SIM66M
Hardware Design

GNSS Module

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1 Introduction

This document describes the hardware interface of the SIMCom module SIM66M 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 SIM66M, all functional components of SIM66M are described in great detail.

SIM66M is for global applications, supports GPS, GLONASS, 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, SIM66M can relax antenna requirement and don’t need for external LNA. SIM66M can track as low as -160dBm signal even without network assistance. The SIM66M has excellent low power consumption characteristic (acquisition 27mA, tracking 28mA). SIM66M supports various location and navigation applications, including autonomous GPS, GLONASS,Galileo.

Key Features

- GPS receiver, supports GPS、GLONASS、Galileo, SBAS ranging,WAAS, EGNOS, GAGAN, MSAS.
- Small footprint: 10.1x 9.7 x 2.5mm, 18-pin LCC package
- Indoor and outdoor multi-path detection and compensation
- The fixed update rate is 1 Hz
- Interface
  1. UART
  2. PPS
- Operating temperature: -40 ~ +85ºC
- Accuracy <2.5 m CEP
- RoHS compliant

The module provides complete signal processing from antenna input to host port in either NMEA messages. The module requires 3.6V power supply. The host port is configurable to UART. Host data and I/O signal levels are 3.3V compatible.

1.1 SIM66M Functional Diagram

The following figure shows a functional diagram of the SIM66M and illustrates the mainly functional parts:

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

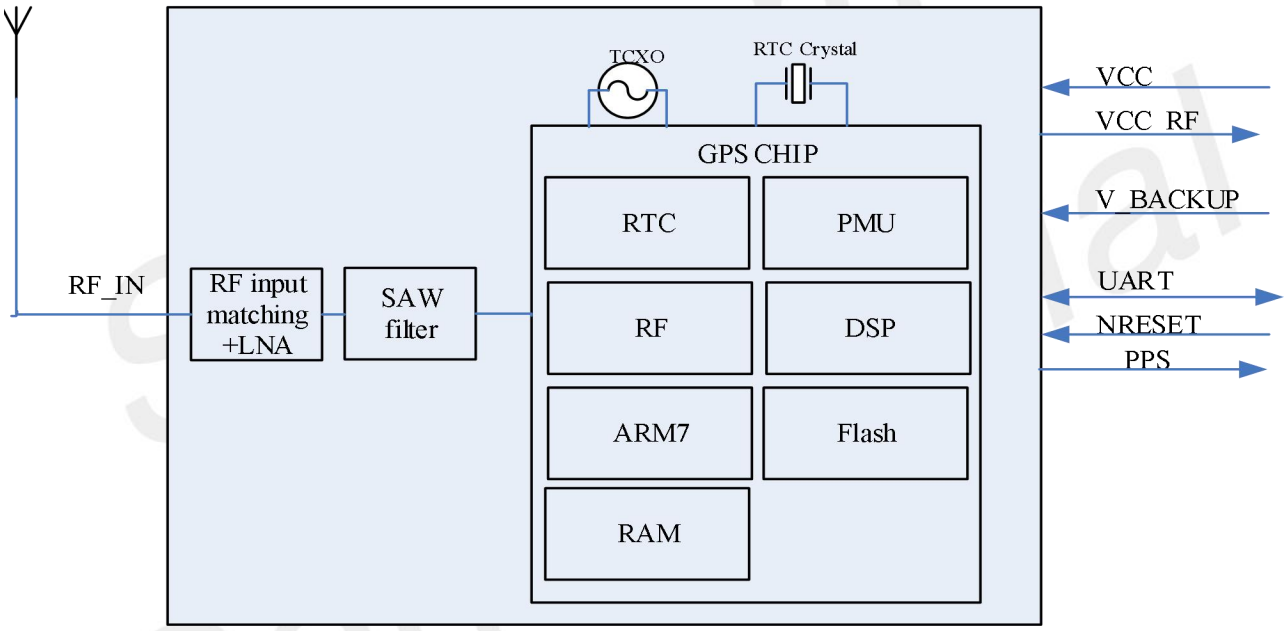


Figure 1: SIM66M functional diagram

1.2 GPS Performance

Table 1: GPS performance

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy(1)	Autonomous		2.5		m
Velocity Accuracy(2)	Without Aid		0.1		m/s
	DGPS		0.05		m/s

Acceleration Accuracy	Without Aid		0.1		m/s^2
Timing Accuracy			0.05		ns
Dynamic Performance	Maximum Altitude			18000	m
	Maximum Velocity			515	m/s
	Maximum Acceleration			4	G
GPS +GLONASS Time To First Fix(3)	Hot start		1.29		s
	Warm start		21.8		s
	Cold start		26.5		s
A-GPS TTFF	Hot start		<1		s
	Warm start		1.02		s
	Cold start				s
GPS Sensitivity	Autonomous acquisition(cold start)		-146.5		dBm
	Re-acquisition		-159		dBm
	Tracking		-160		dBm
GPS+GLONASS Sensitivity	Autonomous acquisition(cold start)		-146.5		dBm
	Re-acquisition		-160		dBm
	Tracking		-161		dBm
	Tracking		-160		dBm
Receiver	Channels		46 tracking/64 acquisition-channel		
	Update rate		1		Hz
	Tracking L1				
	Protocol support NMEA				
Power consumption(4)	Acquisition		27		mA
	Continuous tracking		28		mA
	Backup current		60		uA

(1) 50% 24hr static, -130dBm
(2) 50% at 30m/s
(3) GPS signal level: -130dBm
(4) Single Power supply 3.6V@-130dBm

1.3 General features

Table 2: General features

Parameters	Value
Supply voltage VCC	3.2V~4.0V

Power consumption(acquisition)	27 mA type. @ VCC=3.6 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

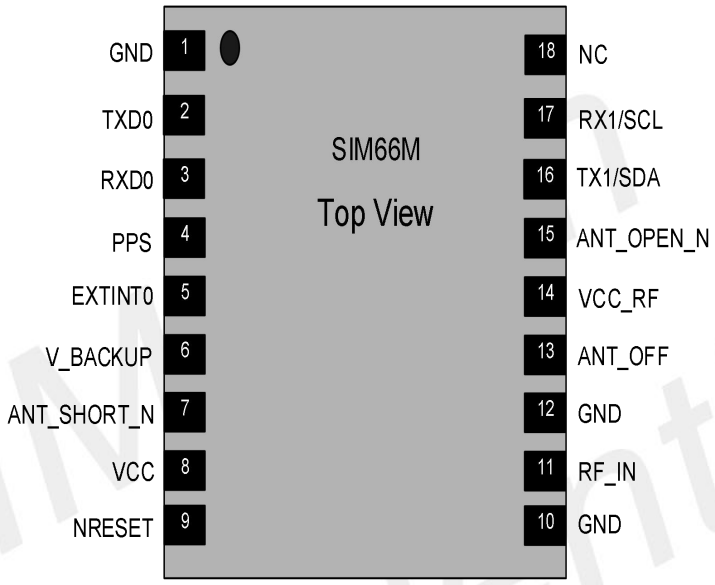


Figure 2: SIM66M pin out diagram (Top view)

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.
VCC_RF	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				
RXD0	3	I	Serial data input for firmware update	
TXD0	2	O	Serial data output of NMEA	
RX1/SCL	17	I	UART1 RX or I2C SCL	If unused, keep open, I2C function is not supported currently.
TX1/SDA	16	O	UART1 TX or I2C SDA	If unused, keep open, I2C function is not supported currently.
GPIOs				
NRESET	9	I	Reset input, active low， default pull-up	If unused, keep open.
EXTINT0	5	I	Interrupt input	If unused, keep open.
PPS	4	O	1PPS output	If unused, keep open.
ANT_OPEN_N	15	I	Antenna detection input	If unused, keep open.
ANT_SHORT_N	7	I	Antenna status detection input	If unused, keep open.
ANT_OFF	13	O	Antenna power supply control output, Output status is related to PIO15 status	If unused, keep open.
RF interface				
RF_IN	11	I	Radio antenna connection	Independence must be controlled to 50Ω.
Other interface				
NC	18		Not Connected	

2.3 Package Dimensions

Following figure shows the Mechanical dimensions of SIM66M (top view, side view and bottom view).

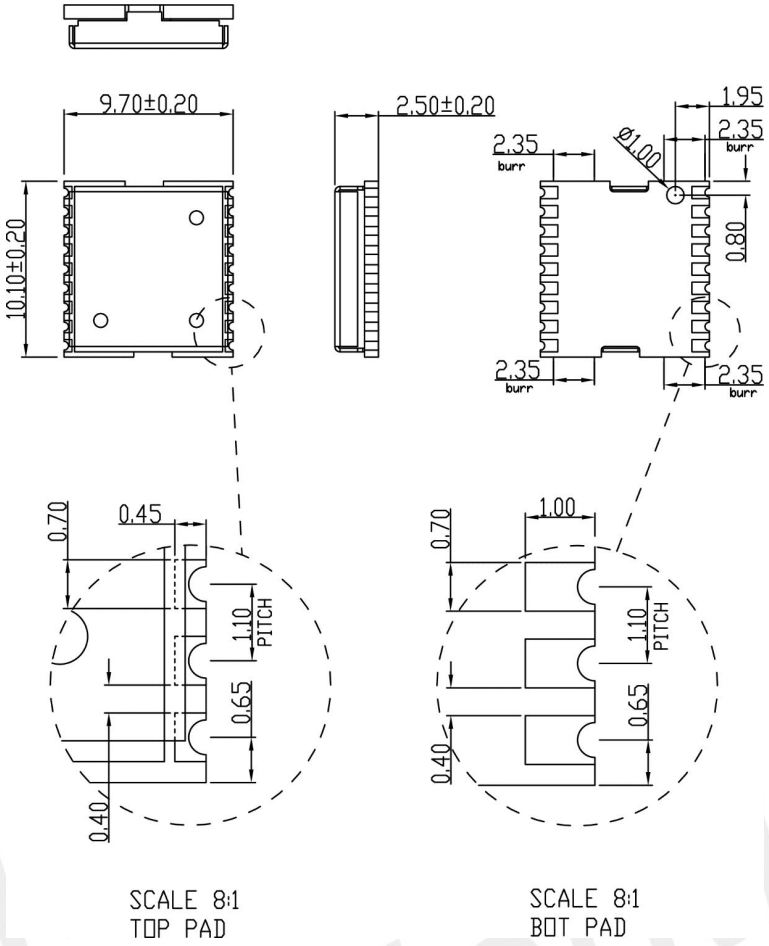


Figure 3: SIM66M mechanical dimensions (Unit: mm)

3 Application Interface

3.1 Power Management

3.1.1 Power Intput

The power supply range of SIM66M is from 3.2V to 4.0V, typical 3.6V. The power supply should be able to provide sufficient current up to 100mA. SIM66M positioning modules require a stable power supply, consider the following points:

1. Wide power lines or even power planes are preferred.
2. 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 .
3. The ripple of the VCC supply cannot be higher than 20mV.
4. VCC supply needs a surge protection.

The power supply range of V_BACKUP is from 1.4V to 3.6V, typical 3.0V, suggest customer keep the V_BACKUP supply active all the time, the module will perform a quick start every time it is power-on.

Table 4: Recommended VCC power supply and surge protection list

No.	Manufacturer	Part number	Package	Remark
1	SGMICRO	SGM2036-ADJYN5G/TR	SOT-23-5	VCC power supply
2	LRC	LEDZ5.1BT1G	SOD-523	surge protection
	Prisemi	PZ5D4V2H	SOD-523	

3.1.2 Starting SIM66M

When power is first applied, SIM66M goes into operation mode.

3.1.3 Verification of SIM66M Start

System activity indication depends upon the chosen serial interface:

- When it is activated, SIM66M will output messages at the selected UART speed and message types.

3.1.4 Operating Mode

SIM66M supports two modes: continuous tracking mode(full on) and backup mode.

Table 5: Power supply and clock state according to operation mode

Mode	VCC	V_BACKUP	Internal LDO	Main clock	RTC clock
Full on	on	on	on	on	on
Backup	off	on	off	off	on

3.1.4.1 Full on Mode

Full on 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.

3.1.4.2 Backup Mode

SIM66M provides very low leakage battery backup memory, which contains all the necessary GPS information for quick start up and a small amount of user configuration variables.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 1.4~3.6V, 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.

3.1.5 VCC_RF

Power supply for active antenna or external LNA, the power domain is VCC

3.2 UART Interface

SIM66M includes one UART interface for NMEA output. The baud rate is 115200 as default.

The following figure shows the connection between module and client.

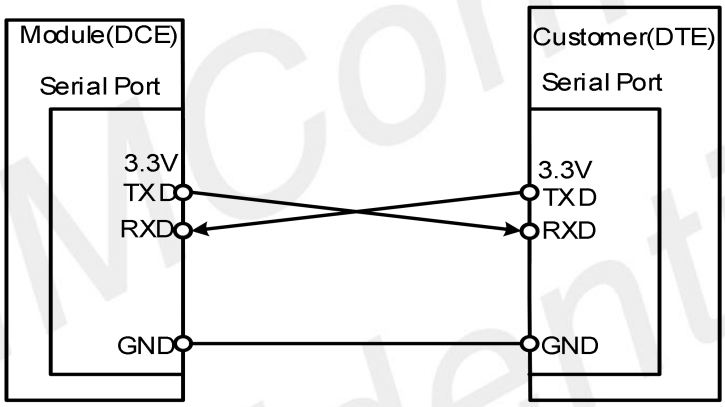


Figure 4: Connection of the serial interfaces

3.3 NRESET Input

The NRESET pin (active low) is used to reset the system, normally external control of NRESET is not necessary. The signal can be left floating, if not used.
When NRESET 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.

3.4 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 +/- 10ns accuracy, support for time service application, which is achieved by the PPS vs NMEA feature.

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

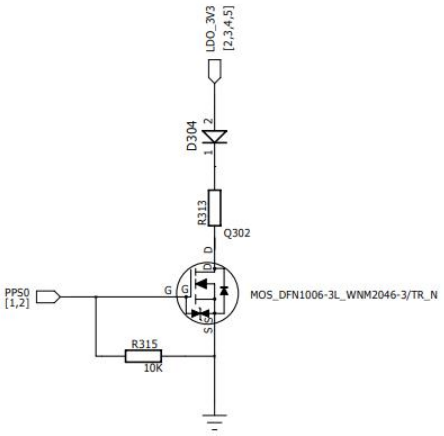


Figure 5: TIMEMARK application circuit

3.5 Antenna

The antenna is a critical item for successful GPS 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 GPS antenna. In a typical application, SIM66M with an active antenna can get a tracking sensitivity about 3dB better than SIM66M with a passive antenna.

It is suggested the active antenna should be chosen as following:

Table 6: Antenna Specifications

Parameter	Specification	
Passive Antenna Recommendations	Frequency range	1575±3MHz
	Polarization	RHCP & Linear
	Gain	> 0dBi
	VSWR	< 2
Active Antenna Recommendations	Frequency range	1575±3MHz
	Polarization	RHCP & Linear
	VSWR	< 2
	Noise Figure	< 1.5dB
	Gain	> -2dBi

3.5.1 Antenna Interface

The SIM66M receives L1 band signals from GPS satellites at a nominal frequency of 1575.42 MHz. The RF signal is connected to the RF_IN pin. And the trace from RF_IN to antenna should be 50Ω controlled.

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.

3.5.2 Antenna Choice and RF Design Consideration

To obtain excellent GPS 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

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 GPS 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 5 shows a minimal setup for a GPS receiver with SIM66M module.

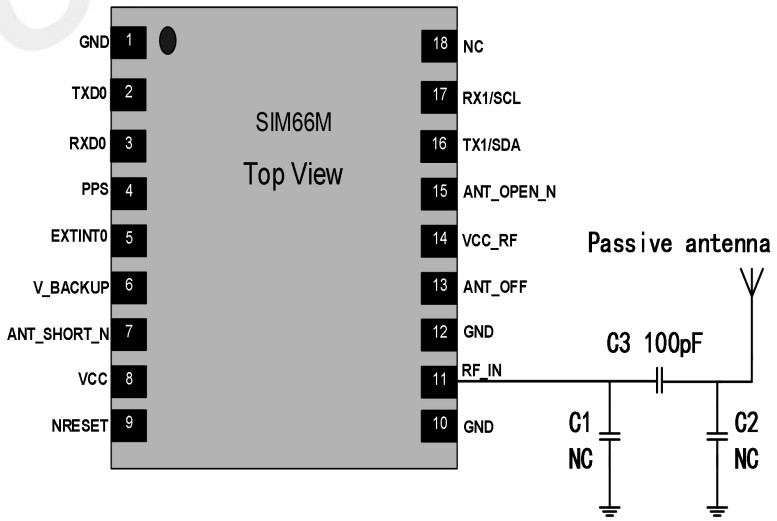


Figure 6: SIM66M passive antenna design

For best performance with passive antenna designs user can use an external LNA to increase the sensitivity up 3~4 dB. Please see Figure 6.

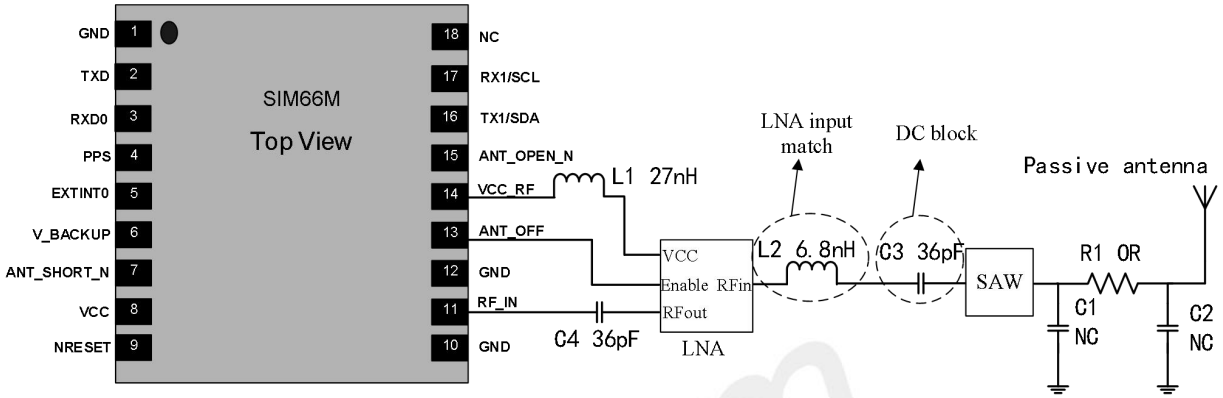


Figure 7: SIM66M passive antenna design (with external LNA and SAW)

Active Antennas

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

Usually Pin 14 VCC_RF is directly used for the active antenna power input, as shown in Figure 7. The voltage range is from 2.8V to 3.6V, typical value is 3.3V, and the max driver current is 50mA. If the VCC_RF 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 VCC_RF 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.

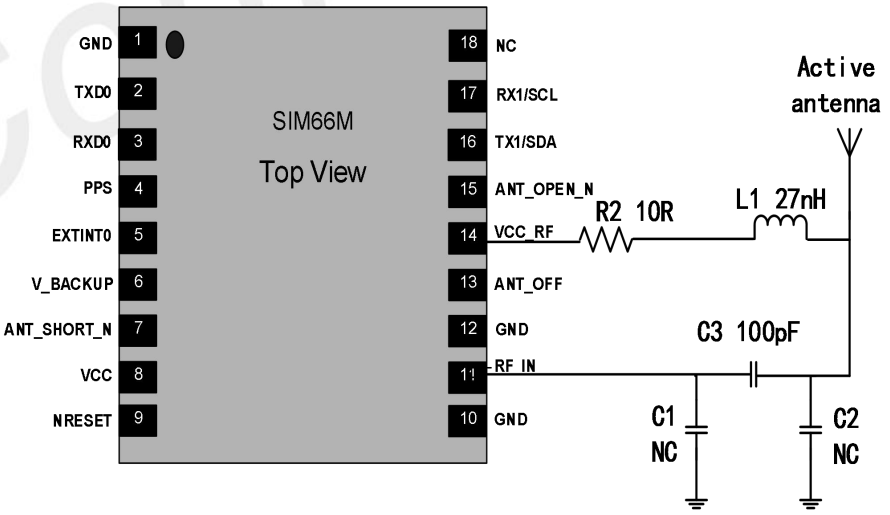


Figure 8: SIM66M Active antenna simplified design

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 GPS 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 SIM66M.

Table 7: Absolute maximum ratings

Parameter	Min	Max	Unit
VCC	-0.2	4.0	V
VCC_RF	-0.2	3.6	V
Input Power at RF_IN	-	-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: SIM66M operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature range		-40	+25	85	℃
Main supply voltage	VCC	3.2	3.6	4.0	V
Backup battery voltage	V_BACKUP	1.4	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 SIM66M 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
VCC_RF	±4KV	±8KV
GND	±4KV	±8KV
RXD0, TXD0	±4KV	±8KV
PPS	±4KV	±8KV
NRESET	±4KV	±8KV
EXTINT0	±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 SIM66M

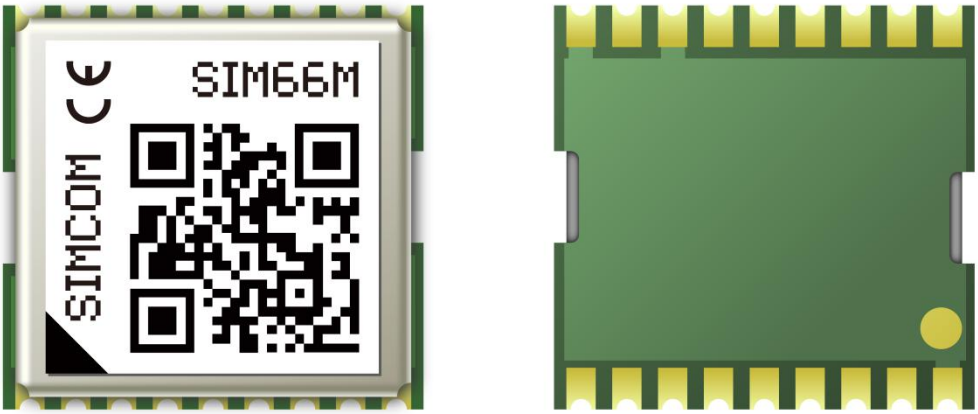


Figure 9: Top and bottom view of SIM66M

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 SIM66M.

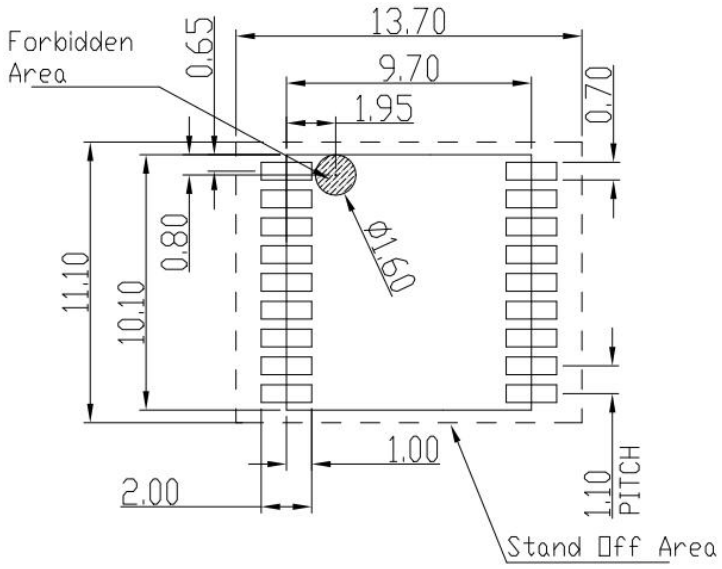


Figure 10: Recommended PCB footprint

5.3 Recommended SMT Stencil

The following figure shows the SMT stencil of SIM66M.

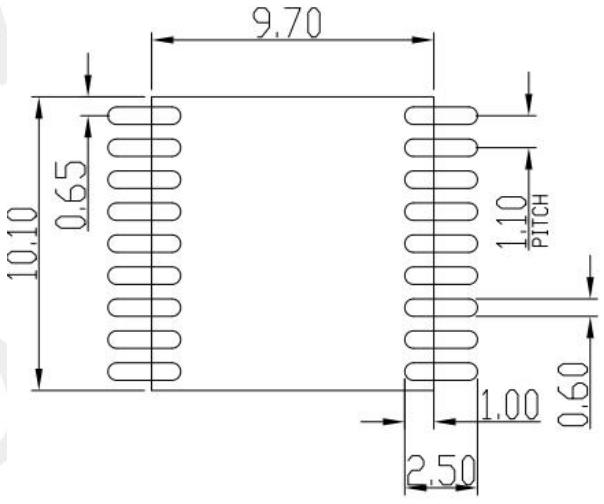


Figure 11: Recommended SMT stencil

5.4 Assembly and Soldering

The SIM66M 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 SIM66M:

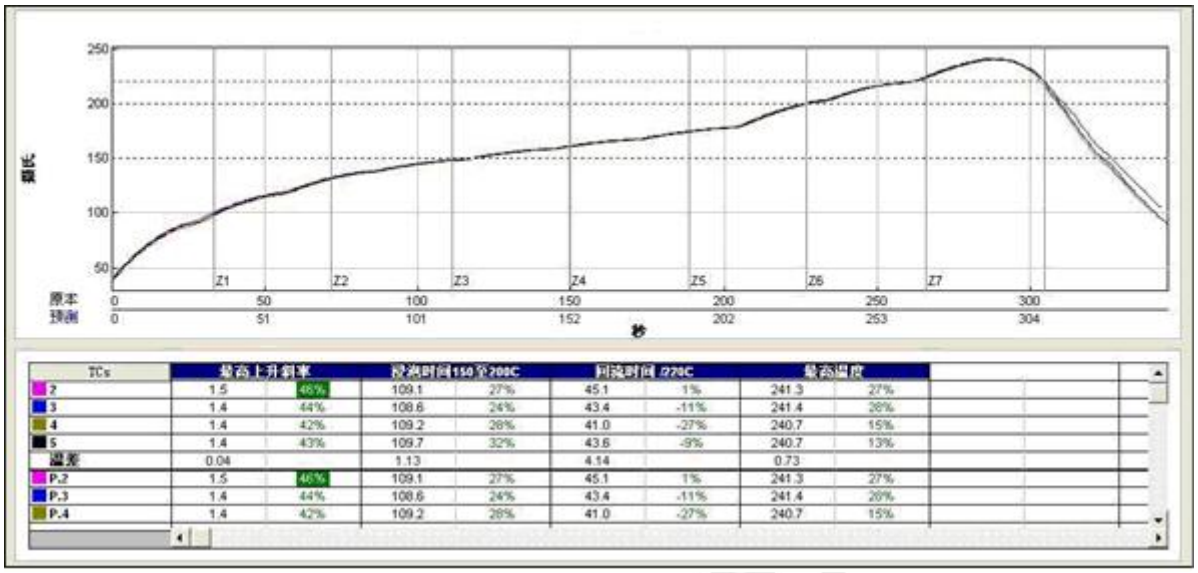


Figure 12: The Ramp-Soak-Spike reflow profile of SIM66M

SIM66M is Moisture Sensitive Devices (MSD), appropriate MSD handling instruction and precautions are summarized in Chapter 5.3.

SIM66M modules are also Electrostatic Sensitive Devices (ESD), handling SIM66M 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

SIM66M 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, SIM66M 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

SIM66M 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

SIM66M is designed and packaged to be processed in an automatic assembly line, and it is now packaged tray and reel.

6 Package

SIM66M module support tray packaging.

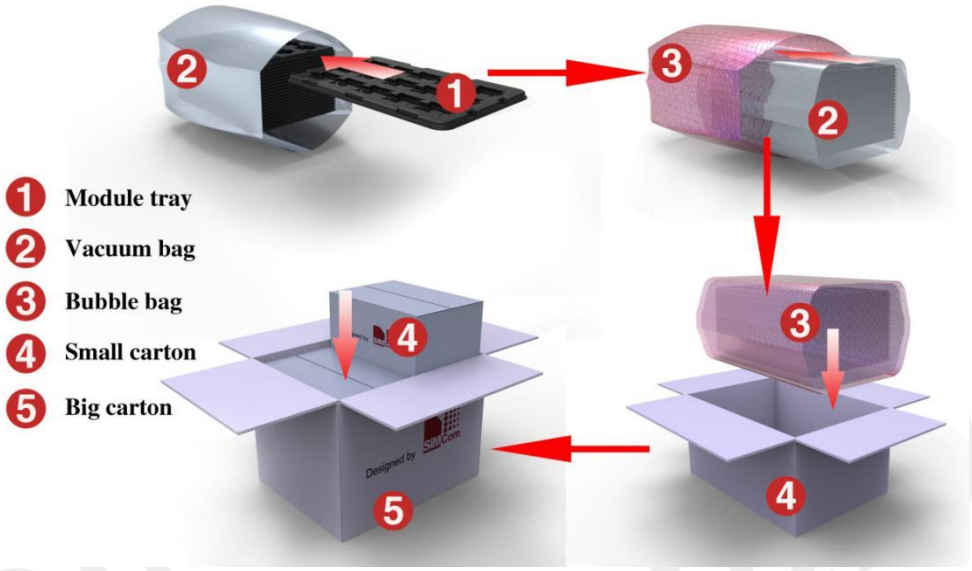


Figure 13: packaging diagram

Module tray drawing：

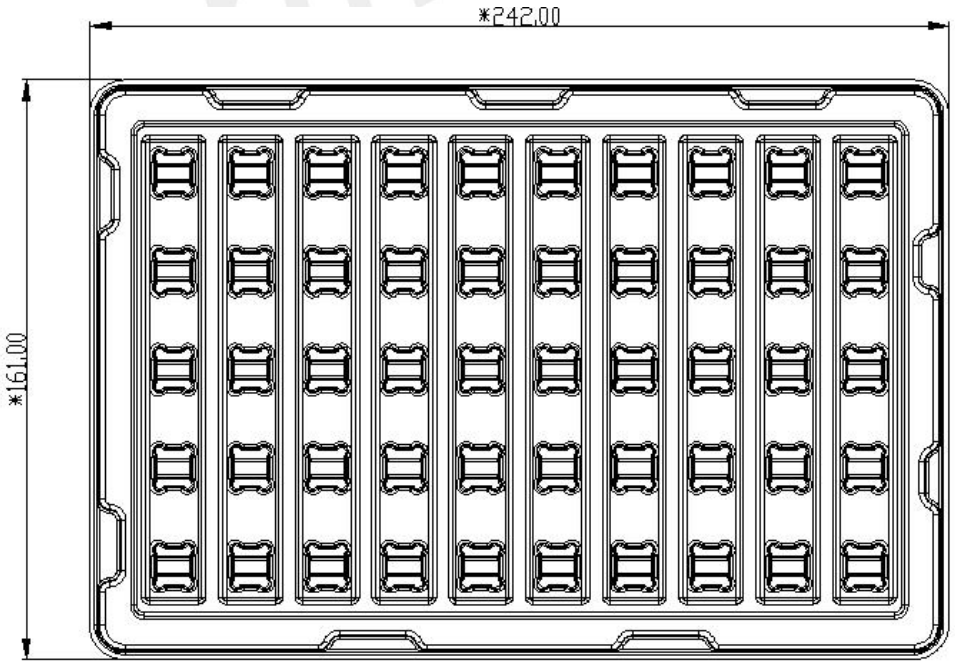


Figure 14: Tray drawing

Table 11: Tray size

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

Small carton drawing：

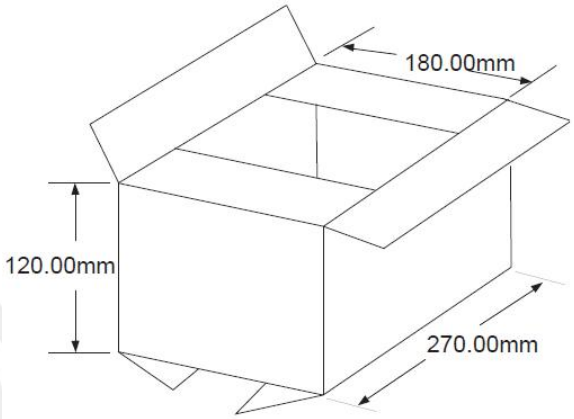
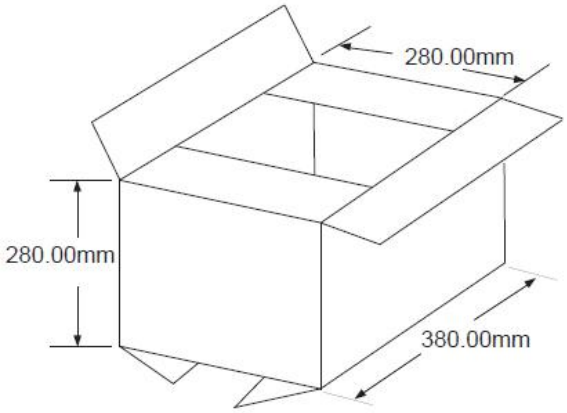


Figure 15: Small carton drawing

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

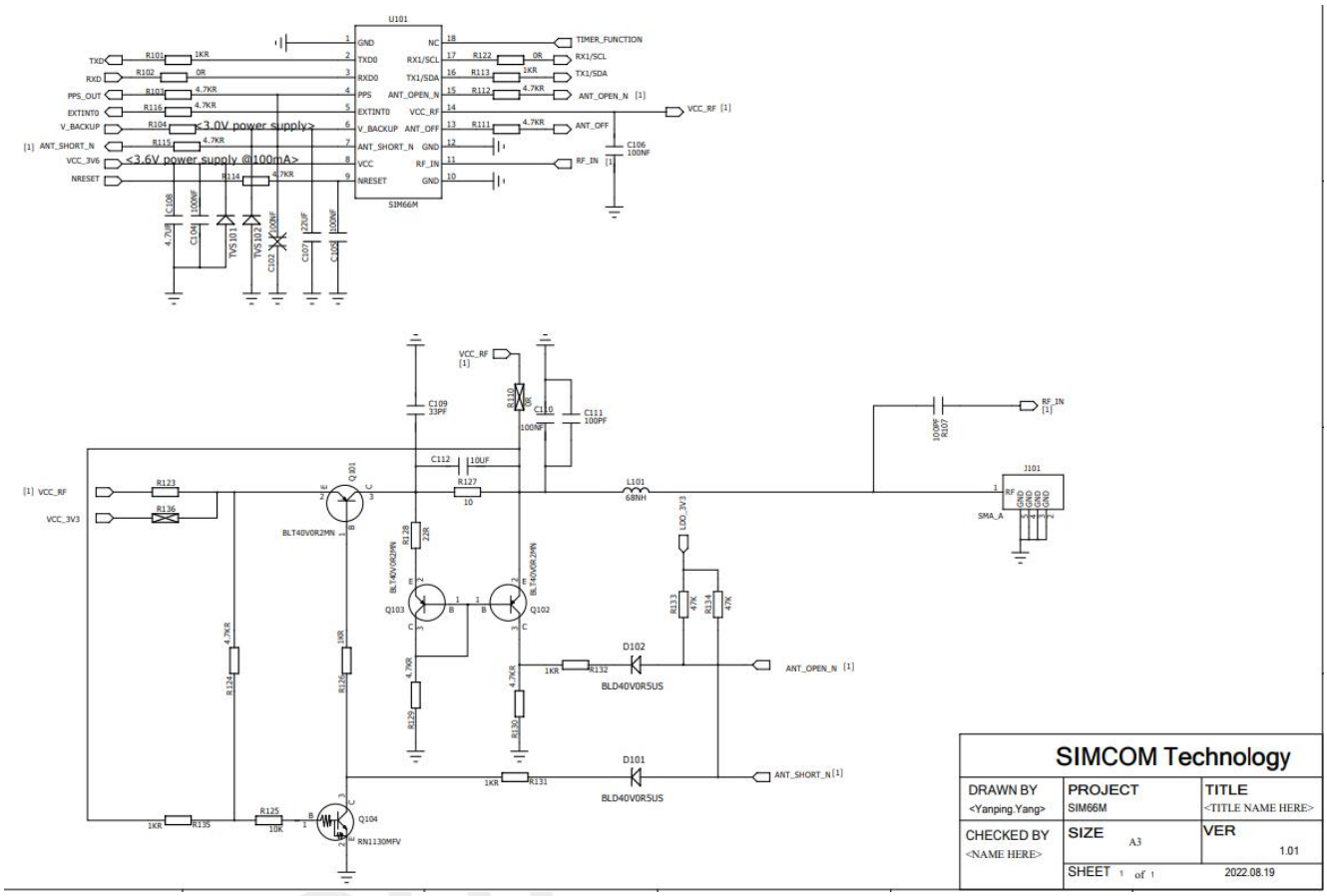


Figure 17: Application schematics

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.