM66MD are described in great detail.

SIM66MD is for global applications, supports GPS, GLONASS, BD, Galileo, and can be combined with multiple systems and supports a variety of SBAS signal reception and processing provide users with a fast, accurate and high-performance positioning experience. With built-in LNA, SIM66MD can relax antenna requirement and don't need for external LNA. SIM66MD can track as low as -160dBm signal even without network assistance. The SIM66MD has excellent low power consumption characteristic (acquisition and tracking consumption is 35mA). SIM66MD supports various location and navigation applications, including autonomous GPS, GLONASS, BD, Galileo.

Key Features

- GPS receiver, supports GPS, GLONASS, BD, Galileo, SBAS ranging, WAAS, EGNOS, GAGAN, MSAS.
- Small footprint: 10.1x 9.7 x 2.5mm, 18-pin LCC package
- Support L1+ L5/L2 dual-frequency multi-system original observation output, can perform centimeter-level RTK positioning and sub-meter-level RTD positioning, suitable for applications such as vehicles, robots, drones, etc.
- The fixed update rate is 10 Hz
- Interface
  1. UART
  2. PPS
  3. RESET
- Operating temperature: -40 ~ +85ºC
- Accuracy < 1m CEP
- RoHS compliant

The module provides complete signal processing from antenna input to host port in either NMEA messages. The module requires 3.3V power supply. The host port is configurable to UART. Host data and I/O signal levels are 3.3V compatible.

1.1 SIM66MD Functional Diagram

The following figure shows a functional diagram of the SIM66MD and illustrates the mainly functional parts:

- The GPS chip
- SAW filter
- LNA
- The antenna interface
- The communication interface
- The control signals

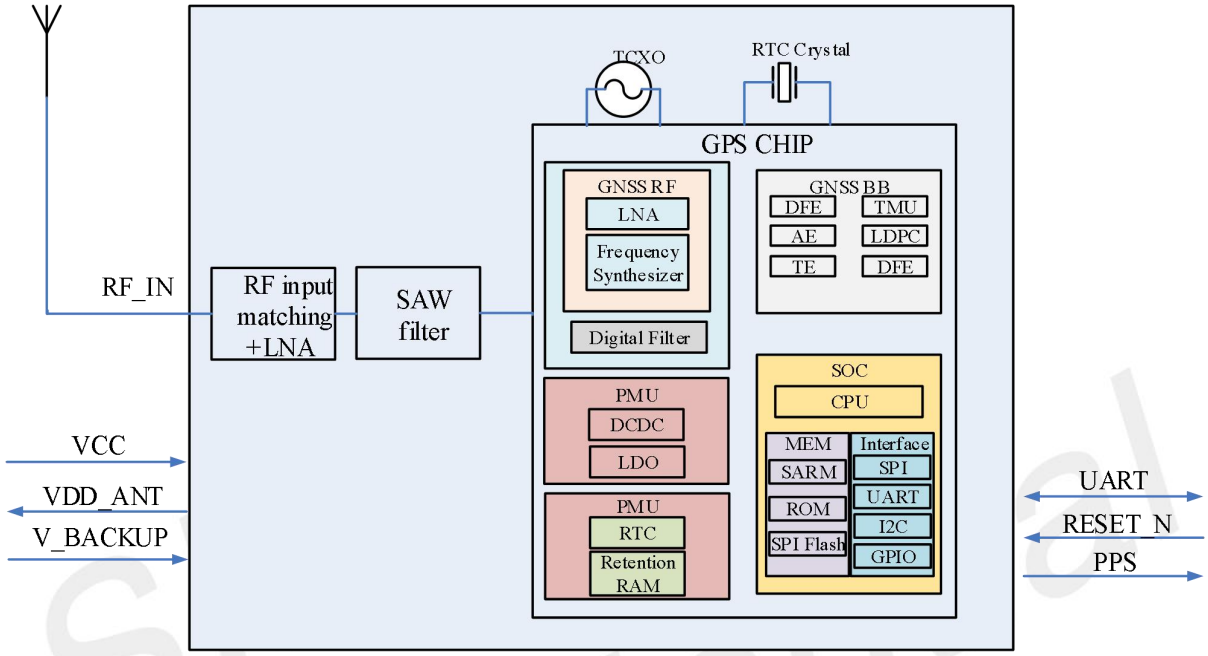


Figure 1: SIM66MD functional diagram

1.2 GPS Performance

Table 1: GPS performance

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy(1)	Autonomous			1	m
Velocity Accuracy(2)			0.1		m/s
Timing Accuracy			15		ns
Dynamic Performance	Maximum Altitude			80000	m
	Maximum Velocity			500	m/s
	Maximum Acceleration			4	G
TTFF(3) GPS +GLONASS + BeiDou	Hot start		0.5		s
	Warm start		25		s
	Cold start		25		s

A-GPS TTFF	Cellular assisted location		5		s
Sensitivity GPS（L1+L5） only mode	Autonomous acquisition(cold start)		-150		dBm
	Re-acquisition		-156		dBm
	Tracking		-166		dBm
Sensitivity GPS（L1+L5） + GLONASS + BeiDou mode	Autonomous acquisition(cold start)		-150		dBm
	Re-acquisition		-156		dBm
	Tracking		-166		dBm
Receiver	Channels L1+L5/L2		96		
	Update rate	1		10	Hz
	Protocol support NMEA,ICOE				
Power consumption(4)	Acquisition		40		mA
	Continuous tracking		40		mA
	Backup current		40		uA

NOTE

(1) 50% 24hr static, -130dBm
(2) 50% at 30m/s
(3) GNSS signal level: -130dBm
(4) Single Power supply 3.3V@-130dBm

1.3 General features

Table 2: General features

Parameters	Value
Supply voltage VCC	2.1V~4.0V
Power consumption(acquisition)	40mA type. @ VCC=3.3 V
Operation temperature	-40ºC~+85ºC
Storage temperature	-45ºC~+95ºC
Host port	UART
Serial port protocol (UART)	NMEA; 8 bits, no parity, 1 stop bit; 115200 baud.

2 Package Information

2.1 Pin out Diagram

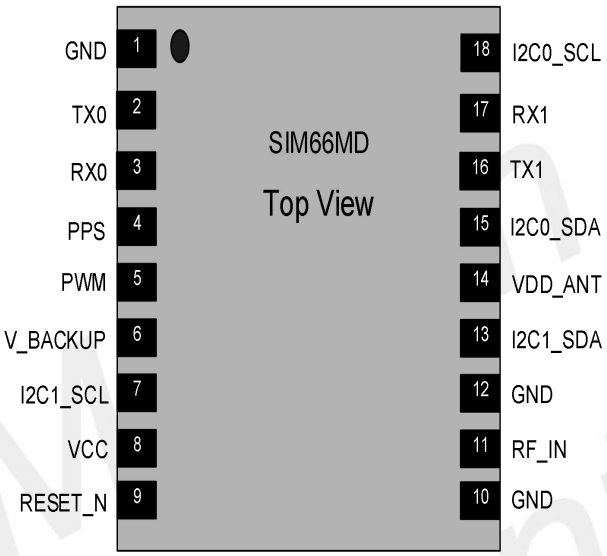


Figure 2: SIM66MD pin out diagram (Top view)

2.2 Pin Description

Table 3: Pin description

Pin Name	Pin No.	I/O	Description	Comment
Power supply				
VCC	8	I	Main power input, which will be used to power the baseband and RF section internally.	Provide clean and stable power source to this pin. Add a 4.7uF capacitor to this pin for decoupling.
VDD_ANT	14	O	Power supply for active antenna or external LNA	If unused, keep open
V_BACKUP	6	I	The backup battery input power supply for RTC	If unused, keep open.
GND	1,10,12		Ground	GND
Host port interface				

RX0	3	I	Serial data input for firmware update	
TX0	2	O	Serial data output of NMEA	
RX1	17	I	Used for auxiliary information transmission or debugging	If unused, keep open.
TX1	16	O		If unused, keep open.
GPIOs				
RESET_N	9	I	Reset input, active low, default pull-up	Need to pull up 10K to 3.3V externally, if unused, keep open.
PWM	5	I/O	Interrupt input	If unused, keep open.
PPS	4	O	1PPS output	Need to connect a 33R resistor, if unused, keep open.
I2C0_SDA	15	I/O	I2C0 data signal, slave mode, used for firmware loading and communication with the master	Need to pull up 2.2K to 3.3V externally, if unused, keep open.
I2C0_SCL	18	I	I2C0 clock signal, slave mode, used for firmware loading and communication with the master	Need to pull up 2.2K to 3.3V externally, if unused, keep open.
I2C1_SCL	7	I	I2C1 clock signal, master mode, used for external sensors	Need to pull up 2.2K to 3.3V externally, if unused, keep open.
I2C1_SDA	13	I/O	I2C1 data signal, master mode, used for external sensors	Need to pull up 2.2K to 3.3V externally, if unused, keep open.
RF interface				
RF_IN	11	I	Radio antenna connection	Independence must be controlled to 50Ω.

2.3 Package Dimensions

Following figure shows the Mechanical dimensions of SIM66MD (top view, side view and bottom view).

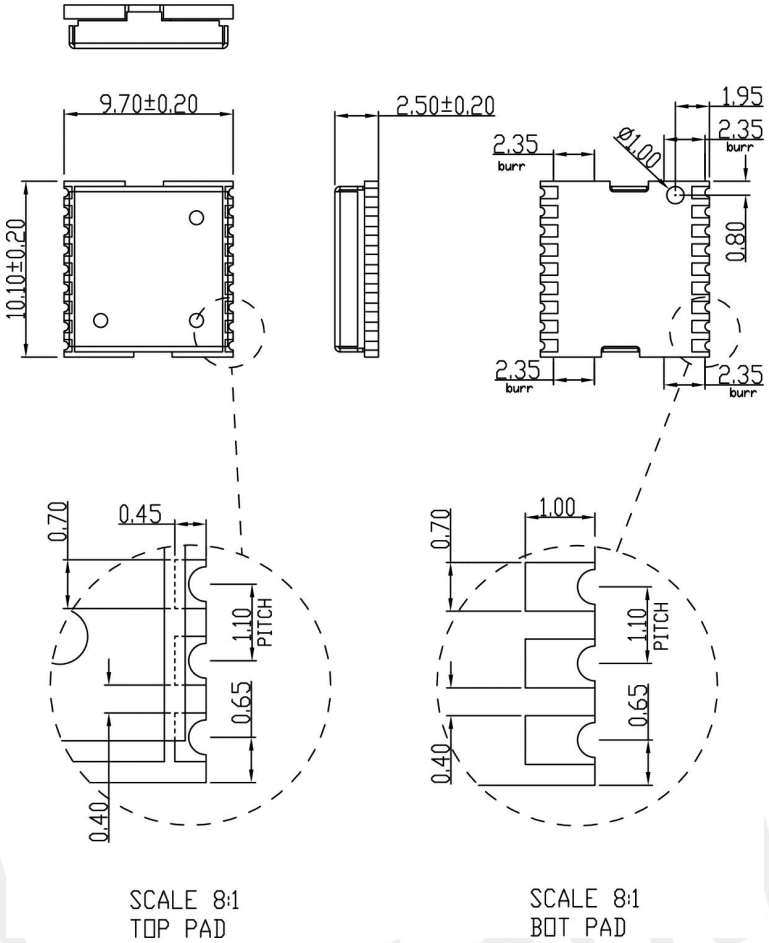


Figure 3: SIM66MD mechanical dimensions (Unit: mm)

3 Application Interface

3.1 Power Management

3.1.1 Power Intput

The power supply range of SIM66MD is from 2.1V to 4.0V, typical 3.3V. The power supply should be able to provide sufficient current up to 100mA. SIM66MD positioning modules require a stable power supply, consider the following points:

- Wide power lines or even power planes are preferred.
- VCC supply needs to add a 4.7uF and 100nF multi-layer ceramic chip (MLCC) capacitors with low ESR in high frequency band, which can be used for EMC performance.
- The ripple of the VCC supply cannot be higher than 30mV.
- VCC supply needs a surge protection.

The power supply range of V_BACKUP is from 1.7V to 3.6V, typical 3V, suggest customer keep the V_BACKUP supply active all the time, the module will perform a quick start every time it is power-on.

3.1.2 Starting SIM66MD

When power is first applied, SIM66MD goes into operation mode.

3.1.3 Verification of SIM66MD Start

System activity indication depends upon the chosen serial interface:

- When it is activated, SIM66MD will output messages at the selected UART speed and message types.

3.1.4 Operating Mode

SIM66MD supports two operating modes: continuous tracking mode and backup mode.

- Continuous tracking mode: In this mode the receiver stays at full on power state. The module processes the satellite signal continuously, and captures and tracks the satellite signal with high quality Tracking support positioning, speed measurement accuracy and TTFF.

- Backup mode: This connects to the backup power of the module. Power source (such as battery or cap) connected to V_BACKUP pin will help the chipset in keeping its internal RTC running when the VCC power source is turned off. The voltage should be kept between 1.7~3.6V, Typical 3.0V. The V_BACKUP power should be kept active all the time, the module will perform a quick start every time it is power-on. In this mode the SIM66MD must be supplied by the V_BACKUP pin and the VCC power should be cut off.

Table 4: Power supply and clock state according to operation mode

Mode	VCC	V_BACKUP	Internal LDO	Main clock	RTC clock
Continuous tracking	on	on	on	on	on
Backup	off	on	off	off	on

3.1.5 VDD_ANT

The power supply range of VDD_ANT is from 1.7V to 3.6V, typical 3.3V. Power supply for active antenna or external LNA.

3.2 UART Interface

SIM66MD includes one UART interface for NMEA output. The baud rate is 115200 as default.

The following figure shows the connection between module and client.

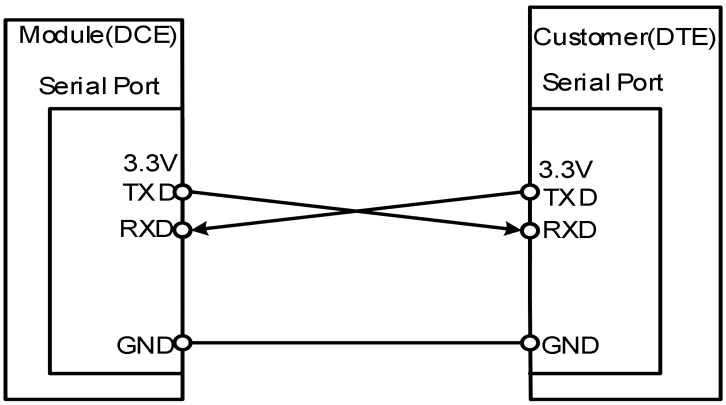


Figure 4: Connection of the serial interfaces

3.3 I2C Interface*

I2C0 supports slave mode, used for firmware loading and communication with the master.
I2C1 supports master mode, used for external sensors.

NOTE

1. “*” means under development.
2. 2.2K needs to be pulled up outside the module.

3.4 SPI Interface*

SIM66MD provides SPI master interface, which can be used to communicate with or control other SPI slave devices. The maximum transmission rate of the SPI master interface is 16Mbps, and the maximum SPI clock frequency is 16MHz. The SPI master interface is not enabled by default.

NOTE

1. “*” means under development.

3.5 RESET Input

The RESET_N pin (active low) is used to reset the system, when the voltage is low, the Core domain reset signal is sent, and the low level duration of RESET_N is no less than 10us, normally external control of RESET_N is not necessary. The signal can be left floating, if not used.

When RESET_N signal is used, it will force volatile RAM data loss. Note that Non-Volatile backup RAM content is not cleared and thus fast TTFF is possible. The input has internal pull up.

3.6 1PPS output

The PPS pin outputs pulse-per-second (PPS) pulse signal for precise timing purposes after the position has been fixed. The PPS signal can be provided through designated output pin for many external applications. This pulse is not only limited to be active every second but also allowed to set the required duration, frequency, and active high/low by programming user-defined settings.

PPS GPS time reference with adjustable duty cycle and +/- 15ns accuracy, support for time service application, which is achieved by the PPS and NMEA feature.

The following figure is the typical application of the PPS function.

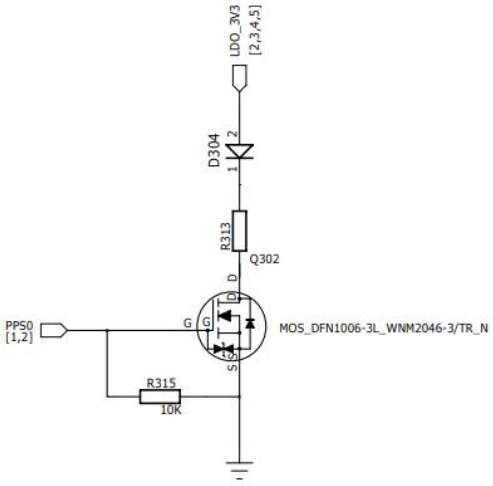


Figure 5: TIMEMARK application circuit

3.7 Antenna

The antenna is a critical item for successful GNSS signal reception in a weak signal environment. Proper choice of the antenna will ensure that satellites at all elevations can be seen, and therefore, accurate fix measurements are obtained.

It is recommended to use an active GNSS antenna. In a typical application, SIM66MD with an active antenna can get a tracking sensitivity about 3dB better than SIM66MD with a passive antenna.

Table 5: GNSS Operating frequencies

Type	Frequecy
GPS L1	1575.42±1.023MHz
GLONASS G1	1601.7±6.75MHz
Galileo E1	1575.42±1.023MHz
BeiDou B1I	1561.098±2.046MHz
GPS L5	1176.45±10.23MHz
BeiDou B2a	1176.45±10.23MHz
Galileo E5a	1176.45±10.23MHz

It is suggested the antenna should be chosen as following:

Table 6: Antenna Specifications

Parameter	Specification	
Passive Antenna Recommendations	Frequency range	L1: 1560～1609MHz L5: 1166～1187MHz
	Polarization	RHCP
	Antenna Gain	> 0dBi
	VSWR	< 2
Active Antenna Recommendations	Frequency range	L1: 1560～1609MHz L5: 1166～1187MHz
	Polarization	RHCP
	VSWR	< 2
	Noise Figure(1)	< 1.5dB
	Total Gain(2)	< 30dB

NOTE

1. The noise figure of LNA in active antenna is less than 1, which is helpful to obtain better performance.
2. Total gain of the active antenna = gain of the internal LNA - total insertion loss of cables and components inside the antenna.

3.7.1 Antenna Interface

The SIM66MD receives L1 and L5 band signals from satellites. The RF signal is connected to the RF_IN pin. And the trace from RF_IN to antenna should be controlled to 50Ω impendence.

To suit the physical design of individual applications the RF interface pad can lead to two alternatives:

- Recommended approach: solderable RF coaxial cable assembly antenna connector, such as HRS' U.FL-R-SMT(10) connector or I-PEX's 20279-001E-01 RF connector.
- SMA connector.

3.7.2 Antenna Choice and RF Design Consideration

To obtain excellent GNSS reception performance, a good antenna will always be required. The RF circuits should also be designed properly based on the type of antenna.

Passive antenna contains only the radiating element, e.g. the ceramic patch, the helix structure, and Chip antennas. Sometimes it also contains a passive matching network to match the electrical connection to 50 Ohms impedance.

The most common antenna type for GNSS applications is the patch antenna. Patch antennas are flat, generally have a ceramic and metal body and are mounted on a metal base plate.

Figure 6 shows a minimal setup for a GNSS receiver with SIM66MD module. It is recommended to use a TVS transient diode with junction capacitance less than 0.6pF as the anti-static protection device

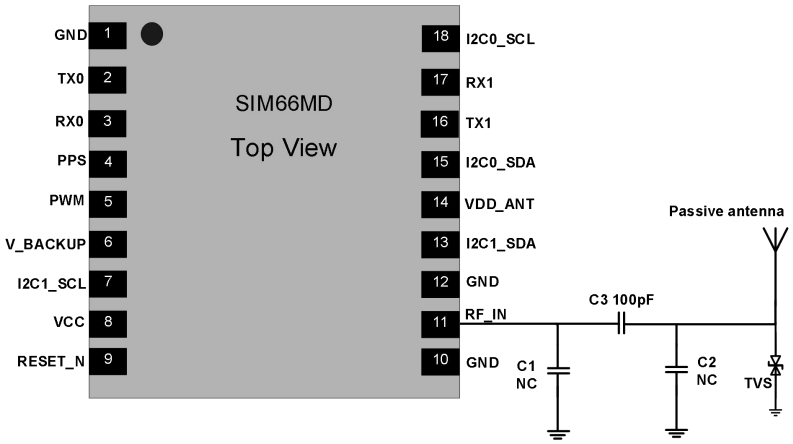


Figure 6: SIM66MD passive antenna design

For best performance with passive antenna designs, user can use an external LNA to increase the sensitivity up 3~4 dB. Please see Figure 7.

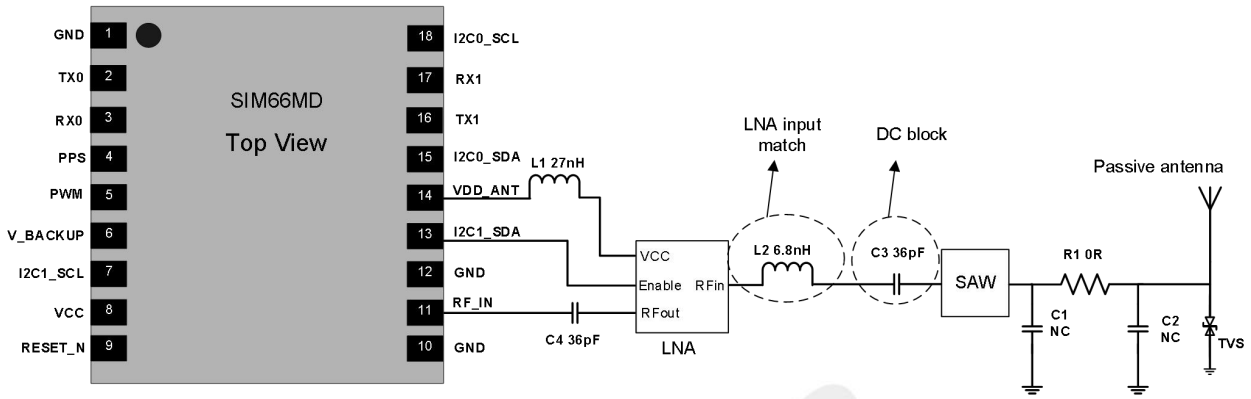


Figure 7: SIM66MD passive antenna design (with external LNA and SAW)

Active antennas have an integrated Low-Noise Amplifier (LNA). Active antennas need a power supply that will contribute to GNSS system power consumption.

Usually Pin 14 VDD_ANT is directly used for the active antenna power supply, as shown in Figure 8. The voltage range is from 1.7V to 3.6V, typical value is 3.3V, and the max driver current is 50mA. If the VDD_ANT 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 VDD_ANT pin and route the bias supply to the active antenna, the recommended value of L1 is no less than 27nH. R2 can protect the whole circuit in case the active antenna is shorted to ground.

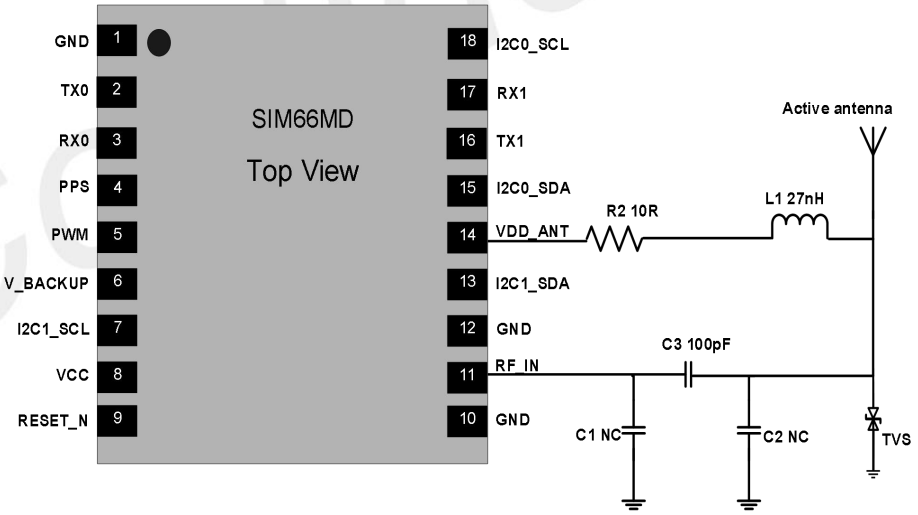


Figure 8: SIM66MD Active antenna simplified design

If the customer's design is for automotive applications, then an active antenna can be used and located on top of the car in order to guarantee the best signal quality.

GPS antenna choice should base on the designing product and other conditions. For detailed Antenna designing consideration, please refer to related antenna vendor's design recommendation. The antenna

vendor will offer further technical support and tune their antenna characteristic to achieve successful GNSS reception performance depending on the customer's design.

4 Electrical Reliability and Radio Characteristics

4.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 6 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to SIM66MD.

Table 7: Absolute maximum ratings

Parameter	Min	Max	Unit
VCC	-0.2	4.0	V
VDD_ANT	-0.2	3.6	V
RF_IN input power	-	-12	dBm
V_BACKUP	-	3.6	V
I/O pin voltage	-0.2	3.6	V
Operation temperature	-40	+85	℃
Storage temperature	-45	+95	℃

4.2 Recommended Operating Conditions

Table 8: SIM66MD operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature range		-40	+25	85	℃
Main supply voltage	VCC	2.3	3.3	4.0	V
Backup battery voltage	V_BACKUP	1.7	3	3.6	V

4.3 Electro-Static Discharge

The GPS engine is not protected against Electrostatic Discharge (ESD) in general. Therefore, it is subject to

ESD handing precautions that typically apply to ESD sensitive components. Proper ESD handing and packaging procedures must be applied throughout the processing, handing and operation of any application using a SIM66MD module. The ESD test results are shown in the following table.

Table 9: The ESD characteristics (Temperature: 25℃, Humidity: 45 %)

Pin	Contact discharge	Air discharge
VCC	±4KV	±8KV
RF_IN	±4KV	±8KV
V_BACKUP	±4KV	±8KV
VDD_ANT	±4KV	±8KV
GND	±4KV	±8KV
RX0, TX0	±4KV	±8KV
PPS	±4KV	±8KV
RESET_N	±4KV	±8KV

NOTE

Test conditions:
1. The external of the module has surge protection diodes and ESD protection diodes.
2. The data in Table 8 were tested using SIMCom EVB.

5 Manufacturing

5.1 Top and Bottom View of SIM66MD

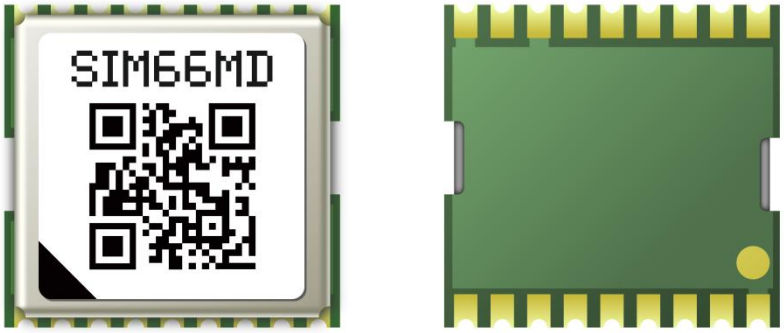


Figure 9: Top and bottom view of SIM66MD

NOTE

The above is the design effect diagram of the module for reference. The actual appearance is subject to the actual product.

5.2 Recommended PCB Footprint

The following figure shows the PCB footprint of SIM66MD.

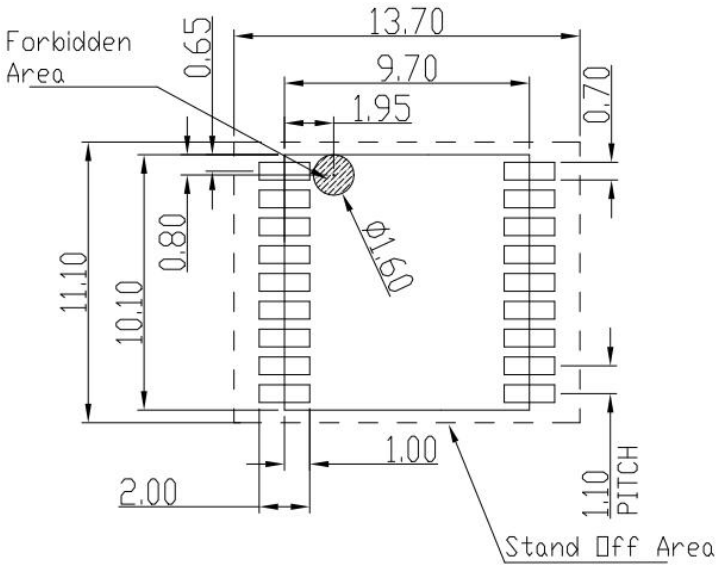


Figure 10: Recommended PCB footprint

5.3 Recommended SMT Stencil

The following figure shows the SMT stencil of SIM66MD.

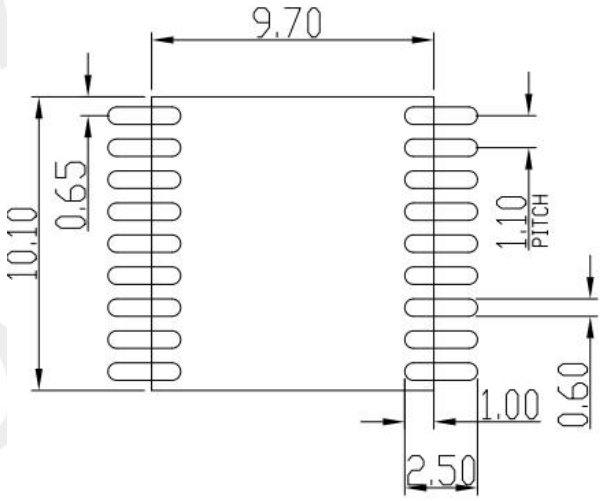


Figure 11: Recommended SMT stencil

5.4 Assembly and Soldering

The SIM66MD module is intended for SMT assembly and soldering in a Pb-free reflow process on the top side of the PCB. Suggested solder paste stencil height is 150um minimum to ensure sufficient solder volume. If required paste mask pad openings can be increased to ensure proper soldering and solder wetting over pads.

The following figure is the Ramp-Soak-Spike Reflow Profile of SIM66MD:

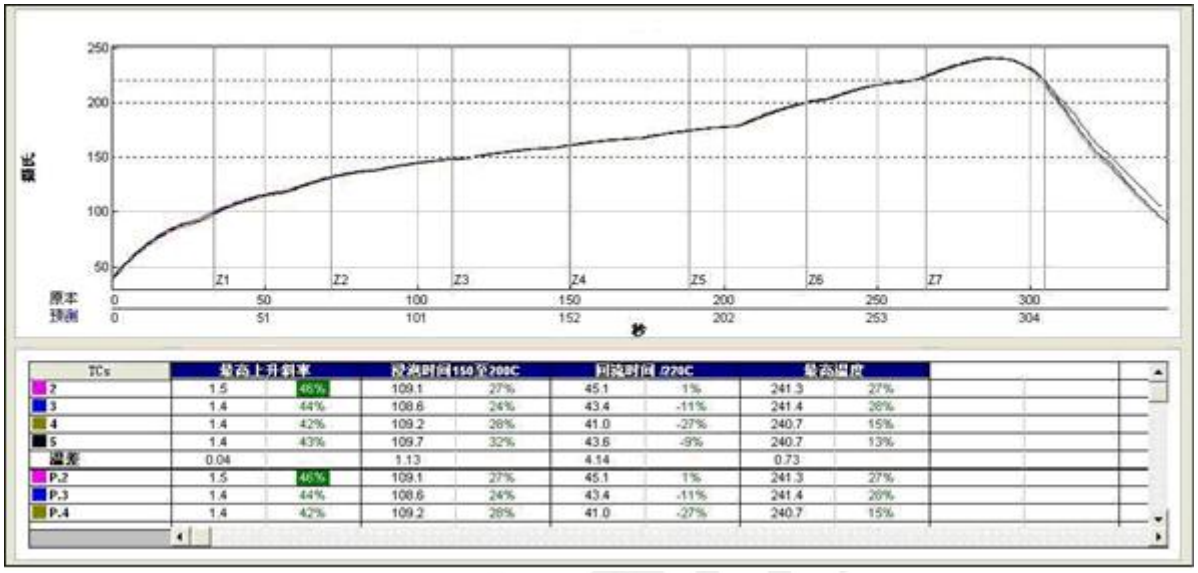


Figure 12: The Ramp-Soak-Spike reflow profile of SIM66MD

SIM66MD is Moisture Sensitive Devices (MSD), appropriate MSD handling instruction and precautions are summarized in Chapter 5.3.

SIM66MD modules are also Electrostatic Sensitive Devices (ESD), handling SIM66MD modules without proper ESD protection may destroy or damage them permanently.

Avoid ultrasonic exposure due to internal crystal and SAW components.

5.5 Moisture sensitivity

SIM66MD module is moisture sensitive at MSL level 3, dry packed according to IPC/JEDEC specification J-STD-020C. The calculated shelf life for dry packed SMD packages is a minimum of 6 months from the bag seal date, when stored in a non-condensing atmospheric environment of <40°C/90% RH.

Table 9 lists floor life for different MSL levels in the IPC/JDEC specification:

Table 10: Moisture Classification Level and Floor Life

Level	Floor Life(out of bag)at factory ambient≦+30℃/60%RH or as stated
1	Unlimited at ≦+30℃/85% RH
2	1 year
2a	4 weeks
3	168 hours

4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, module must be reflowed within the time limit specified on the label.

Factory floor life is 1 week for MSL 3, SIM66MD must be processed and soldered within the time. If this time is exceeded, the devices need to be pre-baked before the reflow solder process.
Both encapsulate and substrate materials absorb moisture. IPC/JEDEC specification J-STD-020 must be observed to prevent cracking and delamination associated with the "popcorn" effect during reflow soldering. The popcorn effect can be described as miniature explosions of evaporating moisture. Baking before processing is required in the following case:
Floor life or environmental requirements after opening the seal have been exceeded, e.g. exposure to excessive seasonal humidity.
Refer to Section 4 of IPC/JEDEC J-STD-033 for recommended baking procedures.

NOTE

Oxidation Risk: Baking SMD packages may cause oxidation and/or inter metallic growth of the terminations, which if excessive can result in solder ability problems during board assembly. The temperature and time for baking SMD packages are therefore limited by solder ability considerations. The cumulative bake time at a temperature greater than 90°C and up to 125°C shall not exceed 96 hours.

5.6 ESD handling precautions

SIM66MD modules are Electrostatic Sensitive Devices (ESD). Observe precautions for handling!
Failure to observe these precautions can result in severe damage to the GPS receiver!

GPS receivers are Electrostatic Sensitive Devices (ESD) and require special precautions when handling. Particular care must be exercised when handling patch antennas, due to the risk of electrostatic charges. In addition to standard ESD safety practices, the following measures should be taken into account whenever handling the receiver:

Unless there is a galvanic coupling between the local GND (i.e. the work Table) and the PCB GND, then the first point of contact when handling the PCB shall always be between the local GND and PCB GND.
Before mounting an antenna patch, connect ground of the device

When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10pF, coax cable ~50-80pF/m,

soldering iron)
To prevent electrostatic discharge through the RF input, do not touch the mounted patch antenna.

When soldering RF connectors and patch antennas to the receiver's RF pin, the user must make sure to use an ESD safe soldering iron (tip).

5.7 Shipment

SIM66MD is designed and packaged to be processed in an automatic assembly line, and it is now packaged tray and reel.

6 Package

SIM66MD module support tray packaging.

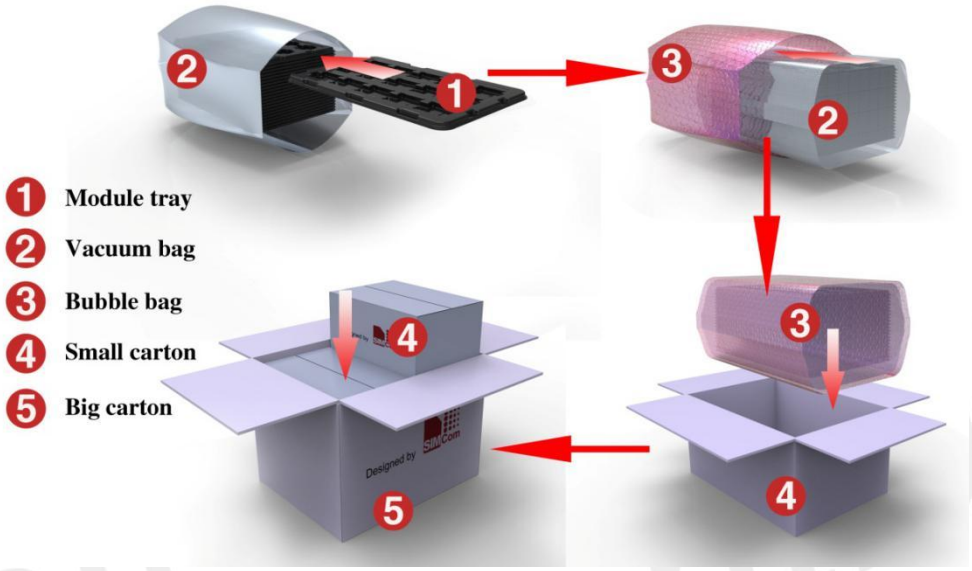


Figure 13: packaging diagram

Module tray drawing：

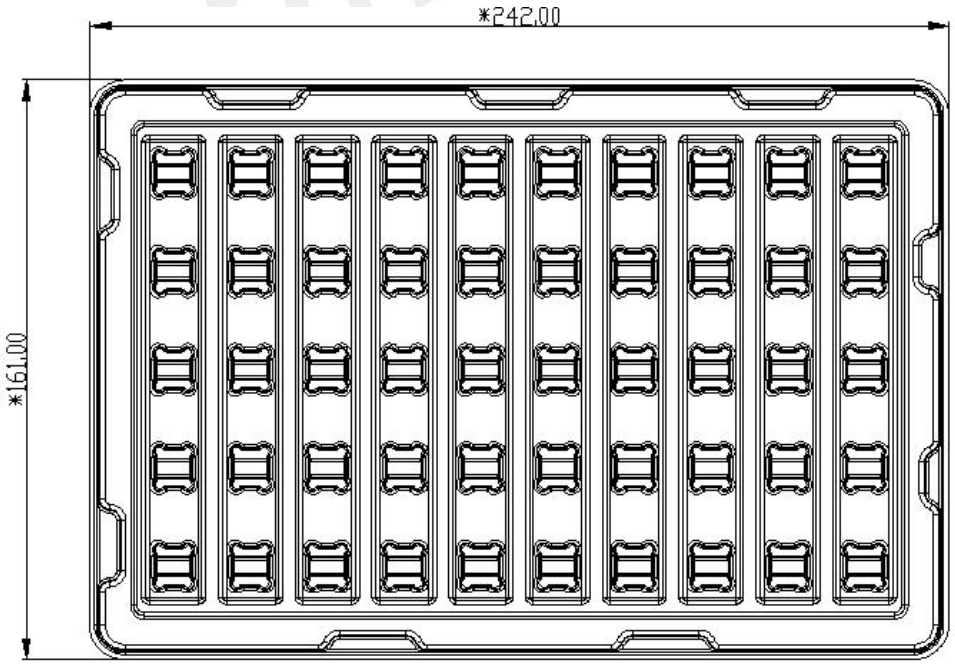
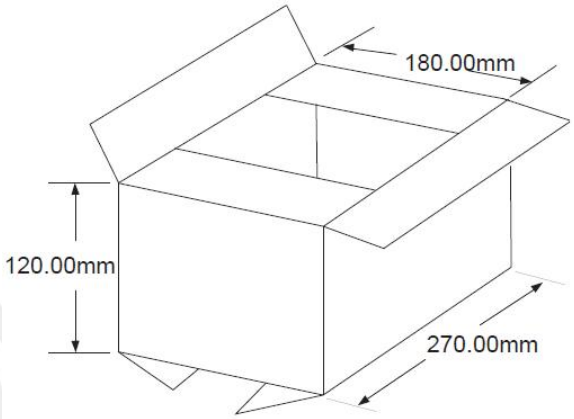


Figure 14: Tray drawing

Table 11: Tray size

Length（±3mm）	Width（±3mm）	Module number
242.0	161.0	50

Small carton drawing：



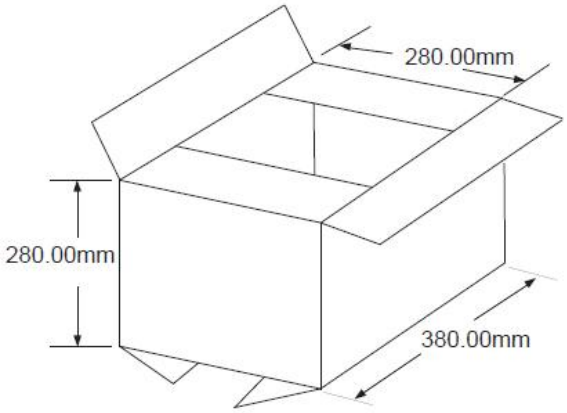
Internal

Figure 15: Small carton drawing

Table 12: Small Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module number
270	180	120	50*20=1000

Big carton drawing：



Internal

Figure 16: Big carton drawing

Table 13: Big Carton size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module number
380	280	280	1000*4=4000

7 Reference Design

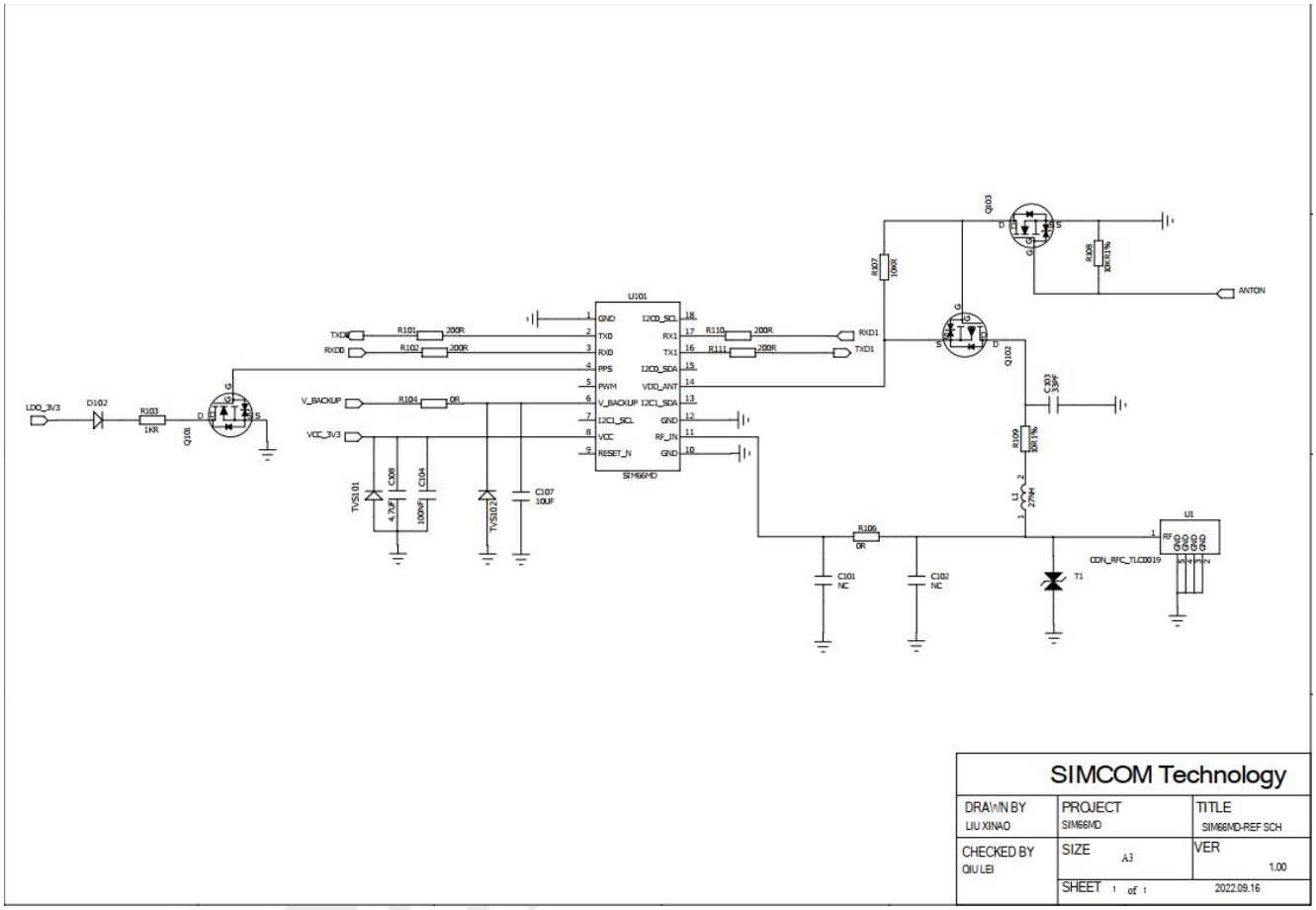


Figure 17: Application schematics

8 Appendix

8.1 Related Documents

Table 14: Related documents

SN	Document name	Remark
[1]	SIM66 Series NMEA Message User Guide	

8.2 Terms and Abbreviations

Table 15: Terms and abbreviations

Abbreviation	Description
A-GPS	Assisted Global Positioning System
CMOS	Complementary Metal Oxide Semiconductor
CEP	Circular Error Probable
DGPS	Difference Global Positioning System
EEPROM	Electrically Erasable Programmable Read Only Memory
EPO	Extended Prediction Orbit
ESD	Electrostatic Sensitive Devices
EASY	Embedded Assist System
EGNOS	European Geostationary Navigation Overlay Service
GPS	Global Positioning System
GAGAN	The GPS Aided Geo Augmented Navigation
I/O	Input/Output
IC	Integrated Circuit
I_{norm}	Normal Current
I_{max}	Maximum Load Current
kbps	Kilo bits per second
MSL	moisture sensitive level
MSAS	Multi-Functional Satellite Augmentation System
NMEA	National Marine Electronics Association
PRN	Pseudo Random Noise Code
QZSS	Quasi-Zenith Satellites System
SBAS	Satellite Based Augmentation Systems
WAAS	Wide Area Augmentation System

8.3 Safety Caution

Table 16: Safety caution

Marks	Requirements
	When in a hospital or other health care facility, observe the restrictions about the use of mobiles. Switch the cellular terminal or mobile off, medical equipment may be sensitive and not operate normally due to RF energy interference.
	Switch off the cellular terminal or mobile before boarding an aircraft. Make sure it is switched off. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. Forgetting to think much of these instructions may impact the flight safety, or offend local legal action, or both.
	Do not operate the cellular terminal or mobile in the presence of flammable gases or fumes. Switch off the cellular terminal when you are near petrol stations, fuel depots, chemical plants or where blasting operations are in progress. Operation of any electrical equipment in potentially explosive atmospheres can constitute a safety hazard.
	Your cellular terminal or mobile receives and transmits radio frequency energy while switched on. RF interference can occur if it is used close to TV sets, radios, computers or other electric equipment.
	Road safety comes first! Do not use a hand-held cellular terminal or mobile when driving a vehicle, unless it is securely mounted in a holder for hands free operation. Before making a call with a hand-held terminal or mobile, park the vehicle.
	Mobiles operate over radio frequency signals and cellular networks and cannot be guaranteed to connect in all conditions, especially with a mobile fee or an invalid (U)SIM card. While you are in this condition and need emergent help, please remember to use emergency calls. In order to make or receive calls, the cellular terminal or mobile must be switched on and in a service area with adequate cellular signal strength. Some networks do not allow for emergency call if certain network services or phone features are in use (e.g. lock functions, fixed dialing etc.). You may have to deactivate those features before you can make an emergency call. Also, some networks require that a valid (U)SIM card be properly inserted in the cellular terminal or mobile.