# SIM65M-C
# Hardware Design

**GNSS Module**

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# Version History

| Date | Version | Description of change | Author |
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# 1  Introduction

This document describes the hardware interface of the SIMCom module SIM65M-C.

This document can help you quickly understand the interface specifications, as well as electrical and mechanical details of GNSS module. We also offer you other documents such as SIM65M-C protocol specification and user guider. These documents ensure you can use SIM65M-C module to design and set up mobile applications quickly.

## 1.1  Documentation Overview

Technical information for the module is primarily covered by the documents listed in Table 1. All documents must be studied for a thorough understanding of the device and its applications.

Table 1: Documentation Overview

| SN | Document Name | Remark |
|---|---|---|
| [1] | SIM65M-C_Hardware_Design(this document) | It mainly introduces hardware components such as interface functions, recommended circuits, PCB layout guides, packaging, and software instructions |
| [2] | SIM65M-EVB_User_Guide | Introduction to how to use the SIM65M with EVB |
| [3] | SIM65M_EVB SCH&PCB | SIM65M-EVB schematic and PCB PDF document |
| [4] | MOD_SIM65M_18 SCH&PCB | SIM65M module reference package |
| [5] | SIM65M-C Series_NMEA Message_User Guide | The SIM65M-C series software instruction pole usage method is introduced in detail |
| [6] | Module Secondary SMT Process User Guide | This paper mainly introduces the SMT process of module production, the requirements of steel mesh production, reflow welding, welding and repair |

## 1.2 Overview

SIM65M-C is a single-band, multi-satellite system small package GNSS positioning module with independent GPS (support A-GPS)/GLONASS/BEIDOU/Galileo receiver, built-in LNA, no need for external LNA. The SIM65M-C supports a wide range of positioning and navigation applications, including GPS, GLONASS, BeiDou, Galileo, QZSS, and A-GPS.

## 1.3 Key Features

The SIM65M-C module provides customers with different power supply ranges with different options, and can be adapted to a variety of customer application circuits. The SIM65M-C power supply range is 1.7V to 3.6V, and the modules communicate with the HOST through the UART interface.

SIM65M-C supports the following GNSS satellites:

● GPS, BEIDOU, GLONASS, Galileo also supports QZSS , SBAS.

Besides, module provides the following services:

● Small footprint: 10.1x 9.7 x 2.5mm, 18-pin LCC package
● Support Jamming Removing (AIC)
● Low-noise amplifier has been integrated (LNA)
● Support AGNSS assisted positioning
● Fixed update rate 1Hz to 5Hz[1]
● Pulse-per-second (PPS) GPS time reference
　1．Adjustable duty cycle
　2.Typical accuracy: +/- 20ns
● Interface: UART * 1
● Operating temperature: -40 ~ +85ºC

**NOTE**

Default is 1 HZ.

## 1.4  SIM65M-C Functional Diagram

The following figure shows a functional diagram of the SIM65M-C and illustrates the mainly functional parts:

- The main chip
- SAW filter
- Integrated LNA
- The antenna interface
- The communication interface
- The control signals
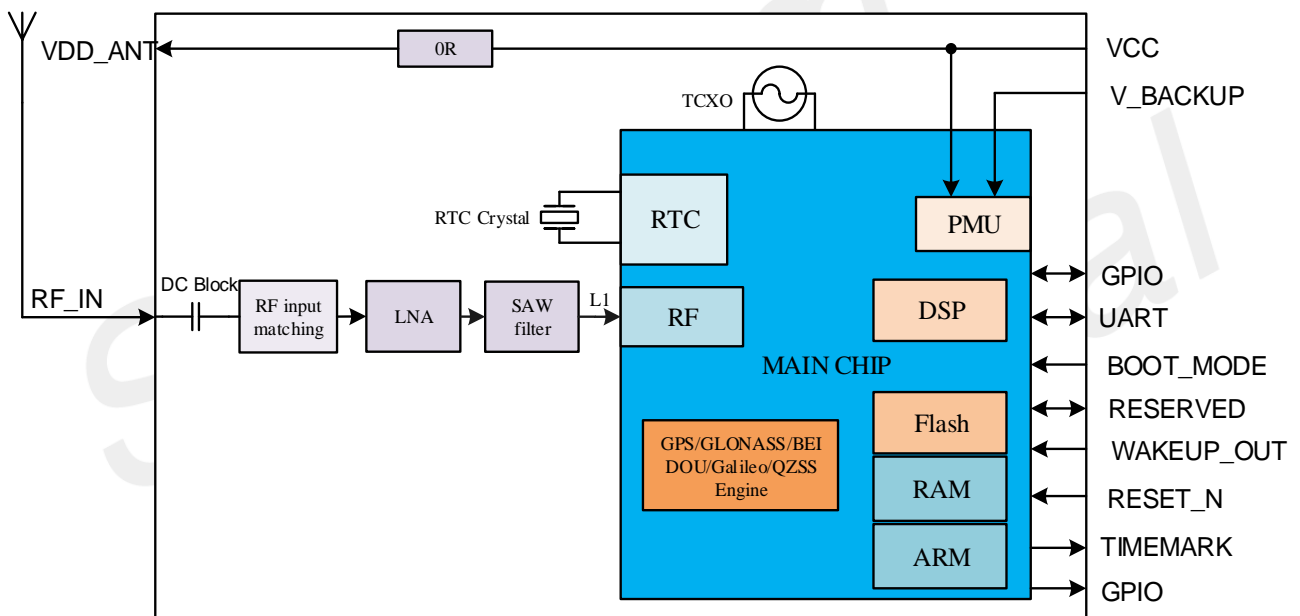


Figure 1: SIM65M-C functional diagram

## 1.5  GNSS Performance

Table 2: GNSS Performance

| Parameter | Description | Performance | | | |
|---|---|---|---|---|---|
| | | **Min** | **Type** | **Max** | **Unit** |
| Horizontal Position Accuracy[1] | Automatic position | | | 2 | m |
| Velocity Accuracy[2] | | | 0.1 | | m/s |
| Timing Accuracy | | | 20 | | ns |
| Dynamic Performance | Maximum Altitude | | | 18000 | m |
| | Maximum Velocity | | | 500 | m/s |
| | Maximum Acceleration | | | 4 | G |
| TTFF(without AGPS)[3] | Hot start | | 1 | | s |
| | Cold start | | 20 | | s |
| A-GPS TTFF | Cold start | | 3.5 | | s |
| Sensitivity (GPS+BD+GLO+GAL) | Autonomous acquisition(cold start) | | -149 | | dBm |
| | Re-acquisition | | -159 | | dBm |
| | Tracking | | -165 | | dBm |
| Receiver | Channels | | L1:64 | | |
| | Update rate | | 1 | 5 | Hz |
| | Tracking L1, CA Code | | | | |
| | Protocol support | NMEA-0183, ICOE Protocol | | | |

**NOTE**

1. In all-satellite mode, CEP50 24hr static, -130dBm;
2. 50% at 30m/s;
3. GNSS signal level: -130dBm.

## 1.6 General features

Table 3: General features

| Parameters | Value |
|---|---|
| Supply voltage VCC | +1.7V~+3.6V typical:3.3V |
| Supply voltage ripple VCC | 54 mV(RMS) max @ f = 0~3MHz<br>15 mV(RMS) max @ f > 3 MHz |
| Storage temperature | -45ºC~+95ºC |
| Operating temperature | -40ºC~+85ºC |
| Host port | UART0 |
| Serial port protocol (UART) | NMEA; 8 bits, no parity, 1 stop bit; 115200 baud (configurable) |
| TM output (1PPS) | 3D-FIXED 1 pulse per second, synchronized at rising edge, The rising edge of the pulse is aligned with UTC seconds, with an accuracy of about 20ns pulse length 100ms |

Table 4: IO features

| Pin voltage domain | Parameter | Description | Min | Typ | Max |
|---|---|---|---|---|---|
| I/O Signal Level (V) | $V_{IL}$ | Active low-level input | 0 V | - | 0.3 V |
| | $V_{IH}$ | Active high-level input | 1.53V<br>3.0V | 1.8V<br>3.3V | VCC |
| | $V_{OL}$ | Low-level output range | 0 | - | 0.4 V |
| | $V_{OH}$ | High-level output range | 1.53 V<br>3.0V | 1.8V<br>3.3V | VCC |

## 1.7 Power consumption

Table 5: Consumption data (typical value)

| Parameter | Description | GPS | GPS+BD | GPS+BD +GLO | GPS+GLO+ GAL+BDS |
|---|---|---|---|---|---|
| Acquisition | @VCC=3.3V | 38 mA | 43 mA | 43 mA | 47 mA |
| Tracking | | 29 mA | 31 mA | 31 mA | 33 mA |
| IDLE | | 10 mA | | | |
| Hardware RTC | @V_BACKUP=3.3V | 21 uA | | | |

## 1.8 GNSS operating frequency

The SIM65M-C is a single-band, multi-galaxy GNSS positioning module that can receive and track multi-galaxy GNSS signals. The GNSS operating frequencies are shown in the following table:

Table 6: GNSS Operating frequencies

| Type | Frequecy (MHz) |
|------|----------------|
| GPS   L1C/A | 1575.42±1.023 |
| GPS   L1C* | 1575.42±12.276 |
| QZSS L1C/A | 1575.42 |
| GLONASS G1 | 1601.7±6.75 |
| Galileo E1B/C | 1575.42±1.023 |
| BeiDou B1I | 1561.098±2.046 |
| BeiDou B1C* | 1575.42±16.368 |

**NOTE**

"*" indicates that the development is under development, if you have such requirements, please contact SIMCom.

## 1.9 A-GPS

A-GPS is the meaning of Assisted GPS, which is a system that can under certain conditions improve the startup performance, or time-to-first-fix (TTFF) of a GPS satellite-based positioning system. SIM65M-C module supports SBAS and RTCM output.

### 1.9.1 SBAS

SBAS is the abbreviation of Satellite Based Augmentation System. The SBAS concept is based on the transmission of differential corrections and integrity messages for navigation satellites that are within sight of a network of reference stations deployed across an entire continent. SBAS messages are broadcast via geostationary satellites able to cover vast areas.

Several countries have implemented their own satellite-based augmentation system. Europe has the European Geostationary Navigation Overlay Service (EGNOS) which covers Western Europe and beyond. The USA has its Wide Area Augmentation System (WAAS). Japan is covered by its Multi-functional

Satellite Augmentation System (MSAS). India has launched its own SBAS program named GPS and GEO Augmented Navigation (GAGAN) to cover the Indian subcontinent.

### 1.9.2   RTCM

The module only supports software RTCM output and is not enabled by default. Customers who want to apply RTCM in the design can contact SIMCom for supporting.

## 1.10   AIC

The module supports multi-tone AIC (Multi-tone AIC, Active Interference Cancellation) function, which can effectively suppress or eliminate RF noise harmonics such as Wi-Fi, Bluetooth, and 2/3/4/5G.

**NOTE**

AIC is enabled by default, users can use the command to control the switch, please refer to "SIM65M-C Series_NMEA Message_User Guide " for more information.

## 1.11   Firmware update

The module is shipped with firmware pre-installed. SIMCom may release firmware versions that contain bug fixes or performance optimizations, so it is important to implement a firmware upgrade mechanism in the client's system. A firmware upgrade is the process of transferring a binary image file to a receiver and storing it in flash. For details on firmware upgrades, refer to the firmware upgrade manual.

# 2  Package Information

## 2.1  Pin out Diagram
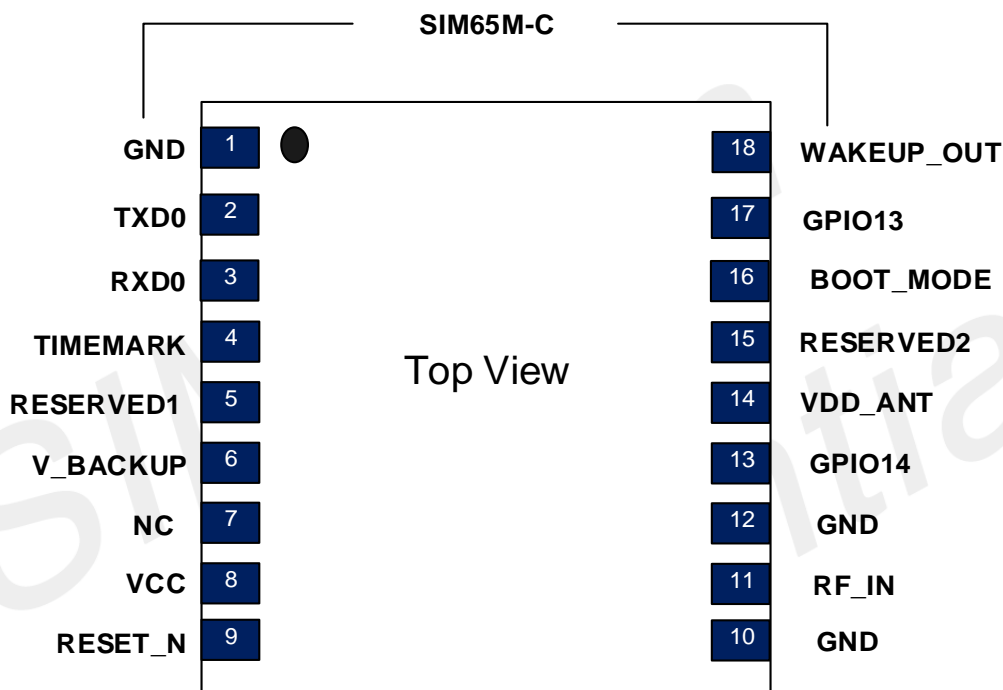


Figure 2: SIM65M-C pin diagram (Top view)

## 2.2  Pin Description

Table 7: I/O parameter definition

| Type | Description |
|------|-------------|
| AI | Analog Input |
| AO | Analog Output |
| DI | Digital Input |
| DO | Digital Output |
| DIO | Digital Input/Output |
| PI | Power Input |
| PO | Power Output |
| OD | Open-drain |

Table 8: Pin description

| Pin name | Pin number | I/O | Description | Comment |
|----------|-----------|-----|-------------|---------|
| **Power supply** | | | | |
| VCC | 8 | PI | Main power input, which will be used to power the baseband and RF section internally. Input voltage range: SIM65M-C: 1.7~3.6V, Typ: 3.3V The supply current requirement can reach 200mA. | Provide clean and stable power source to this pin. Add a 4.7uF capacitor to this pin for decoupling. |
| VDD_ANT | 14 | PO | Internal power output to power the active antenna The output is typically VCC±0.1V | If unused, keep open. It is necessary to ensure that the active antenna used is powered within this range, otherwise it is recommended to additionally supply power to the active antenna |
| V_BACKUP | 6 | PI | The backup battery input power supply for RTC The input voltage range is 1.70V~3.60V, the typical value is 3.3V | Must be connected. |
| GND | 1,10,12 | - | Ground | GND |
| **Communication interface** | | | | |
| TXD0 | 2 | DO | NMEA serial output/ input | Voltage domain is VCC If unused, keep open. |
| RXD0 | 3 | DI | | |
| **System control** | | | | |
| RESET_N | 9 | DI | Input pin, which is pulled below 0.4V and held for at least 100ms before being released, can reset the module | Internal default pulls 3.3V |
| **GPIOs** | | | | |
| WAKEUP_OUT | 18 | DO | GNSS chip wakeup host | Voltage domain is VCC High active If unused, keep open. |
| TIMEMARK | 4 | DO | Timemark outputs timing pulse related to receiver time | After successful positioning, the default output is 1Hz pulse. |

| | | | | Voltage domain is VCC If unused, keep open. |
|---|---|---|---|---|
| GPIO13 | 17 | DIO | General purpose input/output | Voltage domain is VCC If unused, keep open. |
| GPIO14 | 13 | DIO | General purpose input/output | Voltage domain is VCC If unused, keep open. |
| BOOT_MODE | 16 | DI | Boot mode control | Default high . Keep floating. |
| RESERVED | 5, 15 | - | Reserved pins, default high | Keep floating. |
| NC | 7 | - | - | Keep floating. |
| **RF interface** | | | | |
| RF_IN | 11 | AI | Radio antenna connection | Impendence must be controlled to 50Ω. |

## 2.3  Machine Dimensions

Following figure shows the Mechanical dimensions of SIM65M-C (top view, side view and bottom view).
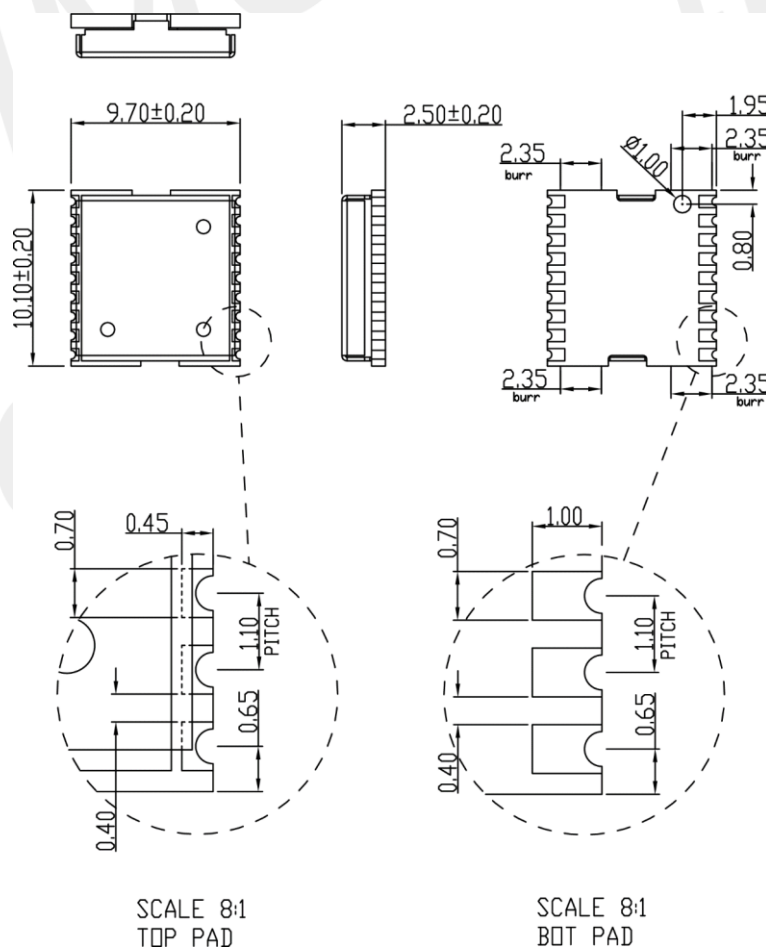


Figure 3: SIM65M-C mechanical dimensions (Unit: mm)

**NOTE**

Outline dimensional tolerances do not include burr areas.

# 3 Application Interface

## 3.1 Power Management

### 3.1.1 Power Input

① VCC supply requirements

VCC is the power supply pin of the module, SIM65M-C power supply range: 1.7V~3.6V, typical value: 3.3V. The power supply should be able to provide sufficient current up to 200mA. SIM65M-C 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 15mV.
● VCC supply needs a ESD and surge protection.
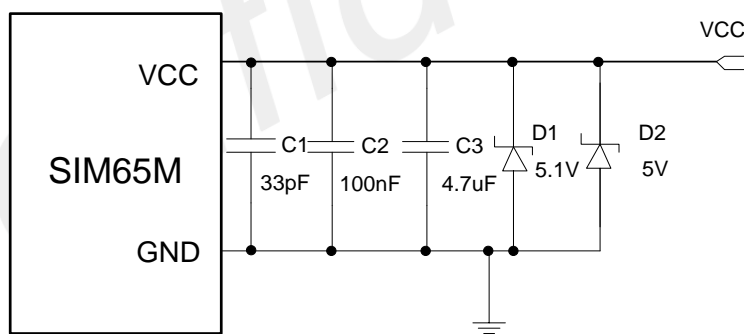
Figure 4: Power supply reference circuit

**NOTE**

D2 is used for ESD protection and D1 is used for surge protection.

Table 9: Recommended D1 and D2 list

| No. | Manufacturer | Part number | VRWM | Package | Ref. Designator |
|-----|-------------|-------------|------|---------|-----------------|
| 1 | JCET | ESDBW5V0A1 | 5V | DFN1006-2L | D2 |
| 2 | WAYON | WS05DPF-B | 5V | DFN1006-2L | |
| 3 | LRC | LEDZ5.1BT1G | 5.1V | SOD-523 | D1 |
| 4 | Prisemi | PZ5D4V2H | 5.1V | SOD-523 | |

② Backup supply (V_BACKUP)

The V_BACKUP pin is backup power, and the power supply range is 1.7V~3.6V. By using valid time and GNSS track data at start-up, the module enables hot (warm) start-up. When the module is turned on, the V_BACKUP should be connected to the power supply and maintain the power supply all the time; If RTC entry is required, power is maintained V_BACKUP VCC is maintained after sending a command to enter RTC mode[1].
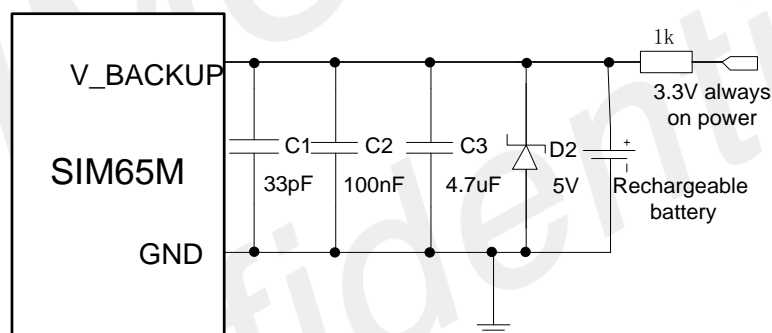


Figure 5: V_BACKUP input reference circuit

**NOTE**

1. The V_BACKUP voltage must not be lower than the minimum recommended operating voltage, otherwise the module may operate abnormally.
2. If a battery is connected, it is recommended to use a rechargeable battery, and please select the current limiting resistor according to the charging current requirements of the rechargeable battery

### 3.1.2  Power on

When power is first applied, SIM65M-C goes into operation mode. VCC should power up quickly within

50ms, and to ensure proper power-up sequencing, backup power should be started no later than VCC, so V_BACKUP must be powered up before or at the same time as VCC. The module power-up and disconnection timing diagram is shown in Figure 6.

### 3.1.3 Power off

When the power supply of the module VCC is disconnected, the voltage should be guaranteed to drop rapidly within 50ms. In order to ensure that the power-on sequence is abnormal when the module is powered on next time it is powered on and restarted, ensure that the module VCC is powered down to less than 1V and maintained for at least 5s, and then perform power-on restart.
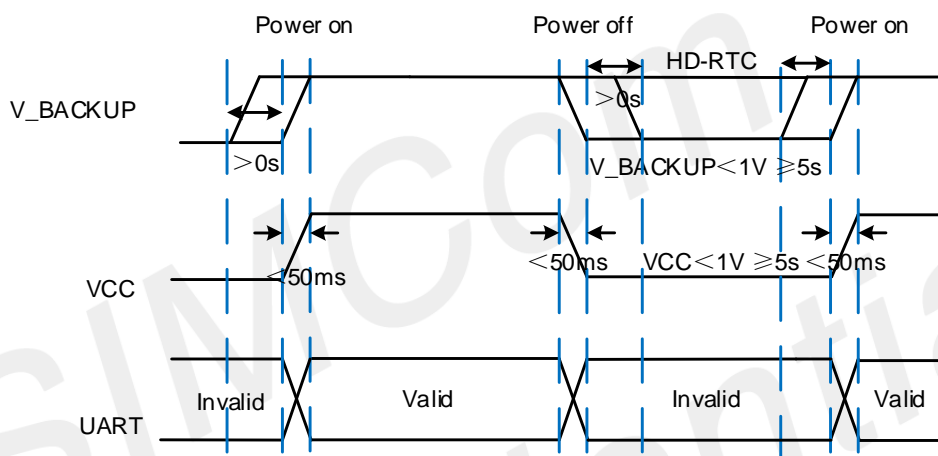


Figure 6: Timing sequence of module power-on and power-off

### 3.1.4 Verification of SIM65M-C Start

System activity indication depends upon the chosen serial interface:
When it is activated, SIM65M-C will output messages at the selected UART speed, and message types.
The default baud rate is 115200bps.

### 3.1.5 Power Saving Modes

SIM65M-C supports power saving modes for reducing average power consumption like IDLE mode, RTC mode.

● Idle mode**:** In this mode, the module enters standby mode, retaining some peripherals. The host can wake up the module by sending a wake-up command.
● RTC mode**:** The host side sends instructions through the communication interface and enters the software RTC mode.

> **NOTE**
>
> The modes mentioned above are operated by commands, users can refer to "SIM65M-C Series_NMEA Message_User Guide" for more information.

## 3.2  Operating Mode

Table 10: Power supply and clock state according to operation mode

| Mode | VCC | V_BACKUP | Internal LDO | NMEA | Power consumption |
|------|-----|----------|--------------|------|-------------------|
| Full mode | on | on | on | on | High |
| Idle mode | on | on | on | off | low |
| RTC mode | off | on | off | off | lowest |

### 3.2.1  Full on Mode

The module will enter full on mode after first power up with factory configuration settings. Power consumption will vary depending on the amount of satellite acquisitions and number of satellites in track. This mode is also referenced as full on, full power or navigation mode.

First positioning (different CN value, different positioning time), can download complete ephemeris data 15 minutes after positioning.

Navigation is available and any configuration settings are valid as long as the VCC power supply is active. When the power supply is off, settings are reset to factory configuration and receiver performs a cold start on next power up.

### 3.2.2  Idle Mode

Idle mode means that the power supply is in the low active state and RTC and backup RAM are enabled. Inside the module, such as the baseband digital circuit part and the RF part, go to the standby. The power management chip switches to low-power mode, where the power input VCC and V_BACKUP should always remain powered. Commands can be sent through the UART interface to control the module to enter/exit idle mode.

● Entering into Idle mode:
Send the command $RESET,3,0, the module returns $OK*04, and then enter Idle mode.

● Exiting sleep mode:

Send the command $RESET,0,0, the module returns $OK*04, and then exits Idle mode

### 3.2.3　RTC mode

The module provides lower power consumption than Idle mode and is suitable for applications that are idle for long periods of time or where power consumption is sensitive. In RTC mode, the module stops capturing and tracking satellite signals, and only the backup domain remains active, continuing to record time.

● Enter hardware RTC mode

1. Disconnect the VCC separately and keep the V_BACKUP powered.

● Exit hardware RTC Mode

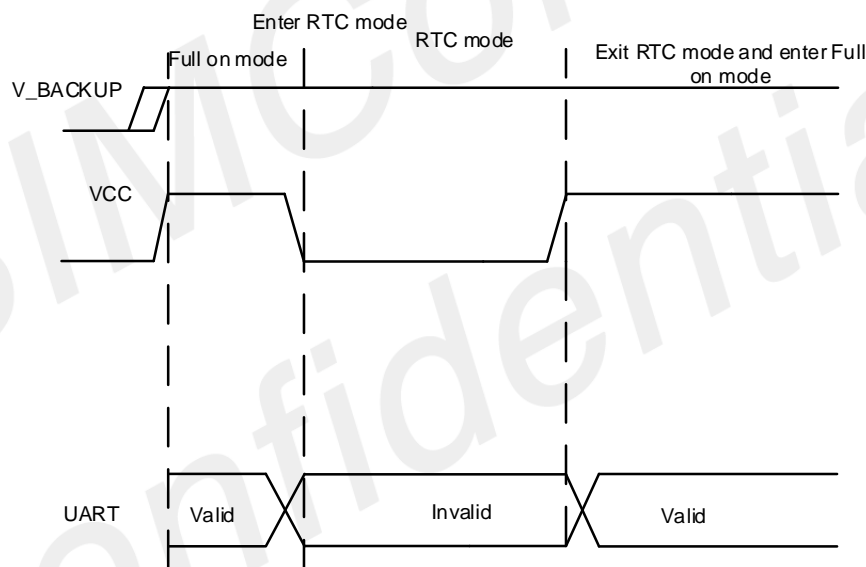1. Reconnect the VCC and module will exit RTC mode automaticly.

Figure 7: Enter and Exit RTC Mode

## 3.3　VDD_ANT

VDD_ANT is a power output pin for powering an active antenna, the output voltage domain is VCC. For the detail usage of VDD_ANT, customer can refer to section 9 for details.

> **NOTE**
>
> VDD_ANT must be connected in series with a current limiting resistor of 10 ohm.

## 3.4 WAKEUP_OUT Signal

The WAKEUP_OUT pin of the SIM65M-C can be used to wake up the host and GNSS interrupt to wake up the master. The output level is low before positioning, and it will be automatically pulled up after positioning, waking up the main control to receive data (no command response).
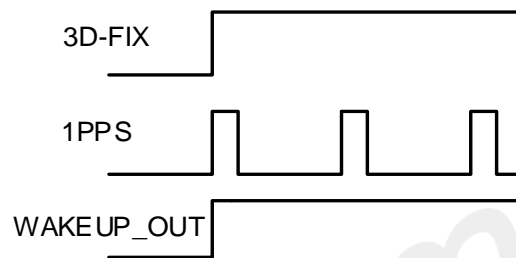
Figure 8: Wakeup host

## 3.5 UART Interface

The SIM65M-C module provides a UART interface, and the default function configuration is as follows.
● Serial communication
● NMEA output
● Command input.
● Firmware upgrade.

Table 11: Host port function pins

| Pin name | Pin number | I/O | Description | Comment |
|----------|-----------|-----|-------------|---------|
| TXD0 | 2 | DO | Serial data output of NMEA | The voltage domain is VCC |
| RXD0 | 3 | DI | Serial data input for firmware update | |

> **NOTE**
>
> 1. The default baud rate is 115200, if other baud rate required please contact SIMCom.
> 2. If the IO voltage of the MCU does not match the module, a level shifting circuit must be added.

The following figure shows the connection between module and client (DTE).
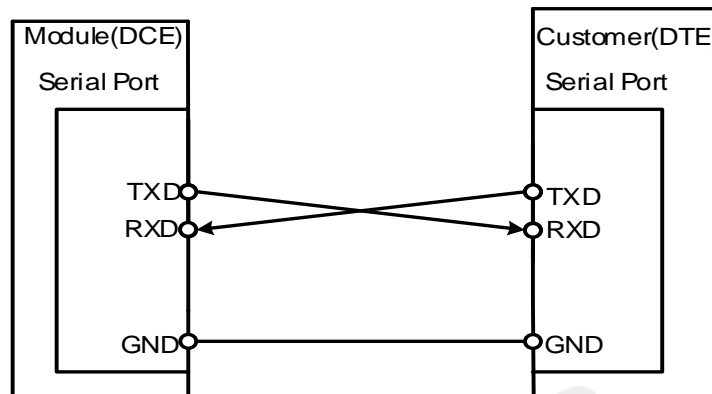


Figure 9: Connection of the serial interfaces

## 3.6 Timemark Output

The Timemark pin outputs pulse-per-second (PPS) pulse signal for precise timing purposes after the position has been fixed. The Timemark 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 +/- 20ns accuracy, support for time service application, which is achieved by the PPS vs NMEA feature.

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



Figure 10: TIMEMARK application circuit

## 3.7 RESET_N

Input enable pin, pull this pin low for 100ms and then release it, which can reset the module and can be used to exit software RTC mode. This pin has been pulled up 10k resistors to VCC inside the module, eliminating the need to add pull-up resistors outside the module. The recommended circuit is as follows:



Figure 11: RESET recommended circuit

# 4  Antenna

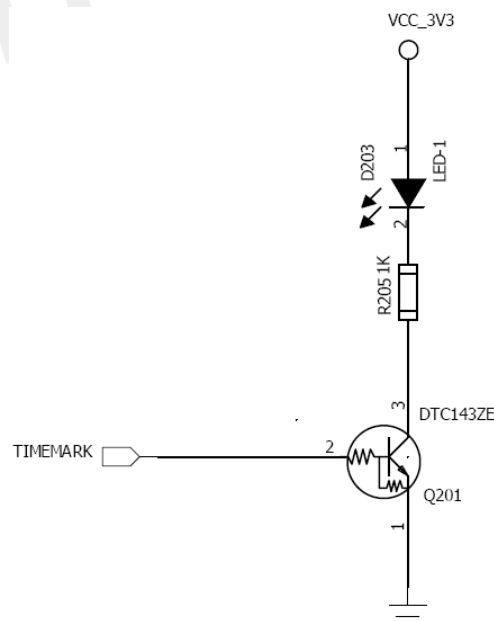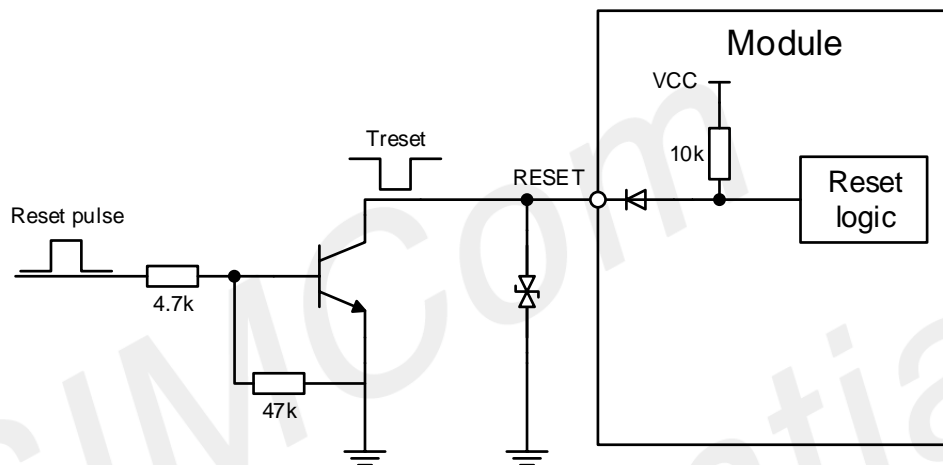The antenna is the most critical item for successful GPS/GLONASS/BEIDOU/Galileo reception in a weak signal environment. Proper choice and placement of the antenna will ensure that satellites at all elevations can be seen, and therefore, accurate fix measurements are obtained.

It is recommended to use an active GPS/GLONASS/BEIDOU/Galileo antenna. In a typical application, SIM65M-C with an active antenna can get a tracking sensitivity about 3dB better than SIM65M-C with a passive antenna.

## 4.1  Antenna Interface

The SIM65M-C receives L1 band signals from GPS/GLONASS/BEIDOU/Galileo 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.

## 4.2 Antenna Choice Consideration

To obtain excellent GNSS reception performance, a good antenna will always be required. Proper choice and placement of the antenna will ensure that satellites at all elevations can be seen, and therefore, accurate fix measurements are obtained.

The total noise figure should be well below 3 dB.

If a patch antenna is the preferred antenna, choose a patch of at least 15x15x4 mm for standalone. GPS/QZSS, or choose a patch of at least 25x25x4 mm for GPS + GLONASS. For smaller antennas, an LNA with a noise figure <2 dB is recommended.

- Make sure the antenna is not located close to noisy parts of the circuitry (e.g. micro-controller or High Power or display).
- To optimize performance in environments with out-of-band jamming sources, use an additional SAW filter.

- The micro strip must be 50 Ω and be routed in a section of the PCB where minimal interference from noise sources can be expected.
- In case of a multi-layer PCB, use the thickness of the dielectric between the signal and the first GND layer (typically the 2nd layer) for the micro strip calculation.
- If the distance between the micro strip and the adjacent GND area (on the same layer) does not exceed 5 times the track width of the micro strip.
- Use an external LNA if your design does not include an active antenna when optimal performance is important.

The suggested active antenna should be chosen as following:

Table 12: Antenna Specifications

| Parameter | Specification | Passive and active antenna |
|---|---|---|
| Active Antenna Recommendations | Frequency range L1 | 1560～1609MHz |
| | Polarization | RHCP |
| | Gain | >25dB |
| | Noise Figure | <1.5 dB |

### 4.2.1  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/GLONASS/BEIDOU/Galileo application is the patch antenna. Patch antennas are flat, generally have a ceramic and metal body and are mounted on a metal base plate.

Figure 12 shows a minimal setup for a GPS/GLONASS/BEIDOU receiver with SIM65M-C module.
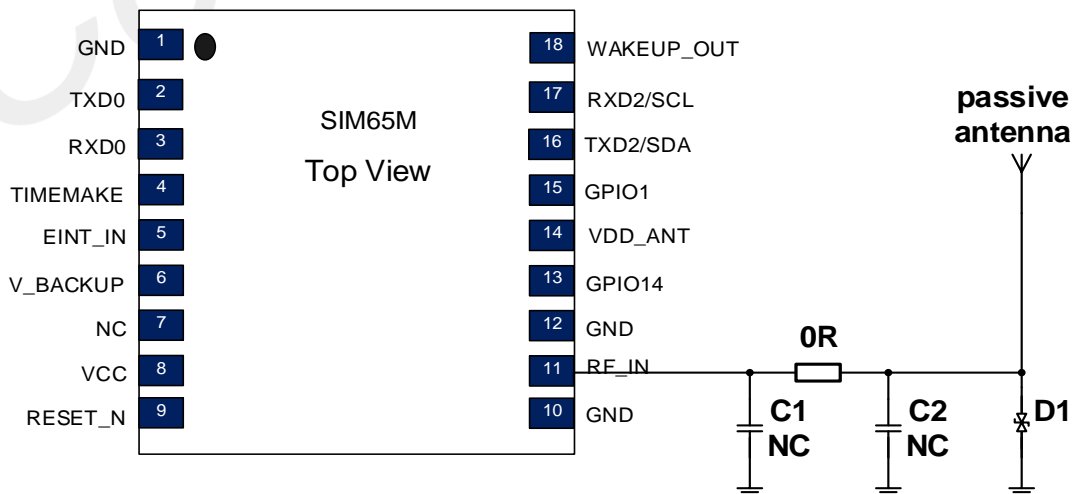


Figure 12: SIM65M-C passive antenna design

> **NOTE**
>
> TVS requires ultra-low junction capacitance, less than 0.3 pF is recommended.

Table 13: TVS recommended list

| No | Vendor | Device | Clamping Voltage | Junction Capacitance | Package |
|----|--------|--------|------------------|----------------------|---------|
| 1 | Prisemi | PESDEC2XD5VBF | 15V | 0.15pF | DFN0603-2L |
| 2 | WAYON | WE05DGCF-B | 20V | 0.18pF | DFN0603-2L |
| 3 | WAYON | WE05DGCMS-BH | 20V | 0.15pF | DFN0603-2L |
| 4 | INPAQ | TVC5VB1SD-DFN0603-2L | 4.7V | 0.18pF | DFN0603-2L |

For better performance with passive antenna designs user can use an external LNA to increase the sensitivity up 3~4 dB. Please see Figure 13.



Figure 13: SIM65M-C passive antenna design (with external LNA and SAW)

For best performance, user can add an external saw based on Figure 12 design to avoid interference, please see Figure 14.

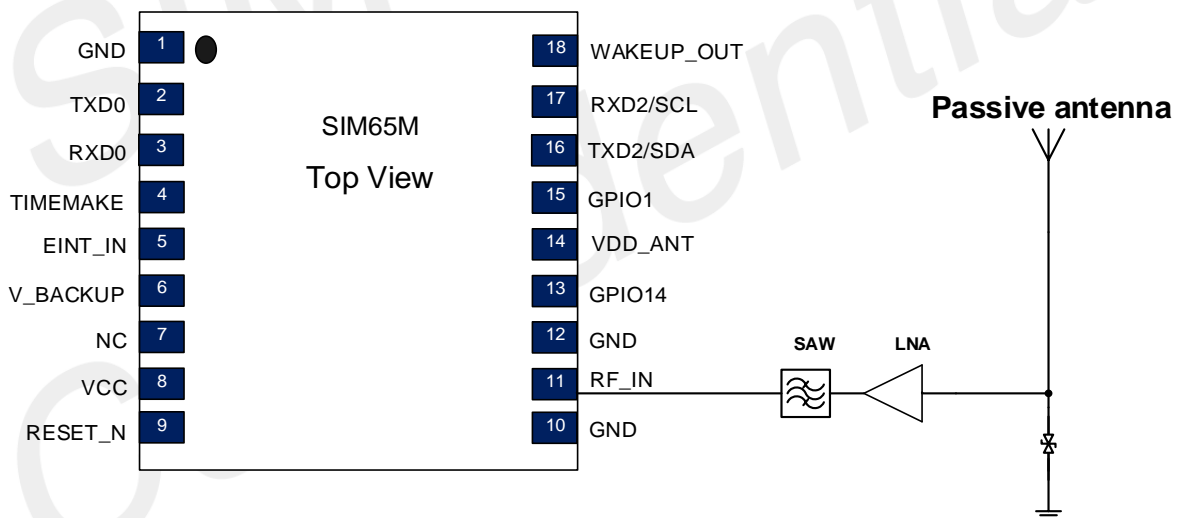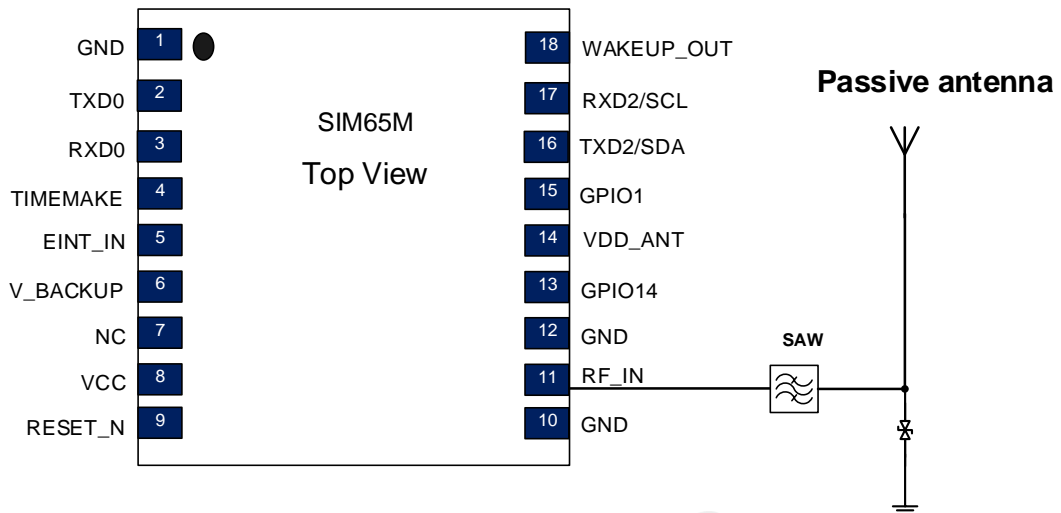Figure 14: SIM65M-C passive antenna design(pre-saw)

## 4.2.2  Active Antenna

Active antenna has an integrated Low-Noise Amplifier (LNA). Active antenna needs a power supply that will contribute to GNSS system power consumption.

Usually, the supply voltage is fed to the antenna through the coaxial RF cable shown as Figure 15. For the output voltage of pin 14, refer to the specific module model used. If the output voltage of pin 14 meets the supply voltage of the active antenna, PIN 14 VDD_ANT can be connected to RF_IN as figure 16 shows. If the requirements are not met, other power should be connected to RF_IN.
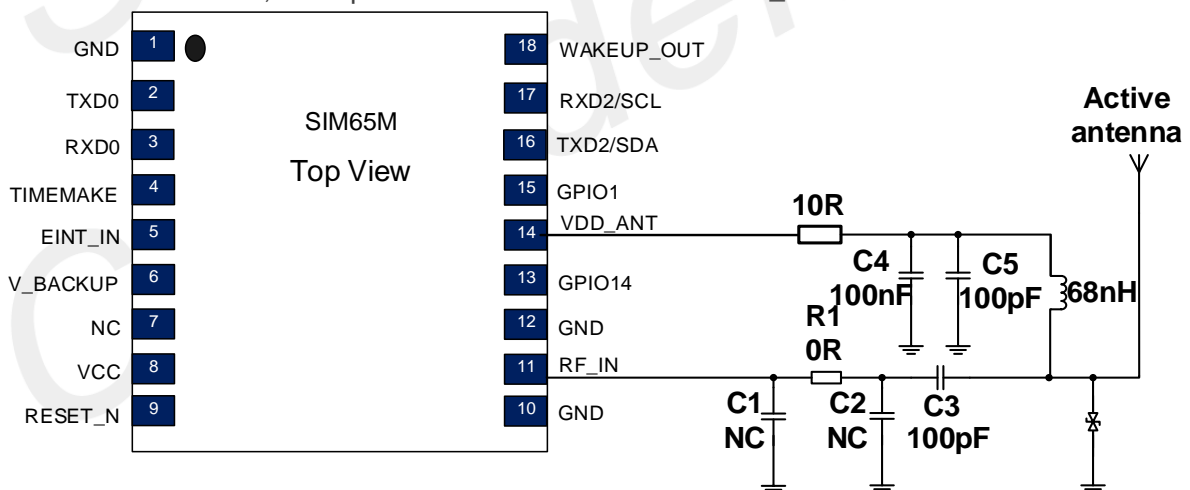


Figure 15: SIM65M-C active antenna design

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.

GNSS 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.

# 5 Coexistence application

GNSS receivers typically receive signals below -130dBm and are susceptible to noise sources in the environment. The 3GPP protocol specifies that the maximum transmission power of LTE and NR PC3 is about 23dBm, and the maximum transmission power of NR PC2 is about 26dBm, when the GNSS receiver and wireless communication module coexist, the system needs to be optimized to avoid GNSS signal interference.

In the system where GNSS receivers and wireless communication modules coexist, both in-band and out-of-band jamming signals can occur, and this section will introduce the sources and effects of jamming signals, and propose anti-jamming design schemes.

## 5.1 In-band jamming

When the frequency of an interfering signal is within the GNSS operating band, it is called in-band jamming. In-band jamming is often generated by adjacent RF transceivers, such as in vehicle tracking and connected car solutions, where cellular communication modules used in combination with GNSS receivers are prone to jamming signals.

Because RF jamming reduces the quality of the GNSS signal and prolongs the search time, it will take longer for the GNSS receiver to achieve the first position. Because the power consumption for the first fix is significantly greater than the power consumption required for tracking after the first position, RF jamming can lead to increased power consumption, ultimately reducing battery life. Therefore, reducing RF jamming is especially important in power-constrained applications, such as battery-powered GNSS location trackers.

In some cases, RF jamming can cause GNSS signal loss, and while newer GNSS receivers can track multiple satellites in multiple GNSS constellations simultaneously, the loss of some useful signals can still lead to reduced positioning accuracy, or in the worst case, complete loss of positioning.

In the case of GPS L1, the band has a center frequency of 1575.42 MHz and a bandwidth of 2.046 MHz. When the 4G/5G communication module in the system is operating, it may generate jamming signals with frequencies between 1574.4MHz ~ 1576.4MHz, and the jamming signal power will be higher than the actual received GPS signal.

Common types of RF jamming are high-order harmonics and intermodulation distortion, which refers to the combination of frequencies of several signals of different frequencies that are the same or similar to the frequency of the useful signal when they pass through a nonlinear circuit, thereby causing jamming to the GNSS receiver. The second harmonic of LTE Band 14 and the in-band jamming caused by the intermodulation distortion of the two different signals are listed in the table below.

Table 14: Intermodulation distortion(IMD)

| Signal S1 | Signal S2 | IM | Intermodulation distortion products |
|-----------|-----------|-----|-------------------------------------|
| LTE Band 14 | N/A | 2 × S1 (788 MHz) | 2nd harmonic = 1576 MHz |
| Wi-Fi 2.4 GHz | LTE Band 5 | S1 (2412 MHz) - S2 (836.5 MHz) | 2nd order intermodulation = 1575.5MHz |
| LTE Band 3 | LTE Band 2 | 2 × S1 (1727.5 MHz) - S2 (1880 MHz) | 3rd order intermodulation = 1575 MHz |
| Wi-Fi 5 GHz | LTE Band 2 | S1 (5295 MHz) - 2 × S2 (1860 MHz) | 3rd order intermodulation = 1575 MHz |

## 5.2  Out-of-band jamming

When the frequency of an interfering signal is outside the GNSS operating band, it is called out-of-band jamming. Out-of-band jamming can leak into the GNSS receiver's spectrum. When the out-of-band signal is strong, it is important to suppress the out-of-band signal in advance, because the GNSS module's low-noise amplifier (LNA) has a maximum output limit, and the strong signal flow transmitted by other communication systems may cause the LNA to saturate, reduce the gain, pre-filter the out-of-band signal, and the useful signal can obtain better gain. Therefore, band-pass filters can be used to reject signals outside the frequency band used.

In practical applications, common strong jamming signals usually come from wireless communication modules, such as LTE, NR, Wi-Fi signals, etc.

## 5.3  Anti-Jamming design

In order to reduce the influence of interference signals on GNSS reception performance, the following anti-interference design scheme is proposed:

● The receiving antenna of the GNSS module should be as far away as possible from the transmitting antenna of the cellular communication module, and it is recommended that the isolation between the antennas be greater than 15dB.

● When the GNSS module and the wireless communication module coexist, the interference source usually has RF power amplifier, single-chip microcomputer, crystal, etc., in the PCB ornament and layout, the interference source should be far away from the GNSS module, the use of shielding frame and shielding cover to ensure sufficient grounding, can effectively prevent strong signal interference.

● Using a narrowband antenna, tuning the antenna to only receive the working band of GNSS can filter out a part of the out-of-band noise and interference signals;

● Refer to Figure 14, the additional use of surface acoustic wave filters (SAWs) can effectively suppress out-of-band interference and improve the signal-to-noise ratio.

# 6 Electrical Characteristics

## 6.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 15 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to SIM65M-C.

Table 15: Absolute maximum ratings

| Parameter | | Min | Max | Unit |
|---|---|---|---|---|
| VCC | @SIM65M-C | - | 3.6 | V |
| V_BACKUP | | - | 3.6 | V |
| Storage temperature | | -45 | +95 | ℃ |
| Operating temperature | | -40 | +85 | ℃ |

## 6.2 Recommended Operating Conditions

Table 16: SIM65M-C operating conditions

| Parameter | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Operating temperature range | | -40 | +25 | +85 | ℃ |
| Main supply voltage | VCC @SIM65M-C | 1.7 | 3.3 | 3.6 | V |
| VDD_ANT Active antenna supply voltage output | VDD_ANT | - | - | VCC | V |
| | Imax | - | - | Ivcc | mA |
| Backup battery voltage | V_BACKUP | 1.7 | 3.3 | 3.6 | V |

## 6.3 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 SIM65M-C module.

Table 17: The ESD characteristics (Temperature: 25℃, Humidity: 45 %)

| Pin | Contact discharge | Air discharge |
|---|---|---|
| VCC | ± 4 kV | ± 8 kV |
| GND | ± 4 kV | ± 8 kV |
| VDD_ANT | ± 4 kV | ± 8 kV |
| RF_IN | ± 4 kV | ± 8 kV |

**NOTE**

Test conditions:

1. The external of the module has surge protection diodes and ESD protection diodes.
2. The data in Table 17 were tested using SIMCom EVB.

# 7  Manufacturing

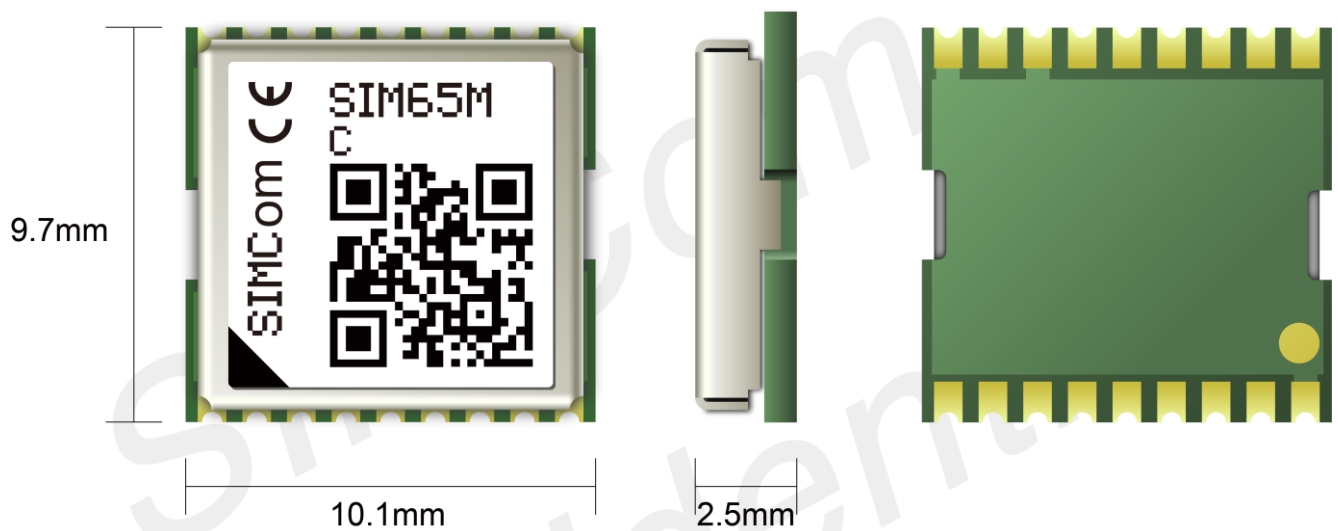## 7.1  Top and bottom View of Modules



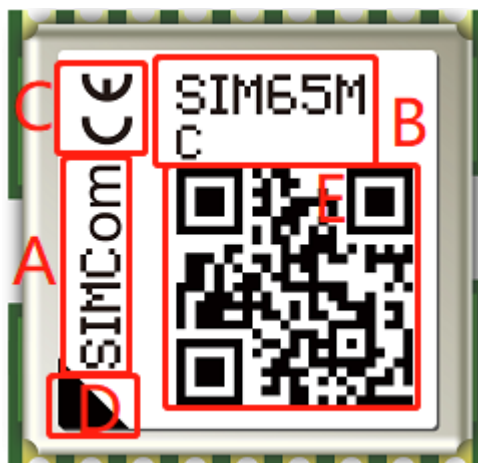Figure 16: Top and bottom view of SIM65M-C

## 7.2  Label Description Information



Figure 17: Label description of module information

Table 18: Label description of module information

| No. | Description |
|-----|-------------|
| A | Logo |
| B | Project name |
| C | Authentication |
| D | 1 pin identification |
| E | QR code, Contains P/N, SN and SW information |

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

## 7.3  Recommended PCB Footprint

The following figure shows the PCB footprint of the modules:
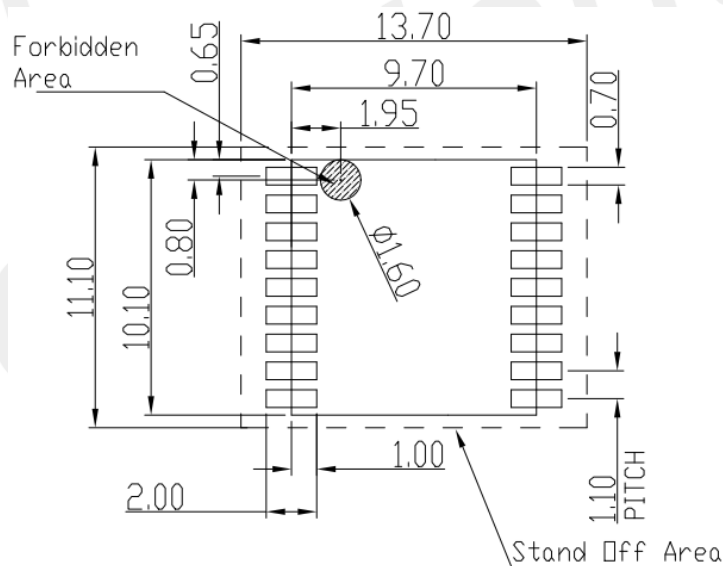


Figure 18: Recommended PCB footprint (top view) (Unit: mm)

## 7.4  Recommended SMT Stencil

The following figure shows the SMT stencil of SIM65M-C. Suggested solder paste stencil height is 120um~150um minimum to ensure sufficient solder volume.
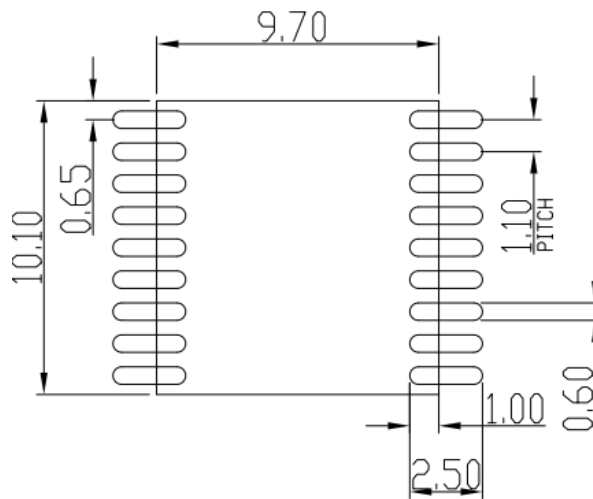
Figure 19: Recommended SMT stencil(top view)

## 7.5 Recommended reflow furnace temperature curve

The following figure is the Ramp-Soak-Spike Reflow Profile of SIM65M-C:
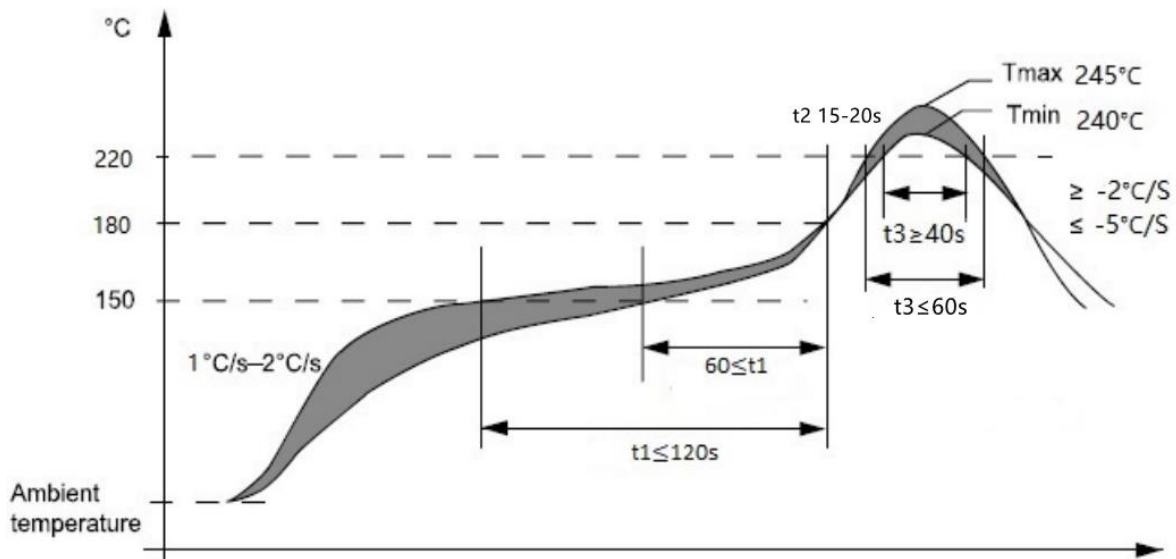


Figure 20: Recommended reflow furnace temperature curve (lead-free)

Table 19: The main board reflux temperature curve requirements (lead-free)

| Zone | Time | Parameter |
|------|------|-----------|
| Preheat Zone (Room temperature~150℃) | NA | Heating rate: 1~2℃/s |
| T1 (150~180℃) | 60~120s | / |
| T2 (180~220℃) | 15~20s | / |
| T3 (≥220℃) | 40~60s | Peak temperature: 240~245℃ |
| Cooling Zone | NA | Cooling rate: -2~-5℃/s |

> **NOTE**
>
> - Recommended lead-free process.
> - In the table above, the temperature testing location includes the solder mask of the module MCU pins, bottom LGA pins, and external LCC pins.
> - The actual welding temperature is affected by other external factors, such as the presence of furnace carriers, solder paste, size and thickness of the substrate, and component resistance. Thermal requirements and panel design, etc. Please confirm with our engineering and technical personnel in time if the recommended parameters cannot be reached. Otherwise, the module may be damaged.
> - For boards with thickness less than 1.2mm, it is recommended to use board supported by furnace carrier or high Tg to prevent warping and PCB when heated. Deformation, thus affecting module welding. For modules larger than 35.0 mm *35.0 mm and 5G products, it is recommended to use the furnace carrier to pass through the furnace to reduce the cause of the bottom plate and mold. Due to the difference of Tg value of block, the phenomenon of unbalanced thermal stress appears in the process of high temperature welding reflow, resulting in the defect rate of virtual welding and little tin.
> - After the module is welded, X-ray and optical inspection methods shall be used to check the welding quality. For specific standards, please refer to relevant standards of IPC-A-610H.
> - For more information about shipping and manufacturing, please refer to "Module Secondary SMT Process User Guide".
> - Due to the complexity of the SMT process, in case of uncertainty or processes not mentioned in this document (such as selective wave soldering, ultrasonic welding), please contact SIMCom support team before SMT process starts.

## 7.6 Moisture Sensitivity Level and Storage conditions

Modules are shipped in vacuum-sealed aluminum foil bag bags, vacuum packaging according to IPC/JEDEC standard J-STD-020C specification.

- Recommended storage conditions: temperature 23℃± 5℃, and relative humidity 35%~60%.
- Storage period: 12 months (Under recommended storage conditions and in sealed vacuum packaging).

The module meets the humidity sensitivity level 3 (MSL-3), and the storage period after unpacking is shown in table below.

The out-of-bag floor life of the module with MSL-3 is 168 hours. If the workshop temperature is 23℃±5℃ and the relative humidity is less than 60%, the module needs to be unpacked within 168 hours of reflux production or other high temperature operations. Otherwise, the module shall be stored in an environment with relative humidity less than 10% (for example, a moisture-proof cabinet) to keep the product dry.

Table 20: MSL levels

| MSL | Out-of-bag floor life | Comment |
|---|---|---|
| 1 | Unlimited | ≤+30℃/85% RH |
| 2 | 1 year | ≤+30℃/60% RH |
| 2a | 4 weeks | |
| 3 | 168 hours | |
| 4 | 72 hours | |
| 5 | 48 hours | |
| 5a | 24 hours | |
| 6 | Mandatory bake before use. After bake, it must be reflowed within the time limit specified on the label. | |

Before use, it is necessary to confirm whether the package is in good condition; After unpacking, check the status of humidity indicator card in vacuum bag (Figure 21). The module needs to be baked before use if any of the following conditions occur.

- Explanation Humidity indicator card: 30%, 40%, and 50% of any indicator circle has discolouring
- The module has been un-packed and the module exceeds the humidity sensitivity level corresponding to the exposed workshop time. For example, MSL=3 is 168.
- Packed，but the Shelf Life exceeds 12 months；
- Exceeds the Floor Life；
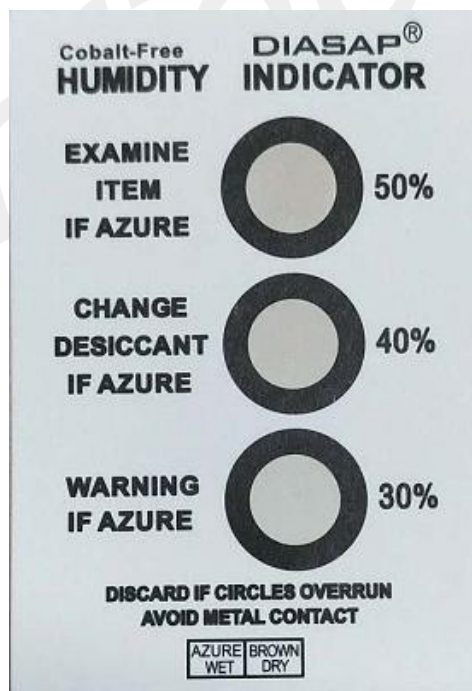- Unable to track and determine the status of the module.



Figure 21: Humidity card

The following conditions also need to be pre-baked.
- The storage temperature and humidity do not meet the recommended storage conditions.
- Vacuum sealed bag leak, bulk materials
- Before repairing the module.
- After unpacking, the module failed to complete production or storage under the control of humidity sensitive level 3.

## 7.7  Baking Requirements

If baking is required, proceed according to the requirements in the table below. Preferentially choose a nitrogen-filled oven.

Table 21: Baking requirements

| Baking conditions | Baking time | Comment |
|---|---|---|
| 120°C±5°C, <5% RH | 8 hours | Not applicable to original packaging pallets |

**NOTE**

- In order to prevent and reduce the occurrence of poor welding caused by moisture, such as foaming and delamination, the module should be strictly controlled. It is not recommended to expose the module to air for a long time after unpacking the vacuum package。
- Before baking, it is necessary to remove the module from the package and place the bare module on the high temperature resistant device to avoid high temperature damage to the plastic tray or coil; The modules for secondary baking must be welded within 24 hours after baking, otherwise they need to be stored in vacuum packaging or in a drying oven.
- Please pay attention to ESD protection when unpacking and placing modules, such as wearing anti-static gloves.

## 8  Packaging

Module support tray and reel packaging. The module is packaged in trays by default, select REEL if reel packaging is required.
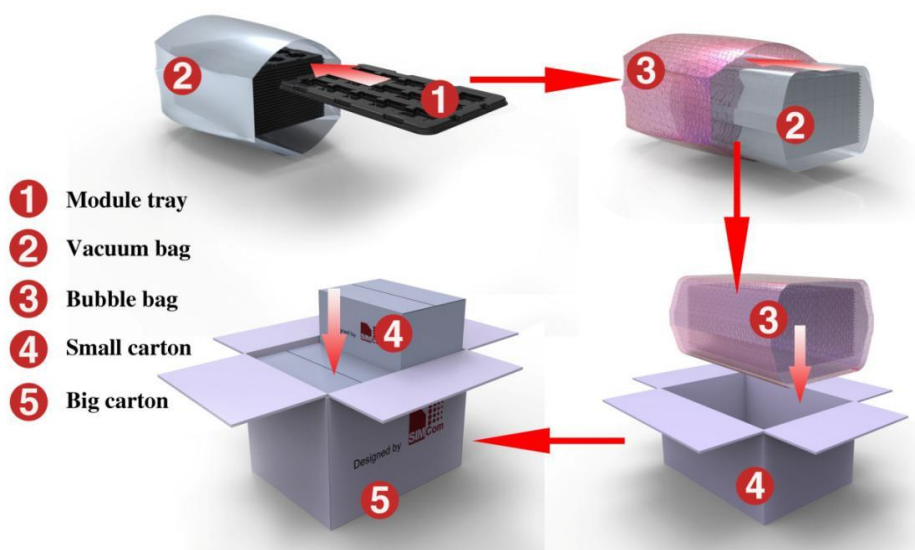
### 8.1  Tray packaging



1. Module tray
2. Vacuum bag
3. Bubble bag
4. Small carton
5. Big carton

Figure 22: packaging diagram

Module tray drawing：
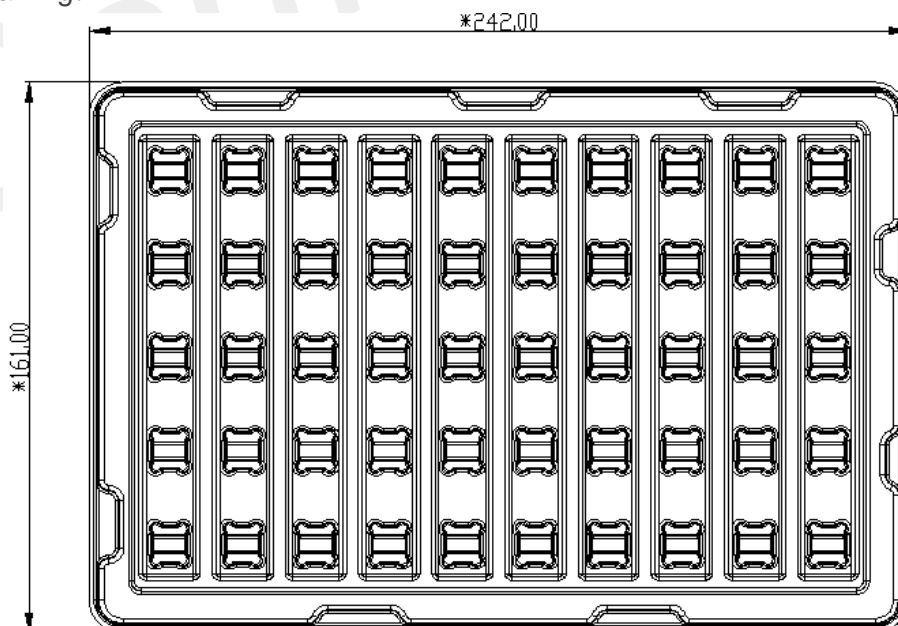


Figure 23: Tray drawing

Table 22: Tray size

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

Small carton drawing：
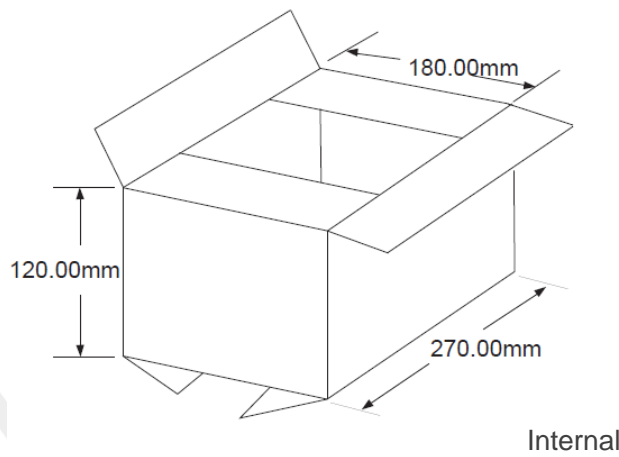


Figure 24: Small carton drawing

Table 23: Small Carton size

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

Big carton drawing：
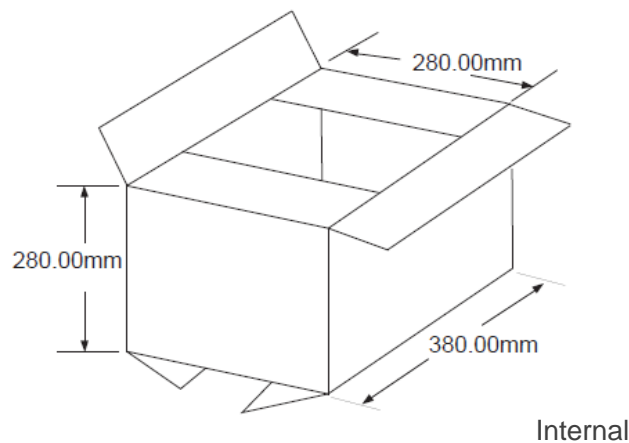


Figure 25: Big carton drawing

Table 24: Big Carton size

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

## 8.2  Reel packaging
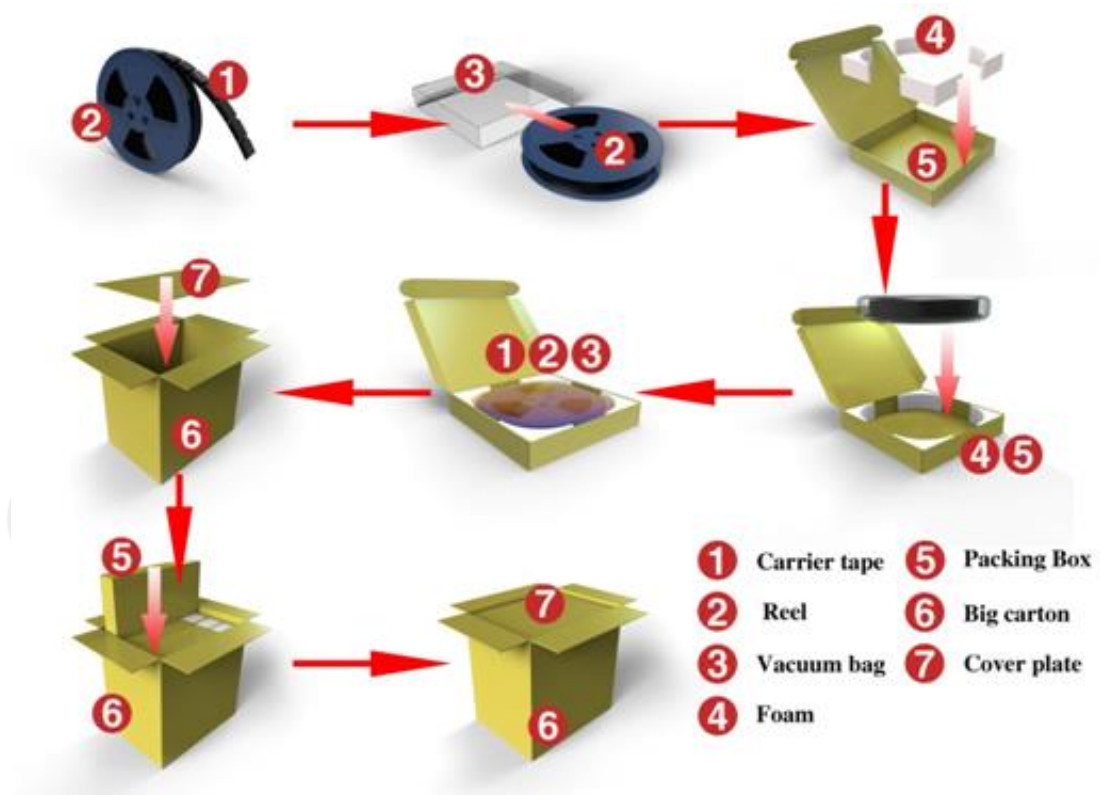


Figure 26：Packaging introduce

Carrier tape drawing：



| 外观 | 尺寸(mm) |
|---|---|
| E | 1.75 ± 0.10 |
| F | 11.5 ± 0.10 |
| P2 | 2.00 ± 0.10 |
| ØDo | 1.50 ± 0.10 / 0.00 |
| ØD1 | 1.50 MIN |
| Po | 4.00 ± 0.10 |
| 10Po | 40.0 ± 0.20 |
| W | 24.0 ± 0.30 |
| P | 16.0 ± 0.10 |
| Ao | 10.0 ± 0.10 |
| B0 | 10.4 ± 0.10 |
| K0 | 3.00 ± 0.10 |
| t | 0.30 ± 0.05 |

| 名 称 | 数 量 |
|---|---|
| 塑料盘 | 13' |
| 长 度 | 21.6m/r |
| 元件数 | 1350pcs/r |
| 单 位 | 100mm |
| 载带材料 | PS ESD |
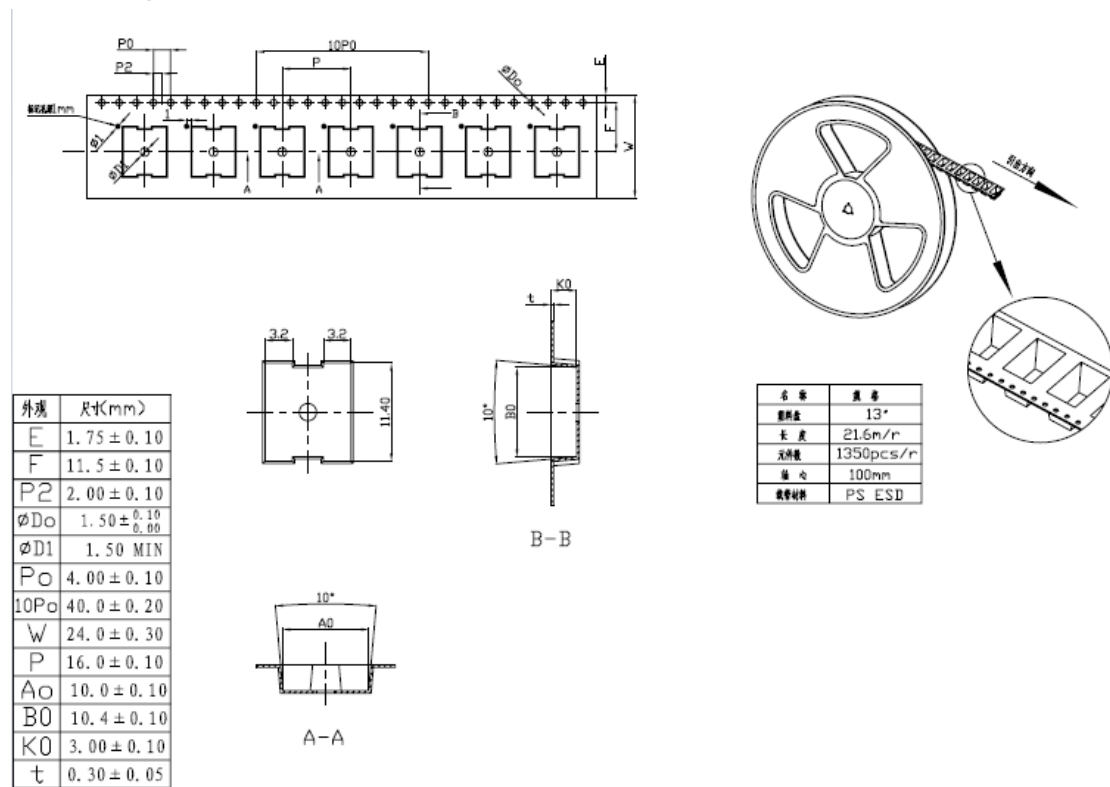
Figure 27: Carrier tape drawing introduce

Table 25: Reel size

| External Diameter （mm） | Width （mm） | Inside Diameter （mm） | Module number |
|---|---|---|---|
| 330.0 | 24.0 | 100.0 | 1000 |

Packing box drawing：
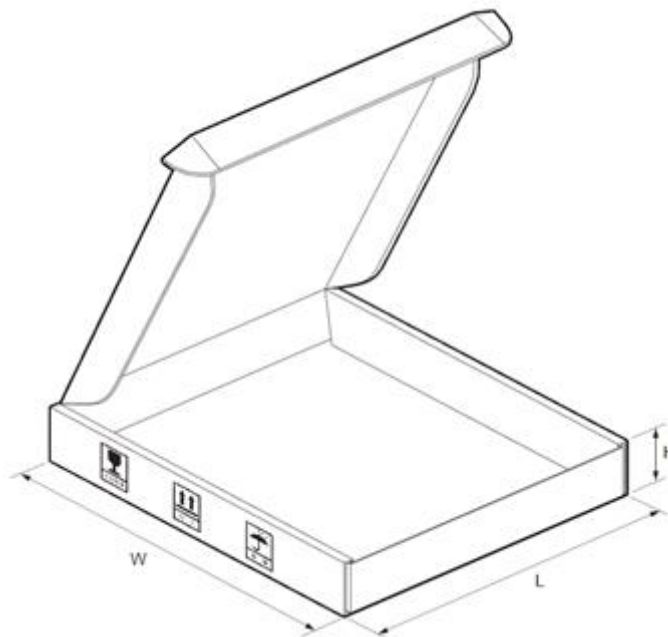


Figure 28: Packing box drawing introduce

Table 26: Packing box size

| Length（±10mm） | Width（±10mm） | Height（±10mm） | Module number |
|---|---|---|---|
| 345 | 340 | 60 | 1000 |

Big carton drawing：
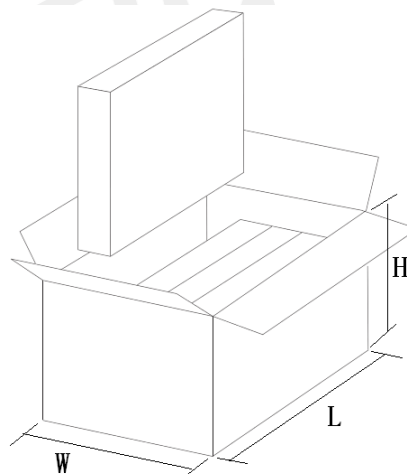


Figure 29: Big carton drawing introduce

Table 27: Big carton size

| Length（±10mm） | Width（±10mm） | Height（±10mm） | Module number |
|---|---|---|---|
| 380 | 275 | 380 | 1000*4=4000 |

# 9  Reference Design

Following figure is the typical application of SIM65M-C with active antenna which supplied by VDD_ANT. If customer applies other kind of active antenna, keep PIN 14 floating and connect other voltage to the R125.
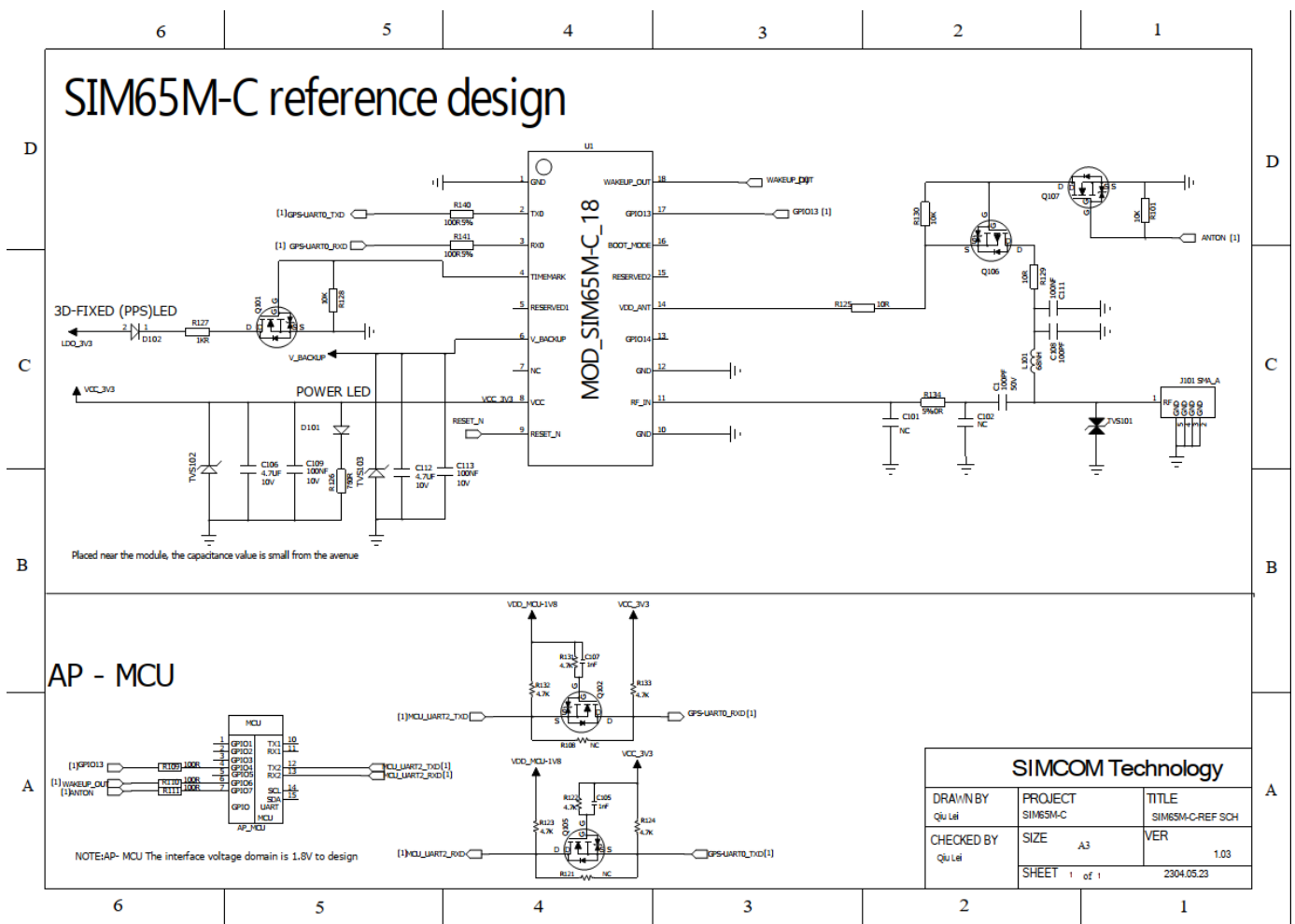


Figure 30: Refer schematic

Please note the I/O level of the SIM65M-C, and users should pay attention to level matching when using it.

# 10　Appendix

## 10.1　Related Documents

Table 28: Related documents

| SN | Document name | Remark |
|----|---------------|--------|
| [1] | SIM65M-C_Hardware_Design(this document) | |
| [2] | SIM65M-EVB_User_Guide | |
| [3] | SIM65M_EVB SCH&PCB | |
| [4] | MOD_SIM65M_18 SCH&PCB | |
| [5] | SIM65M-C Series_NMEA Message_User Guide | |
| [6] | Module Secondary SMT Process User Guide | |

## 10.2　Terms and Abbreviations

Table 29: Terms and abbreviations

| Abbreviation | Description |
|--------------|-------------|
| A-GPS | Assisted- Global Positioning System |
| CMOS | Complementary Metal Oxide Semiconductor |
| DGPS | Difference Global Positioning System |
| EASY | Embedded Assist System |
| EGNOS | Euro Geostationary Navigation Overlay Service |
| EPO | Extended Prediction Orbit |
| ESD | Electrostatic Sensitive Devices |
| FSM | Finite State Machine |
| GAGAN | The GPS Aided Geo Augmented Navigation |
| GPS | Global Positioning System |
| GNSS | Global Navigation Satellite System |
| I/O | Input/Output |
| Inorm | Normal Current |
| Imax | Maximum Load Current |
| kbps | Kilo bits per second |
| LNA | Low Noise Amplifier |

| | |
|---|---|
| MSAS | Multi-Functional Satellite Augmentation |
| MSL | moisture sensitive level |
| NMEA | National Marine Electronics Association |
| QZSS | Quasi-Zenith Satellites System |
| RTCM | Radio Technical Commission for Maritime Services |
| SBAS | Satellite Based Augmentation Systems |
| WAAS | Wide Area Augmentation System |

## 10.3  Safety Caution

Table 30: 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. |
| SOS | 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.<br>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.<br>Also, some networks require that a valid (U)SIM card be properly inserted in the cellular terminal or mobile. |