SIM32EA Series Hardware Design

GNSS Module

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1 Introduction

This document describes the hardware application interface of the module, which can help you quickly understand the details of the interface definition, electrical performance, and structural dimensions of the module. Combined with this and other application documents, users can quickly use the module to design mobile positioning applications. SIMCom provides a set of evaluation boards to facilitate testing and use of the SIM32EA series of modules. The evaluation board tool comprises an EVB board, a USB cable, and an antenna.

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]	SIM32EA Series_Hardware_Design (this document)	It mainly introduces hardware components such as interface functions,recommended circuits, PCB layout guides, packaging, and software instructions
[2]	SIM32EA Series-EVB_User_Guide	Introduction to how to use the SIM32EA with EVB
[3]	SIM32EA_EVB SCH&PCB	SIM32EA-EVB schematic and PCB PDF document
[4]	MOD_SIM32EA_36 SCH&PCB	SIM32EA module reference package
[5]	SIM32 Series_NMEA Message_User Guide	The SIM32EA 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 mes h production, reflow welding, welding and repair

NOTE

This current revision is an early release to support initial product developers. The content is subject to change without advance notice.

1.2 Overview

The SIM32EA series is a single-band, multi-galaxy small package GNSS positioning module with independent GPS (A-GPS support)/Glonass/Beidou*/Galileo receiver, built-in LNA, optional use of built-in ceramic antennas and external antennas. The SIM32EA Series supports a wide range of positioning and navigation applications, including GPS, GLONASS, BeiDou*, Galileo, QZSS, and A-GPS.

1.3 Key Features

The SIM32EA series modules provide customers with different power supply ranges with different options and can be adapted to a variety of customer application circuits. The power supply range of the SIM32EA series is from 1.75V to 3.6V, and the modules communicate with the HOST through the UART interface.

The SIM32EA series has the following features:

- Support GPS/GLONASS/GALILEO/BDS*/QZSS single-frequency multi-system positioning mode.
- Support AGNSS assisted positioning.
- Supports Active Interference Cancellation (AIC).
- Integrated Low Noise Amplifier (LNA).
- It supports low-power mode to ensure that the module can be applied to different application scenarios.
- Update frequency: 1Hz~10Hz (1)
- Surface mount package with 12 LCC pins, 24 LGA pins, dimensions only: 16.0 x 16.0 x 6.75mm.
- PPS：
  1. Adjustable duty cycle
  2. Typical accuracy:±10ns（24h RMS）
- Support communication interface UART.
- Operating temperature: -40 ~ +85ºC

NOTE

1. Default 1HZ.
2. '*' means that the built-in patch antenna does not support BD satellites, if you need to support BD satellites, please contact SIMCom.

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1.4 Functional Block Diagram of the SIM32EA Series

The following diagram illustrates the main functional frameworks inside the SIM32EA series modules:

- GNSS chip
- SAW
- Built-in LNA
- Patch Antenna
- Antenna interface
- Communication interfaces
- Control signals

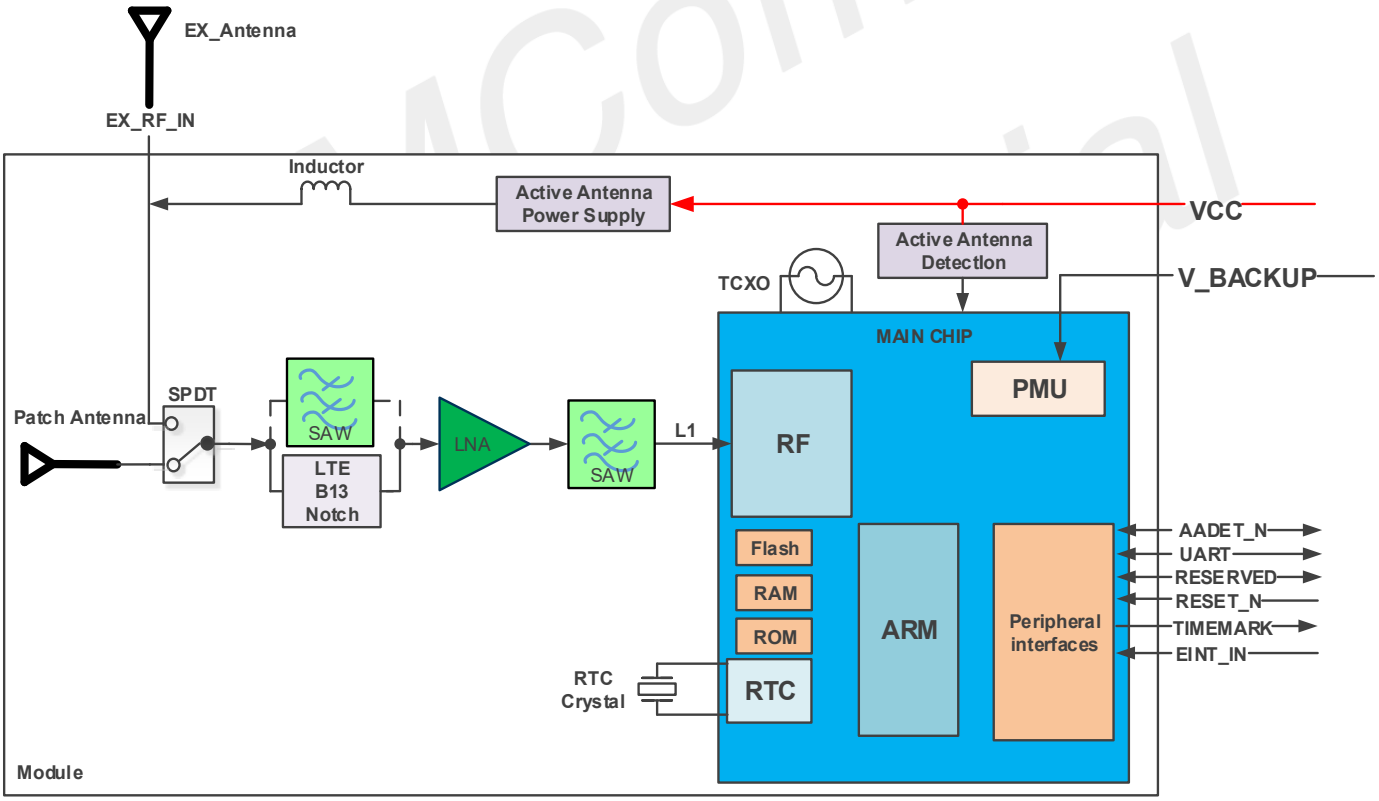


Figure 1: Functional Block Diagram of the SIM32EA Series

1.5 Key Features

Table 2: Key Features of the Module

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy[1]	Automatic position		1		m
Velocity Accuracy[2]	Without Aid		0.1		m/s
Timing Accuracy			10		ns
Dynamic Performance	Maximum Altitude			10000	m
	Maximum Velocity			100	m/s
	Maximum Acceleration			4	g
TTFF (without A-GPS) [1]	Hot start		1		s
	Cold start		23		s
TTFF (with Flash EPO) [1]	Cold start		4		s
Sensitivity [3]	Autonomous acquisition(cold start)		-147		dBm
	Re-acquisition		-160		dBm
	Tracking		-166		dBm
Receiver	Channels		L1:47		
	Update rate		1	10	Hz
	Protocol support NMEA,PAIR	NMEA-0183, PAIR Protocol			

NOTE

1. 50% 24hr static, -130dBm.
2. Room temperature, satellite signal -130dBm test.
3. Conduction sensitivity of patch-free antennas.

1.6 General Features

Table 3: General features

Parameters	Value
Supply voltage VCC	+1.75V~+3.6V, typ: 3.3V
Supply voltage ripple VCC	<40 mVpp @500kHz/100kHz/30kHz/10kHz <20 mVpp @ 1MHz
Storage temperature	-45ºC~+95ºC
Operating temperature	-40ºC~+85ºC
Host port	UART0
TM output (PPS)	NMEA; 8 bits, no parity, 1 stop bit; 115200 baud (configurable)
1PPS	One pulse per second, synchronized at the rising edge. The rising edge of the pulse is aligned with the UTC second, with an accuracy of approximately 10 ns and a pulse length of 100 ms.

Table 4: IO features

Parameter	Description	Pin voltage domain	Min	Typ	Max
V_{IL}	Active low-level input	VCC=1.8V	-0.3 V	-	0.25*VCC
		VCC=2.8V	-0.3 V	-	0.25*VCC
		VCC=3.3V	-0.3 V	-	0.8 V
V_{IH}	Active high-level input	VCC=1.8V	0.75*VCC	-	VCC+0.3 V
		VCC=2.8V	0.625*VCC	-	VCC+0.3 V
		VCC=3.3V	2 V	-	VCC+0.3 V
V_{OL}	Low-level output range	VCC=1.8V	-	-	0.15*VCC
		VCC=2.8V	-	-	0.125*VCC
		VCC=3.3V	-	-	0.4 V
V_{OH}	High-level output range	VCC=1.8V	0.85*VCC	-	-
		VCC=2.8V	0.75*VCC	-	-
		VCC=3.3V	2.4 V	-	-
R_{PU}	Internal pull-up resistor	VCC=1.8V	70 kΩ	150 kΩ	380 kΩ
		VCC=2.8V	40 kΩ	85 kΩ	190 kΩ
		VCC=3.3V	40 kΩ	75 kΩ	190 kΩ
R_{PD}	Internal pull-down resistor	VCC=1.8V	70 kΩ	150 kΩ	380 kΩ
		VCC=2.8V	40 kΩ	85 kΩ	190 kΩ
		VCC=3.3V	40 kΩ	75 kΩ	190 kΩ

1.7 Power Consumption

Table 5: Consumption Data (Typical Value)

Parameter	Description	GPS	GPS+GLO	GPS+GLO +GLA
Acquisition	@VCC=3.3V	10 mA	11 mA	11 mA
Tracking		9 mA	11 mA	11 mA
Sleep mode		2.6mA		
Sleep mode (UART sleep enable)		1mA		
Software RTC	@V_BACKUP=3.3V	13uA		
Hardware RTC		35uA		

1.8 GNSS Operating Frequency

The SIM32EA series 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	1575.42Z±1.023
QZSS L1C/A	1575.42±1.023
GLONASS G1	1602.5625±4
Galileo E1B/C	1575.42±1.023
BeiDou B1I*	1561.098±2.046
BeiDou B1C*	1575.42±16.368

NOTE

'*' means that the built-in patch antenna does not support BD satellites, if you need to support BD satellites, please contact SIMCom.

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1.9 AGNSS

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. SIM32EA Series module supports EPO file, EASY mode, SBAS and RTCM.

1.9.1 EPO

The SIM32EA Series supports the EPO (Extended Prediction Orbit) data service. The EPO data service is supporting 7/14/30-day orbit predictions to customers. It needs occasional download from EPO server. Supply of aiding information like ephemeris, almanac, rough last position and time and satellite status and an optional time synchronization signal will reduce time to first fix significantly.

The user should update the EPO files from the EPO server in the period of validity of EPO file through the internet. Then the EPO data should send to the SIM32EA Series by the HOST side. SIM32EA Series has the shorter cold TTFF and warm TTFF, when the A-GPS is used.

When using EPO, the SIM32EA series will have shorter cold-start TTFFs and warm-start TTFFs.

NOTE

For more information about EPO™, please contact SIMCom.

1.9.2 EPOC

The module supports EPOC. EPOC (Enhanced Prediction Orbit on chip) is a GNSS assisted positioning technology that predicts the orbits of GNSS satellites through the received broadcast ephemeris. This improves the performance of Time To First Fix (TTFF). Due to the lack of EPO aiding data, if the module cannot connect to the network, EPOC aiding data will fill this gap.

EPOC supports three constellation combinations: GPS only, GPS + Galileo, and GPS + BDS (MEO and IGSO), thus increasing the speed of first - time positioning.

NOTE

EPOC is disabled by default, users can use the PAIR command to control the switch, please refer to "SIM32 Series_NMEA Message_User Guide" for more information.

1.10 GNSS Augmentation System

1.10.1 SBAS

The module supports SBAS signal reception. SBAS refers to Satellite-Based Augmentation System. SBAS monitors navigation satellites based on a large number of widely distributed differential stations, obtaining raw positioning data (pseudorange, carrier phase observations, etc.) and sending it to a central processing facility (master control station), which calculates various positioning correction information for each satellite to supplement and improve the original GNSS data.

This system can correct signal measurement errors and provide information regarding signal accuracy, integrity, continuity, and availability, thereby achieving the goal of improving positioning accuracy. SBAS can also serve as a supplementary signal for ranging, further enhancing the availability of GNSS navigation satellite signals.

1.11 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 PAIR command to control the switch, please refer to "SIM32 Series_NMEA Message_User Guide" for more information.

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1.12 LOCUS

The module supports LOCUS technology, which is a technology that supports autonomous recording of log information and can automatically store satellite navigation data in the internal flash of the module to facilitate users to accurately analyze satellite navigation data. In addition, when this function is enabled, the module can reduce power consumption, and the host does not need to receive NMEA information all the time.

NOTE

The LOCUS function is turned off by default, and the switch can be controlled by the PAIR command, please refer to the "SIM32 Series_NMEA Message_User Guide" for more information.

1.13 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.

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2 Package Information

2.1 Pin out Diagram

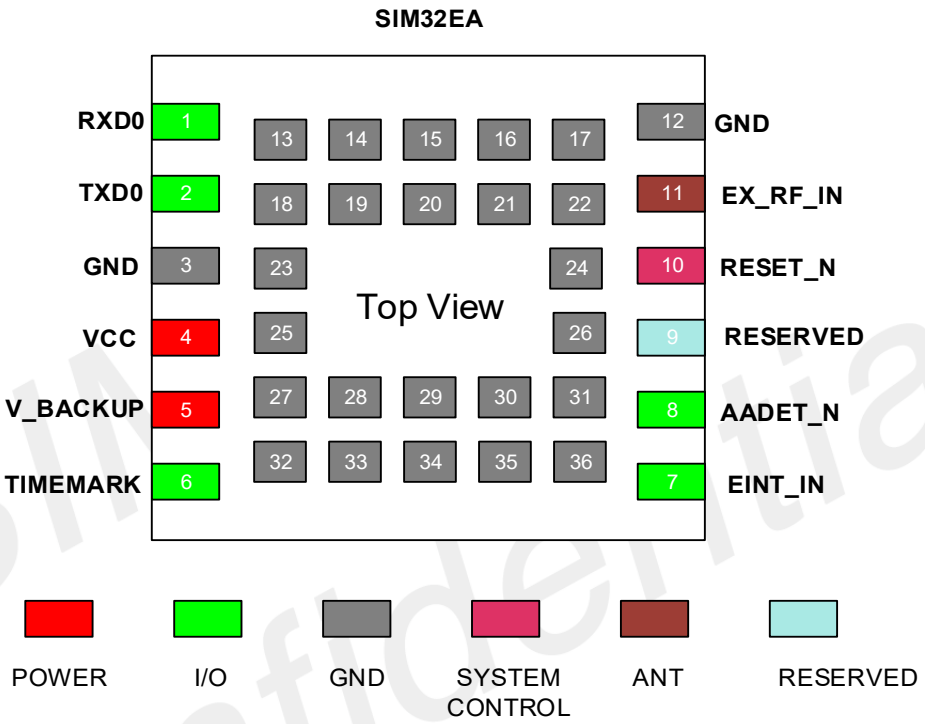


Figure 2: SIM32EA Pin Diagram (Top View)

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

Table 8: Pin Description

Pin Name	Pin Number	I/O	Description	Comment
Power Supply				
VCC	4	PI	Main power input, which will be used to power the baseband and RF section internally. Input voltage range: SIM32EA: 1.75~3.6V, typ: 3.3V， The supply current requirement can reach 100mA.	Provide clean and stable power source to this pin. Add a 4.7uF capacitor to this pin for decoupling.
V_BACKUP	5	PI	The backup battery input power supply for RTC The input voltage range is 1.7V~3.60V, the typical value is 3.3V	Must be connected
GND	3, 12~36	-	Ground	Ground
System Control				
RESET_N	10	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 1.8V high and supports 1.8/3.3V input
Communication Interface				
TXD0	2	DO	Support for RTCM statements and NMEA standard statement output, PAIR command input/output, firmware upgrade.	Voltage domain is VCC The default output is NMEA statements. If unused, keep open
RXD0	1	DI		
GPIOs				
TIMEMARK	6	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
EINT_IN	7	DI	Wake up module UART, low active, default pull high	Default high Voltage domain is VCC
Other				
RESERVED	9	-	Reserved	Keep floating.
RF Interface				
EX_RF_IN	11	AI	Radio antenna connection	Impendence must be

				controlled to 50Ω
AADET_N	8	DIO	The external antenna uses a status indication and can also be switched to an external passive antenna by holding the pin low externally	

2.3 Machine Dimensions

Following figure shows the Mechanical dimensions of SIM32EA Series (top view, side view and bottom view).

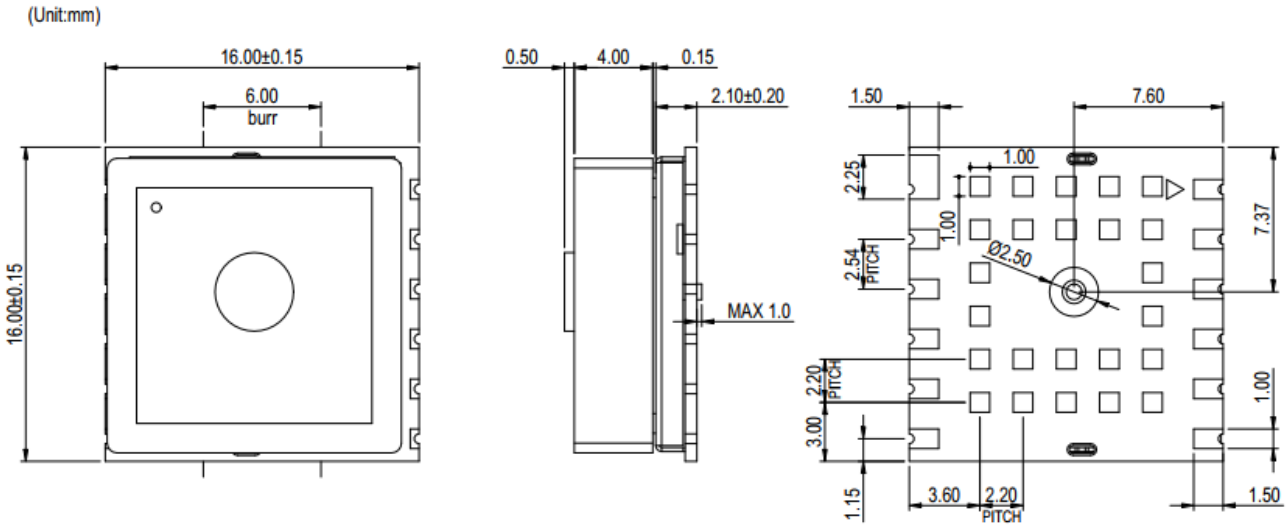


Figure 3: SIM32EA Series Mechanical Dimensions (Unit: mm)

NOTE

Outline dimensional tolerances do not include burr areas.

3 Application Interface

3.1 Power Management

The module is powered by VCC and V_BACKUP pins:

VCC supplies power to PMUs, and its load current will be affected by factors such as VCC voltage level, processor load, and satellite capture, so it is necessary to ensure that the VCC power supply is stabilized. V_BCAKUP power the backup domain, including the RTC clock and RAM.

V_BACKUP allows the module to be started up quickly and TTFF shortened, and when VCC is disconnected, the V_BACKUP power is maintained and all necessary GNSS data and configuration information in RAM can be saved.

3.1.1 VCC

VCC is the power supply pin of the module, the power supply range of the SIM32EA series is: 1.75V~3.6V, typical value is 3.3V, and the power supply needs to provide at least 100mA current. The module needs a stable power supply, so the following suggestions are made:

- Wide power lines or even power planes are preferred.
- VCC supply needs to add a 4.7uF, 100nF and 33pF multi-layer ceramic chip (MLCC) capacitors with low ESR in high frequency band, which can be used for EMC performance .
- DC-DC converters are not recommended for VCC power supplies, and LDOs with high power supply rejection ratios (PSRRs) should be selected。
- ESD and surge protection are required for VCC power supplies。

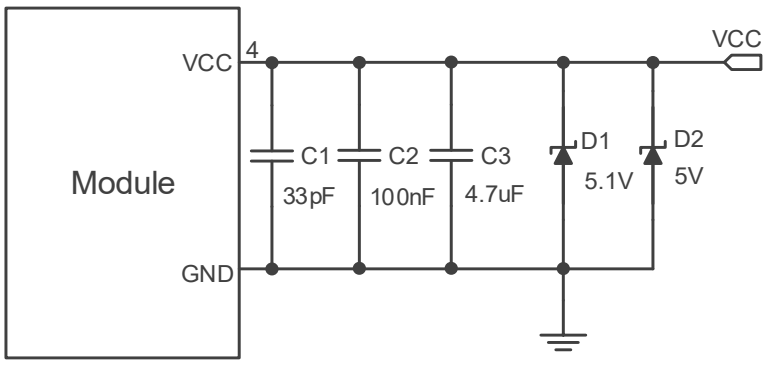


Figure 4: VCC Supply Reference Circuit

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NOTE

1. D1 is used for surge protection, D2 is used for ESD protection.
2. Ensure that the VCC pin of the module can be controlled by the MCU to reduce power consumption, or the module can be restarted when the module enters an abnormal state.

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	

3.1.2 V_BACKUP

The V_BACKUP pin is backup power, and the power supply range is 1.7V~3.6V. By using the effective time and GNSS orbit 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 the RTC function is required, keep the power supply V_BACKUP constant in the event of a VCC power outage[1].

The reference design of V_BACKUP is as follows:

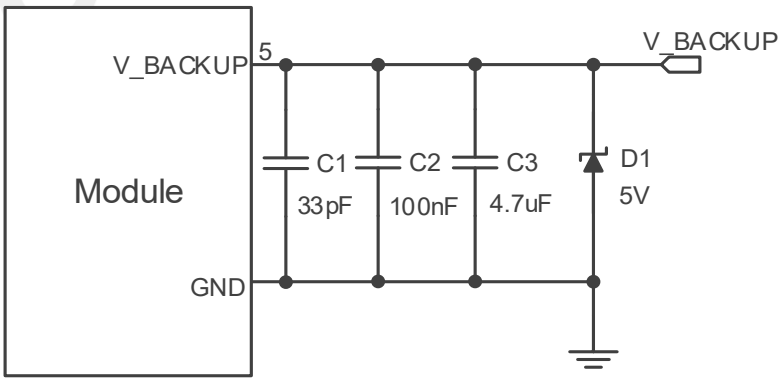


Figure 5: General Reference Design of V_BACKUP

It can also be powered by a battery. The recommended schematic diagram is as follows:

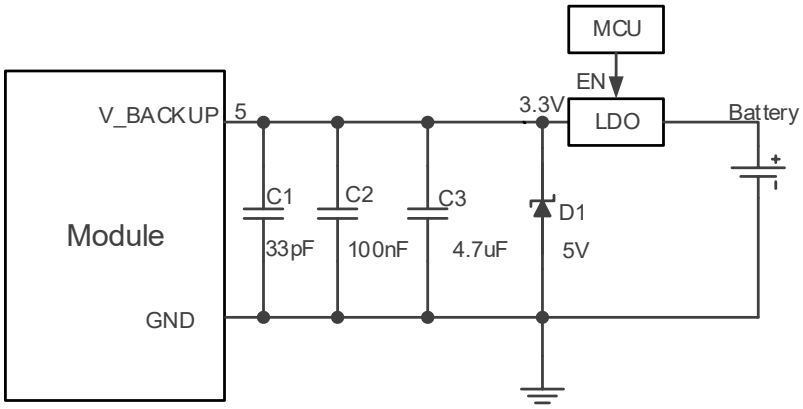


Figure 6: Reference Design of V_BACKUP Using Battery

NOTE

1. The V_BACKUP voltage should not be lower than the minimum value of the recommended working voltage, otherwise the module may work abnormally.
2. If the battery is connected, it is recommended to control the LDO to enable it through the MCU, so that the module can be powered off and restarted when the module is abnormal.

3.1.3 Power on

After the module VCC is powered on, the SIM32EA series will automatically power on and enter the working mode. The VCC should be powered up quickly within 50ms, and to ensure proper power-up timing, the backup power supply should be started no later than VCC, so the V_BACKUP must be powered on before or both times before VCC is powered up. The power-on and power-on sequence diagram of the module is shown in Figure 6.

3.1.4 Power off

When the VCC power supply of the module is disconnected, the voltage should be guaranteed to drop rapidly within 50ms. To ensure that the power-on timing is abnormal when the module is powered on and restarted the next time, ensure that the VCC of the module is powered off to below 0.5V and maintained for at least 2 seconds, and then restart the module at power-on.

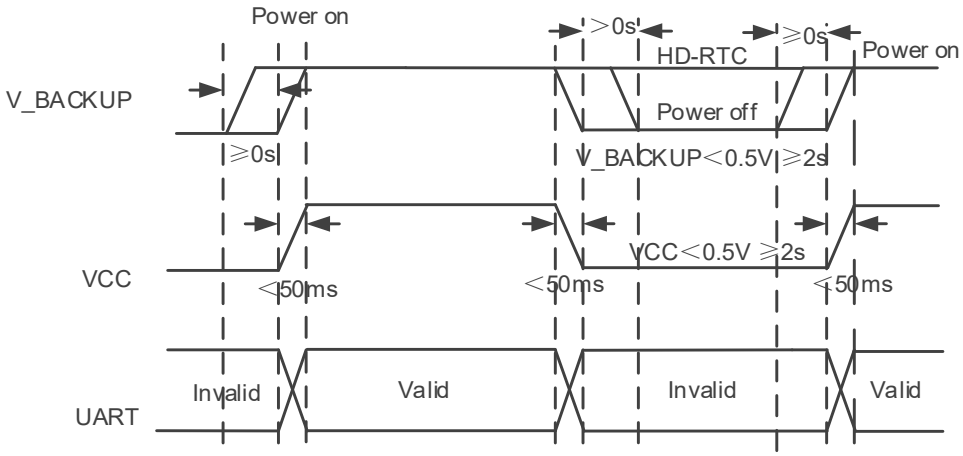


Figure 7: The Module is Powered on and off Sequentially

3.1.5 Verification of SIM32EA Series Start

Once powered on, the module will output messages at the selected UART speed and message type. By default, the NMEA 0183 protocol is output through UART0, and the baud rate is 115200bps.

3.2 Operating Mode

Table 10: 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
Sleep mode	on	on	on	off	on
RTC mode	off	on	off	off	on

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 Sleep Mode

Sleep mode means a low quiescent power state, non-volatile RTC, and backup RAM block is powered on. Other internal blocks like digital baseband and RF are internally sleeping. The PMU is changed to low power mode, The power supply input VCC shall be kept active all the time, even during sleep mode. Commands can be sent through the UART interface to control the module entering/exiting sleep mode

- Enter the sleep mode:

Send the command $PAIR003*39\r\n, the module returns $PAIR001,003,1*39\r\n,$PAIR001,003,0*38\r\n, and then enter sleep mode.

- Exit the sleep mode:

Send the command $PAIR002*38\r\n, the module returns $PAIR001,002,1*38\r\n,$PAIR001,002,0*39\r\n, and then exits sleep mod.

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NOTE

1. $PAIR001,003,1*39\r\n indicates that the module is turning off the power, $PAIR001,003,0*38\r\n indicates that the module is finished powering off.
2. $PAIR001,002,1*38\r\n indicates that the module is turning on the power, $PAIR001,002,0*39\r\n indicates that the module is finished powering on.
3. If you need to achieve lower current consumption in sleep mode, you can turn off the uart function, and the typical power consumption value is 1mA.Please refer to the “3.7 EINT_IN” section for details

3.2.3 RTC Mode

The module provides lower power consumption than sleep 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.

① Software RTC Mode:

- Enter software RTC mode:

1. Entering into RTC mode is controlled by UART interface, send $PAIR650,0*25\r\n to enter RTC mode.
2. Receive $PAIR001,650,0*38\r\n, Receive $PAIR650,0*25\r\n
3. Disconnect the VCC separately and keep the V_BACKUP powered on after receiving $PAIR650,0*25 at least 50ms.

- Exit software RTC Mode

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

② Hardware RTC Mode:

- 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 automatically.

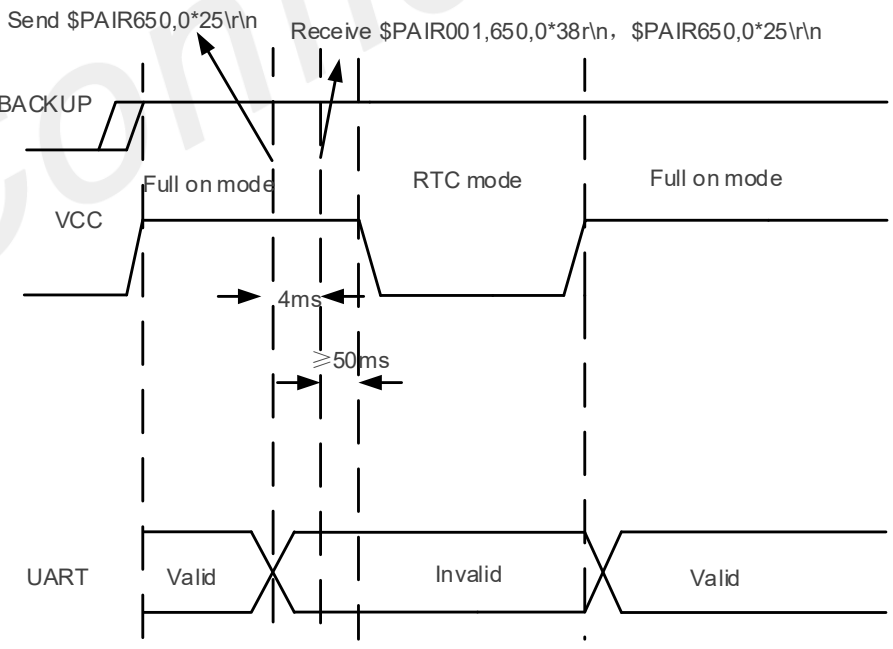


Figure 8: Enter and Exit Software RTC Mode

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NOTE

For command PAIR650, please refer to “SIM32 Series_NMEA Message_User Guide”.

3.3 UART Interface

The SIM32EA series modules provide a UART interface, and the default function configuration is as follows:

- Serial communication.
- NMEA output and PAIR command input.
- Firmware upgrade.

Table 11: Interface Function Pins

Pin Name	Pin Number	I/O	Description	Note
TXD0	2	DO	NMEA output	power domain is VCC
RXD0	1	DI	PAIR command input	

NOTE

1. The default baud rate is 115200, if other baud rate required please refer to “SIM32 Series_NMEA Message_User Guide”.
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).

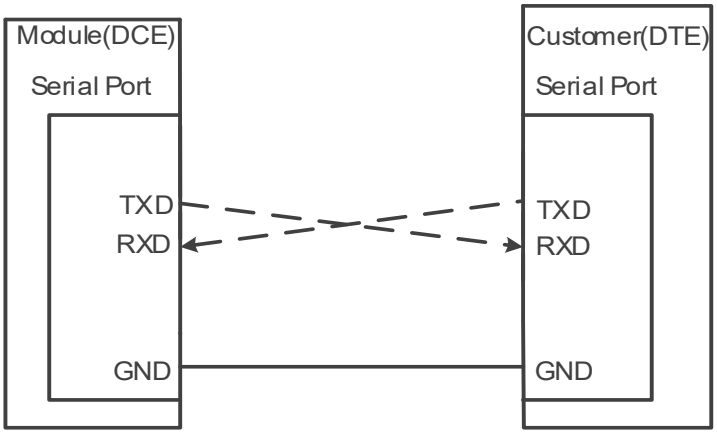


Figure 9: Connection of the Serial Interfaces

3.4 Timemark

The Timemark pin outputs 1PPS (One Pulse Per Second) for precise timing purposes after the position has been fixed. 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 1PPS (One Pulse Per Second) can serve as a clock pulse signal, outputting a periodic signal with one pulse per second. The time interval is synchronized with the GNSS (Global Navigation Satellite System) time grid.

To maintain the high precision of the 1PPS, it is necessary to ensure that there are visible satellites in an open - sky environment, and the VCC (Voltage Common Collector) should maintain power supply.

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3.5 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 1.8V inside the module, eliminating the need to add pull-up resistors outside the module. The module has diodes inside to be compatible with 1.8V/3.3V voltage inputs. The recommended circuit is as follows:

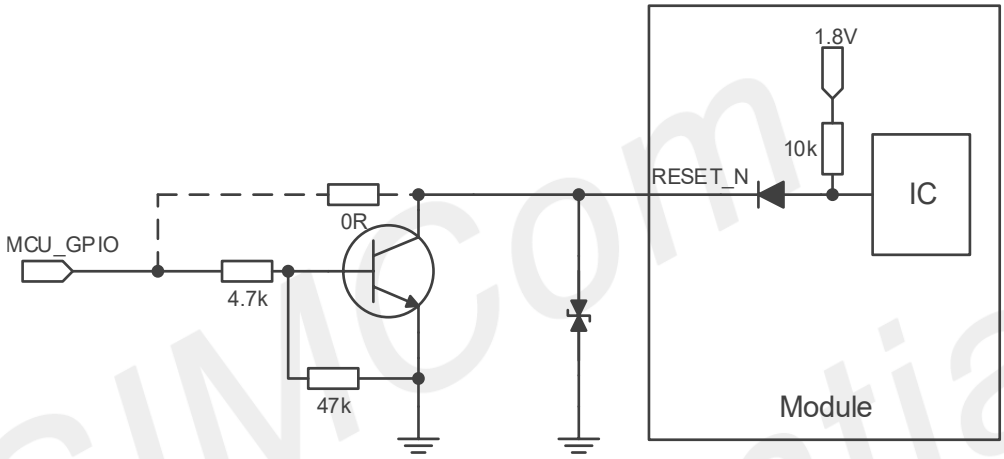


Figure 10: RESET Recommended Circuit

3.6 AADET_N

AADET_N pin is used to indicate the usage status of the external active antenna. When an external active antenna is not connected to the EX_RF_IN pin of the module, the pin outputs high. When the EX_RF_IN pin of the module is well connected to the active antenna, the pin outputs low. If you need to connect a passive antenna to the EX_RF_IN of the module, make sure that the pin is always kept low.

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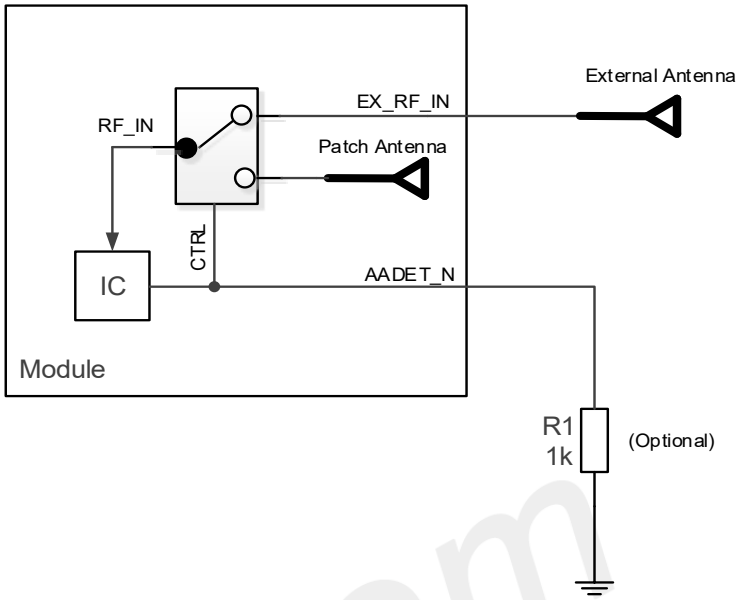


Figure 11: The principle block diagram of AADET_N

There are two ways to set the state of AADET_N.
1. In a hardware-based manner.
2. In a software-based manner.

Table 12: AADET_N status table

Ways	R1	Command	AADET_N	Comment
Hardware	NC	NC	Auto detect (defult)	Auto: the status of the external active antenna is automatically detected. If the external active antenna is working properly, AADET_N will output a low level.
	1k	NC	Low	
Software	NC	$PAIR10030,1,0*39	High	
	NC	$PAIR10030,2,0*3A	Low	

NOTE

1.When the AADET_N pin voltage is not greater than 0.4V, it can be switched to the external antenna.
2. For command PAIR10030, please refer to “SIM32 Series_NMEA Message_User Guide”.

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3.7 EINT_N

The module can be configured with UART sleep to reduce the power consumption of the module, especially in Sleep mode, after the UART sleep is enabled, it EINT_IN used to wake up the UART, and only when the UART is awakened, the module can send and receive instructions normally.

This function is disabled by default in the standard version, but if you need it, you can turn it on by commanding:

- Turn on the UART sleep function: $PAIR382,0*2F
- Turn off the UART sleep function: $PAIR382,1*2E

After the UART hibernation function is enabled, any commands that need to be sent through the UART need to be sent according to the following sequence:

① Pull down the EINT_IN at least 10ms, and in the process of pulling down the EINT_IN pin for 10ms, the module will return $PAIR012*39;
② Within 100 ms after receiving the return value $PAIR012*39, the UART is woken up and can communicate normally。

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4 Antenna

The SIM32EA series module has a built-in passive patch antenna with a size of 15mm*15mm*4mm and built-in LNA, which can have better performance and support the switching of external antenna and internal antenna.

In a weak signal environment, the antenna is the most critical component for the successful reception of GPS/GLONASS/BEIDOU*/Galileo. The correct selection and placement of antennas will greatly affect the quality of GNSS satellite search.

4.1 Built-in Patch Antenna

The quality of the antenna is critical to the sensitivity of a GNSS system.

4.1.1 Antenna Specifications

As mentioned above, the SIM32EA series integrates a GNSS antenna inside, which is a passive patch antenna with a size of 15mm*15mm*4mm, therefore, users do not need to additionally select and adjust the GNSS antenna.

The specifications for the integrated GNSS antenna are shown in the table below:

Table 13: Built-in patch antenna specifications

Parameter	Specification	Passive Antenna
Passive patch antennas	Frequency range	1575.42±2MHz
	Polarization	RHCP
	VSWR	1.5 max
	Output impedance	50 Ω
	Noise Figure	<1.5 dB

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4.1.2 Application Note

A GNSS patch antenna consists of a radiation patch on one side of a dielectric substrate and a ground plane support on the other side, as shown in Figure 12:

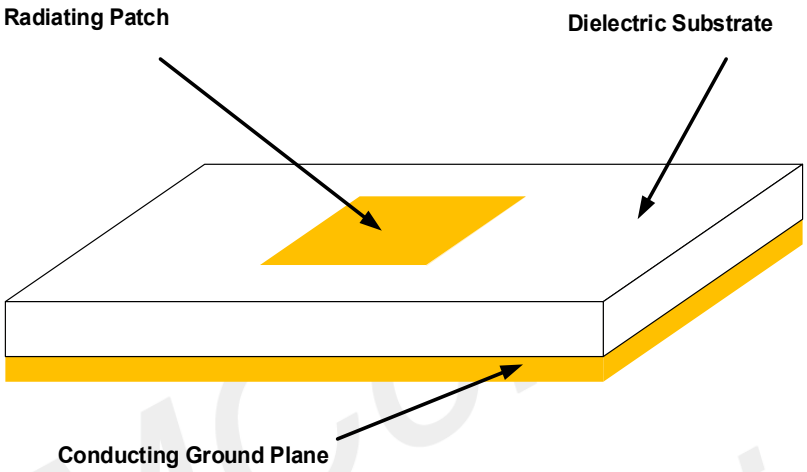


Figure 12: Basic Features of GNSS Patch Antennas

The radiation characteristics of an antenna depend on a variety of factors, including the environment in which the antenna is installed, the mutual coupling effect of the antenna, the size of the PCB, and the dielectric constant of nearby components. When using SIM32EA, the PCB design should strictly adhere to the following rules:

- The SIM32EA should be placed correctly, and the most important thing is to ensure that the antenna is facing the sky.
- Ensure that the antenna is not covered by any metal device or metal shell. This is because metal devices block most GNSS signals.
- The height of the devices around the module should not exceed the antenna at least, otherwise, the antenna performance will be more or less affected.
- If the device carries a large number of interference signals around the module, it should be kept away from the module or placed on the back of the motherboard where the module is located, or the interference signal should be shielded by shielding means.

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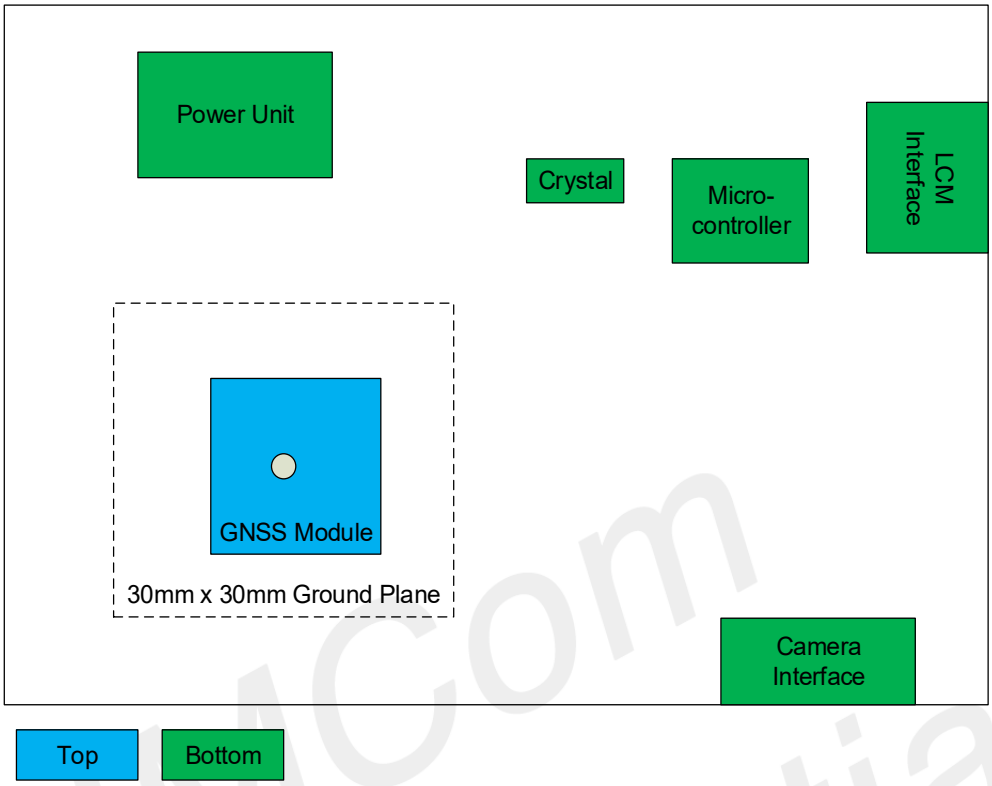


Figure 13: Recommended Placement Between the Module and other Devices

4.2 EX_RF_IN

The SIM32EA series receives L1 band signals from GPS/GLONASS/BEIDOU*/Galileo satellites, and the RF signal is connected to the RF_IN pin. The trajectory from RF_ IN to the antenna should be controlled to 50Ω impedance.

To accommodate the physical design of each application, RF interface pads are available in two options:

- 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.

4.2.1 Antenna Selection is Considered

The recommended antenna should be selected as follows:

Table 14: Antenna Specifications

Parameter	Specification	Active Antenna
Antenna recommendations	Frequency range	1559～1606MHz
	Polarization	RHCP
	VSWR	< 2
	Total gain	< 17 dB
	Noise Figure	< 1.5 dB@Hz

NOTE

Total antenna gain = gain of the internal LNA - total insertion loss inside the antenna.

4.2.2 Passive Antenna

Passive antennas contain only radiating elements, such as ceramic patches, helical structures, and chip antennas. Sometimes it also contains a passive matching network to match the electrical connection to a 50 ohm impedance.

The most common type of antenna for GPS/GLONASS/BEIDOU*/Galileo applications is patch antennas. Patch antennas are flat, typically have a ceramic and metal body, and are mounted on a metal substrate. Figure 14 shows the minimum setup for a GPS/GLONASS/BEIDOU*/Galileo receiver with SIM32EA module.

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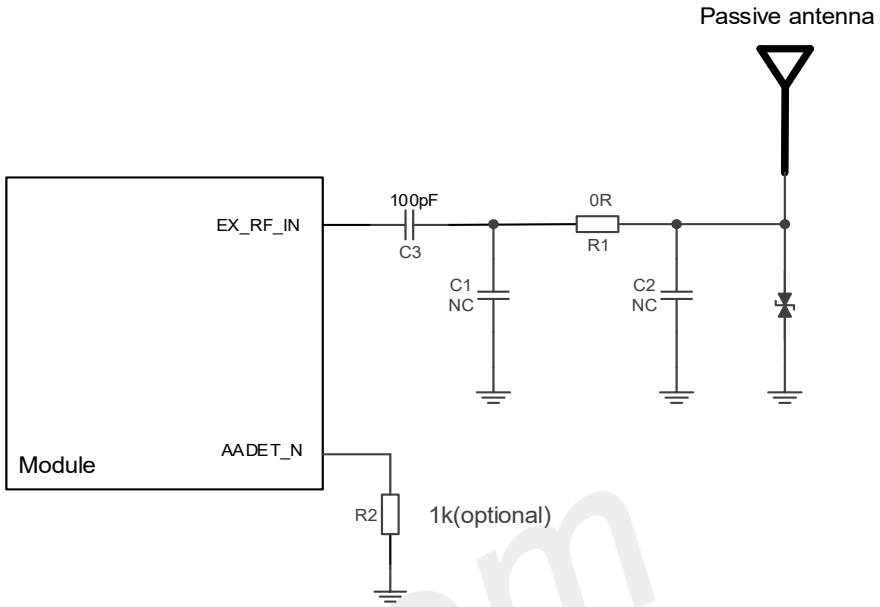


Figure 14: SIM32EA Series Passive Antenna Design

C1, R1, and C2 form a reserved π matching circuit to optimize the input impedance of the antenna. D1[1] is a TVS for electrostatic protection (ESD). C3[2] is a DC-blocking capacitor, since EX_ANT supports powering an active antenna by default, it is recommended to add a DC-blocking capacitor of 100pF when connecting an external passive antenna. The entire RF link must be controlled to an impedance of 50 Ω and the cabling must be as short as possible.

When the EX_ANT pin is connected to an external passive antenna, the RF link of the module cannot be automatically switched to the external EX_ANT, and the internal RF link can be switched in two ways:

- Send $PAIR10030,2,0*3A can be set to AADET_N output low level, at this time, the internal RF link of the module switches to the external passive antenna. After the command is sent, the module will output a $PAIR001,10030,0*39 statement indicating that the module has successfully switched to an external passive antenna.

- Connect the AADET_N pin to GND via an external 1k resistor, no need to send any commands. The reference design is shown in Figure 14.

NOTE

1.TVS requires ultra-low junction capacitance, which is recommended to be less than 0.5pF.
2.When an external passive antenna is connected, C3 is necessary as a DC-blocking capacitor.

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Table 15: 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

4.2.3 Active Antennas

The active antenna has an integrated low-noise amplifier (LNA). The active antenna needs to be powered by a power supply, which will increase the power consumption of the system, and the specific increase in power consumption is determined by the active antenna. By default, the module EX_ANT can output power to supply power to the active antenna, and the output voltage is determined by VCC.

Typically, the supply voltage is fed to the antenna via a coaxial RF cable shown in Figure 15. For the output voltage of pin 14, refer to the module model used. If the output voltage of pin 14 meets the supply voltage of the active antenna, pin 14 can be connected to the RF_IN VDD_ANT, as shown in Figure 15. If not, please use another power supply to power the active antenna. However, in this case, please refer to Figure 14 for the design and add the pull - down resistor R2 and the DC - blocking capacitor C3.

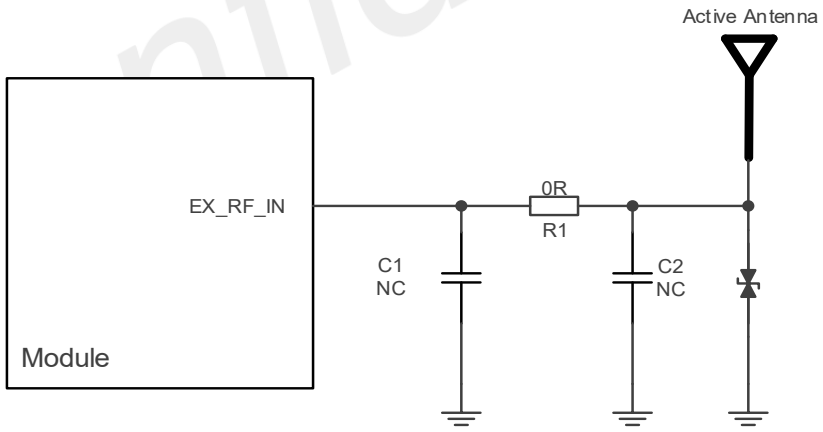


Figure 15: SIM32EA Active Antenna Design

C1, R1, and C2 form a reserved π matching circuit to optimize the input impedance of the antenna. D1 is a TVS for electrostatic protection (ESD). The entire RF link must be controlled to an impedance of 50 Ω and the cabling must be as short as possible.

If the customer's design is for an automotive application, an active antenna can be used and mounted on

top of the car to ensure the best signal quality.

The choice of GNSS antenna should be based on the design, product, and other criteria. For detailed antenna design considerations, please refer to the design recommendations of the relevant antenna vendor. The antenna supplier will provide further technical support and adjust their antenna characteristics based on the customer's design to achieve successful GNSS reception performance.

4.3 External Active Antenna Status Indicator

The module supports the function of external active antenna status detection. The status of the active antenna can be queried through commands, and it can also be observed in real time through NMEA information (default is on, can be configured to turn off through commands).

■ Query active antenna status command: ***$PAIR10031*39***. If the module returns ***$PAIR001,10031,0*38***, it indicates that the command was sent successfully. When the module returns ***$PAIR10031,<mode>,<URC mode>,<ANT Status>*xx***, it provides the following information:

● ***<mode>:*** 0 represents automatic detection of the AADET_N status, 1 represents manually setting AADET_N to a high level, and 2 represents manually setting AADET_N to a low level.

● ***<URC mode>:*** 0 means not outputting the active antenna status statement, and 1 means outputting the active antenna status statement.

● ***<ANT Status> :*** 0 indicates an unknown status, 1 indicates that the active antenna is normal, 2 indicates that the active antenna is open-circuited, and 3 indicates that the active antenna is short-circuited.

● ****xx :*** Checksum.

■ To enable the active antenna status indicator, the command sent is: $PAIR10030,0,1*39. If the module responds with $PAIR001,10030,0*39, it indicates that the command was successfully sent. After this, an additional NMEA sentence will be included, which is ***$ANTSTATUS,<mode>,<URC mode>,<ANT Status>*xx***.

■ To disable the active antenna status indicator, the command sent is: $PAIR10030,0,0*38. If the module responds with $PAIR001,10030,0*39, it indicates that the command was successfully sent. After this, the NMEA sentences will no longer include the ***$ANTSTATUS,<mode>,<URC mode>,<ANT Status>*xx*** statement.

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5 Electrical Characteristics

5.1 Absolute Maximum Ratings

The following table lists the absolute maximum ratings for the power supply and voltage of the SIM32EA series modules. Exceeding these absolute maximum ratings for voltage and storage temperature may cause permanent damage to the device.

Table 16: Absolute Maximum Ratings

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

5.2 Recommended Operating Conditions

Table 17: SIM32EA Series Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature range		-40	+25	+85	℃
Main Power Supply Voltage	VCC	1.75	3.3	3.6	V
Main Power Supply Current	I_{VCC}	-	-	100	mA
EX_RF_IN Voltage (Output)	EX_RF_IN	-	-	VCC	V
	I_{VDD_ANT}	-	-	I_{VCC}	mA
Backup Power Supply Voltage	V_BACKUP	1.7	3.3	3.6	V
Backup Power Supply Current	I_{V_BACKUP}	-	-	200	uA

NOTE

The actual power requirements may vary depending on processor load, external circuits, firmware version, number of tracked satellites, signal strength, test time, and conditions.

5.3 Electrostatic Discharge (ESD) Protection

The SIM32EA is an electrostatic discharge (ESD) sensitive device. Therefore, users must pay attention to ESD protection during production, assembly, and operation of the module. The ESD performance parameters of the module are listed in the following table.

Table 18: ESD Performance Parameters (Temperature: 25°C, Humidity: 45%)

Pin	Contact Discharge	Air Discharge
VCC	± 5 kV	± 10 kV
V_BACKUP	± 5 kV	± 10 kV
GND	± 5 kV	± 10 kV
EX_RF_IN	± 5 kV	± 10 kV

NOTE

Test conditions: The external of the module has surge protection diodes and ESD protection diodes.

6 Manufacturing

6.1 Top and bottom View of SIM32EA Series

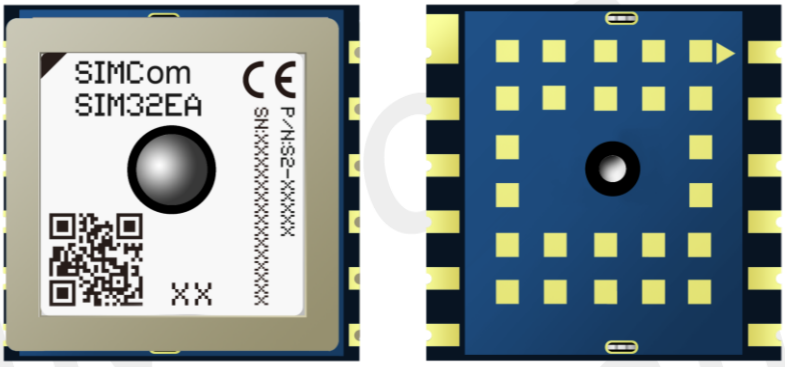


Figure 16: Top and Bottom View of SIM32EA

6.2 Label Information

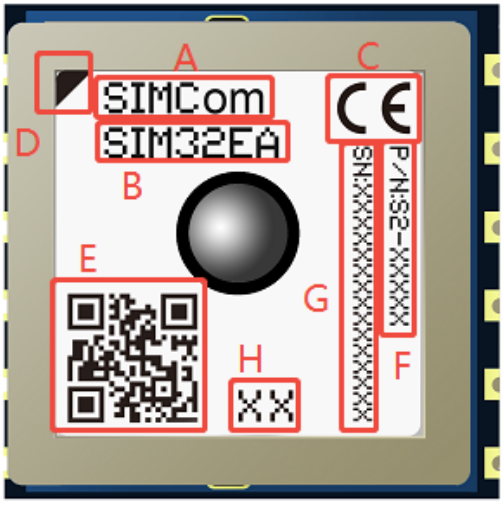


Figure 17: Label of SIM32EA

Table 19: Label of Module Information

Item	Description
A	Logo of SIMCom
B	Module name
C	Certification Information
D	PIN 1 Mark
E	QR code, which contains product information
F	Module part number Hardware number included; ex.S2-10990 is hardware number
G	Module serial number, it contains the production information of the product
H	Model code, which is used to distinguish different models

NOTE

The above is a design rendering of the module for reference only. The actual appearance should be based on the physical product.

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6.3 Recommended PCB Footprint

The following figure shows the PCB footprint of the modules:

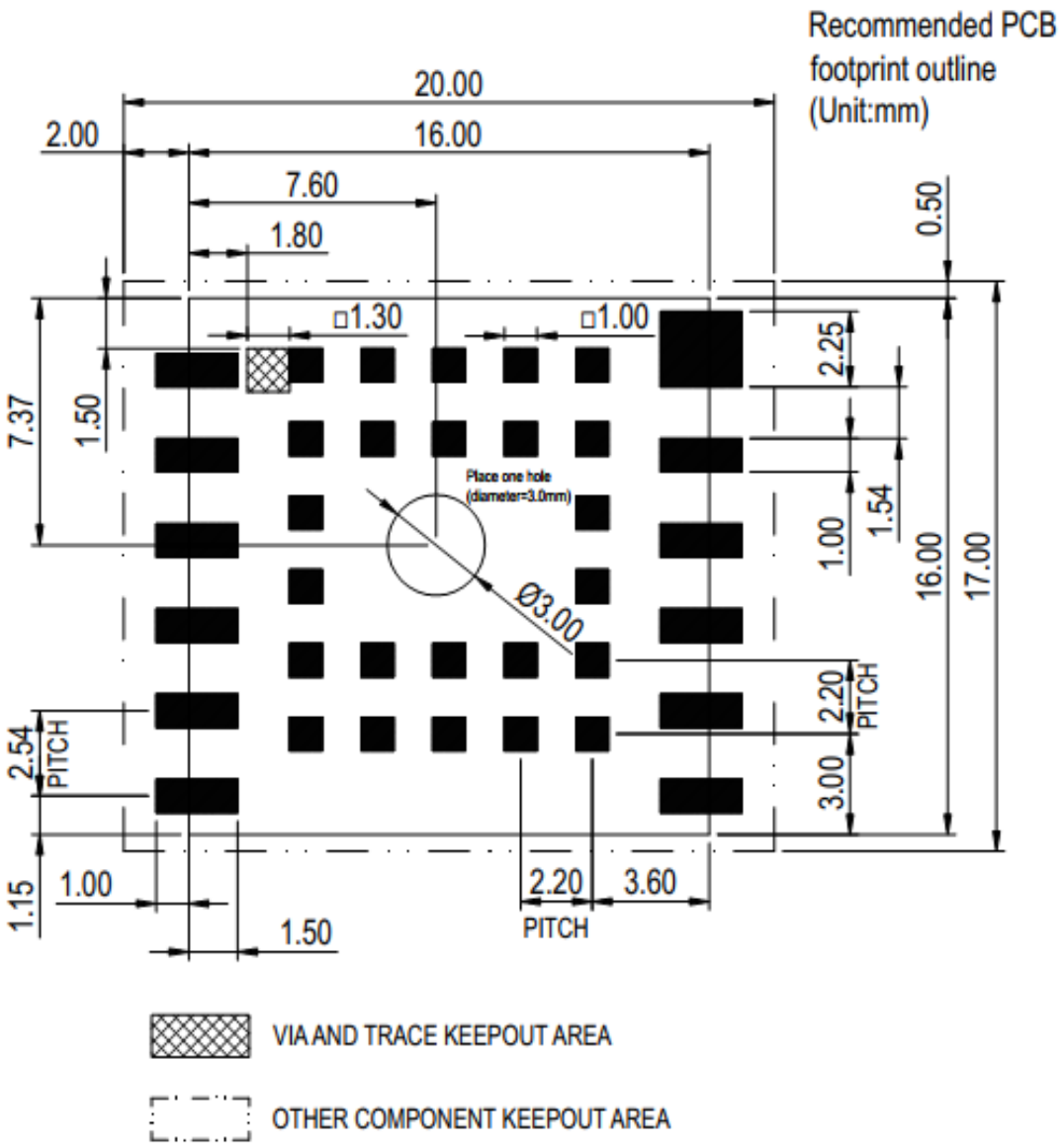


Figure 18: Recommended PCB Footprint (Top View) (Unit: mm)

6.4 Recommended SMT Stencil

The following figure shows the recommended SMT stencil dimensions for the SIM32EA series. The suggested stencil thickness is 150um.

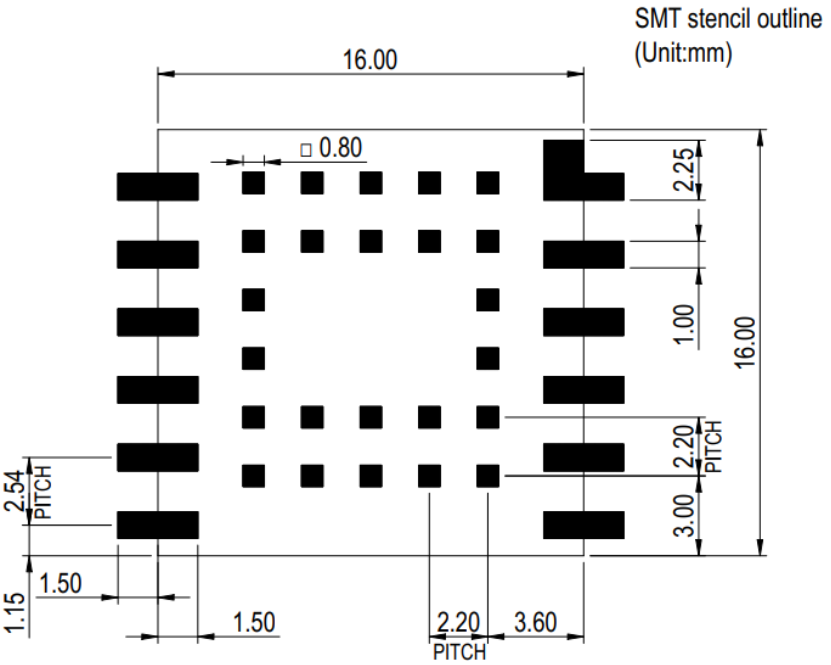


Figure 19: Recommended SMT Stencil(Top View)

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6.5 Recommended Reflow Furnace Temperature Curve

The following figure is the Ramp-Soak-Spike Reflow Profile of SIM32EA Series.

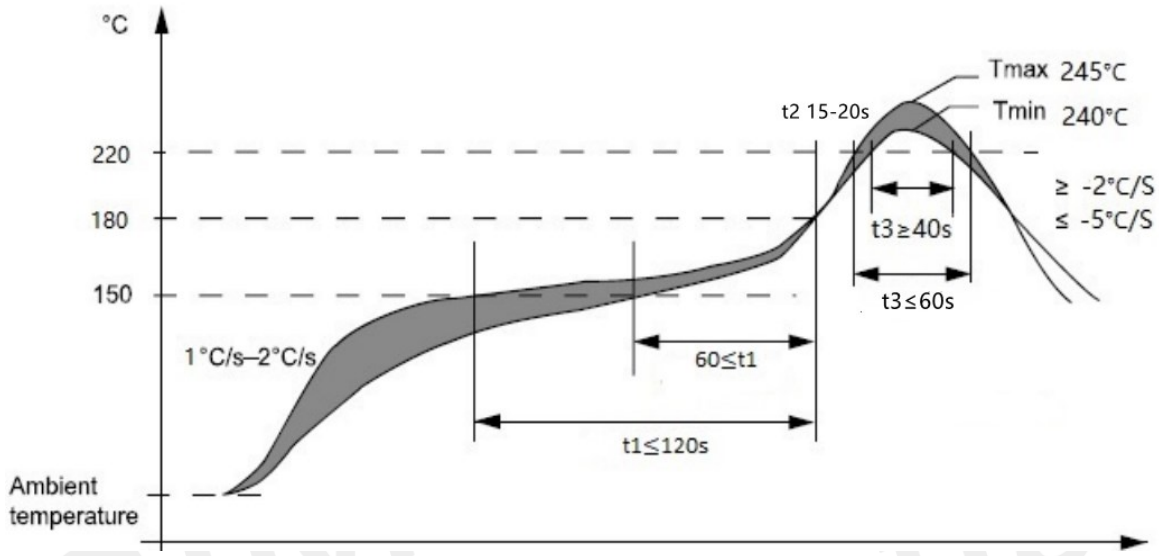


Figure 20: Recommended Reflow Furnace Temperature Curve (Lead-Free)

Table 20: 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.

6.6 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 21: 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 24). 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.

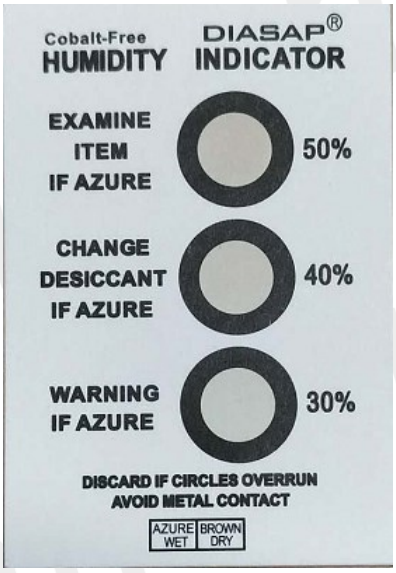


Figure 21: Humidity Card

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.

6.7 Baking Requirements

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

Table 22: 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.

7 Packaging

Module support tray packaging。

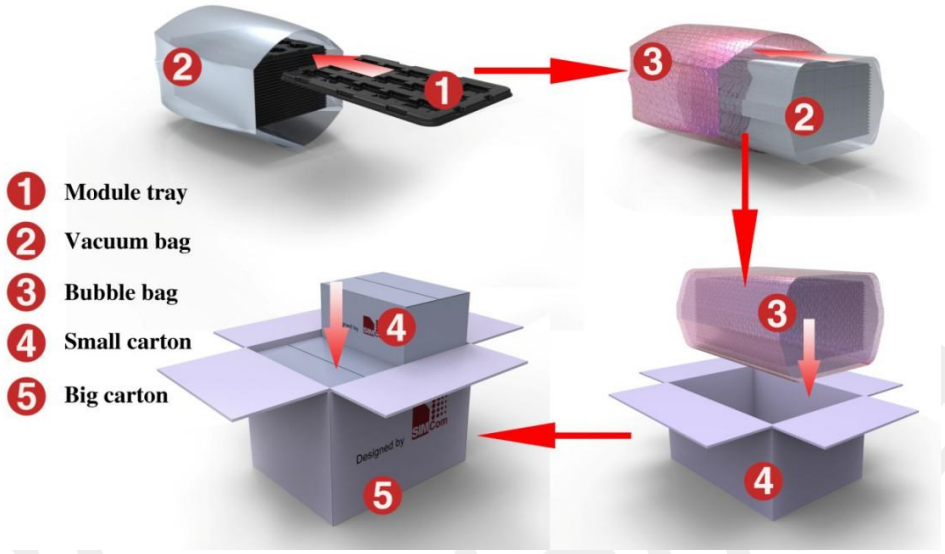


Figure 22: Aackaging Diagram

Module tray drawing:

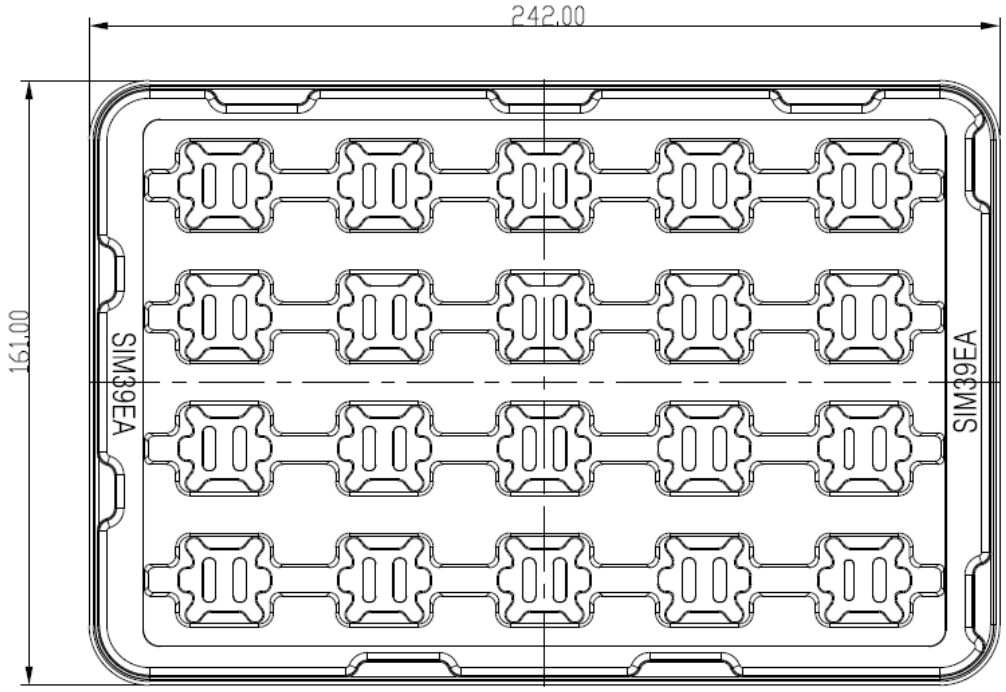


Figure 23: Tray Drawing

Table 23: Tray Size

Length（±3mm）	Width（±3mm）	Module Number
242.0	161.0	20

Small carton drawing:

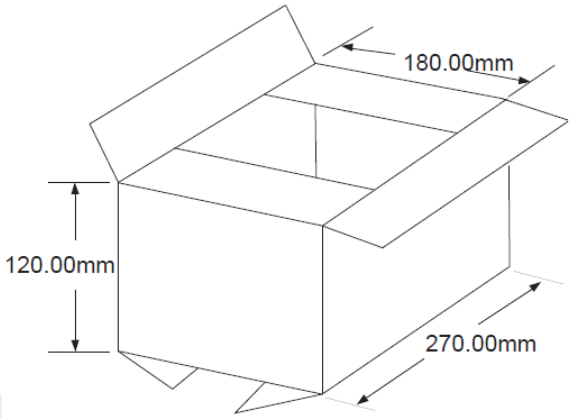


Figure 24: Small Carton Drawing

Table 24: Small Carton Size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module Number
270	180	120	20*10=200

Big carton drawing:

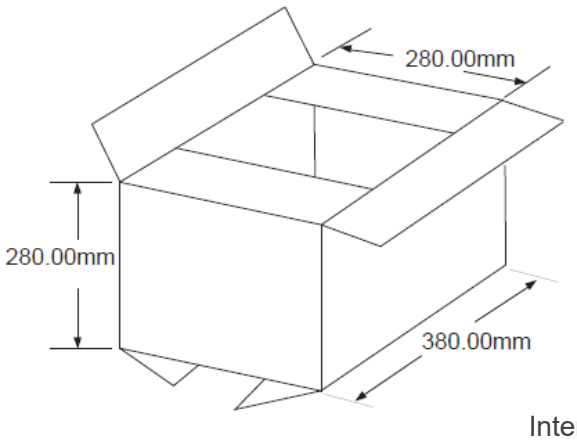


Figure 25: Big Carton Drawing

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Table 25: Big Carton Size

Length（±10mm）	Width（±10mm）	Height（±10mm）	Module Number
380	280	280	200*4=800

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8 Reference Design

The following diagram shows a typical application for SIM32EA module. If you are using an active antenna, please replace C1 with a 0R resistor, and if you need to connect an external passive antenna, short the TP101 and replace C1 with a 100pF capacitor.

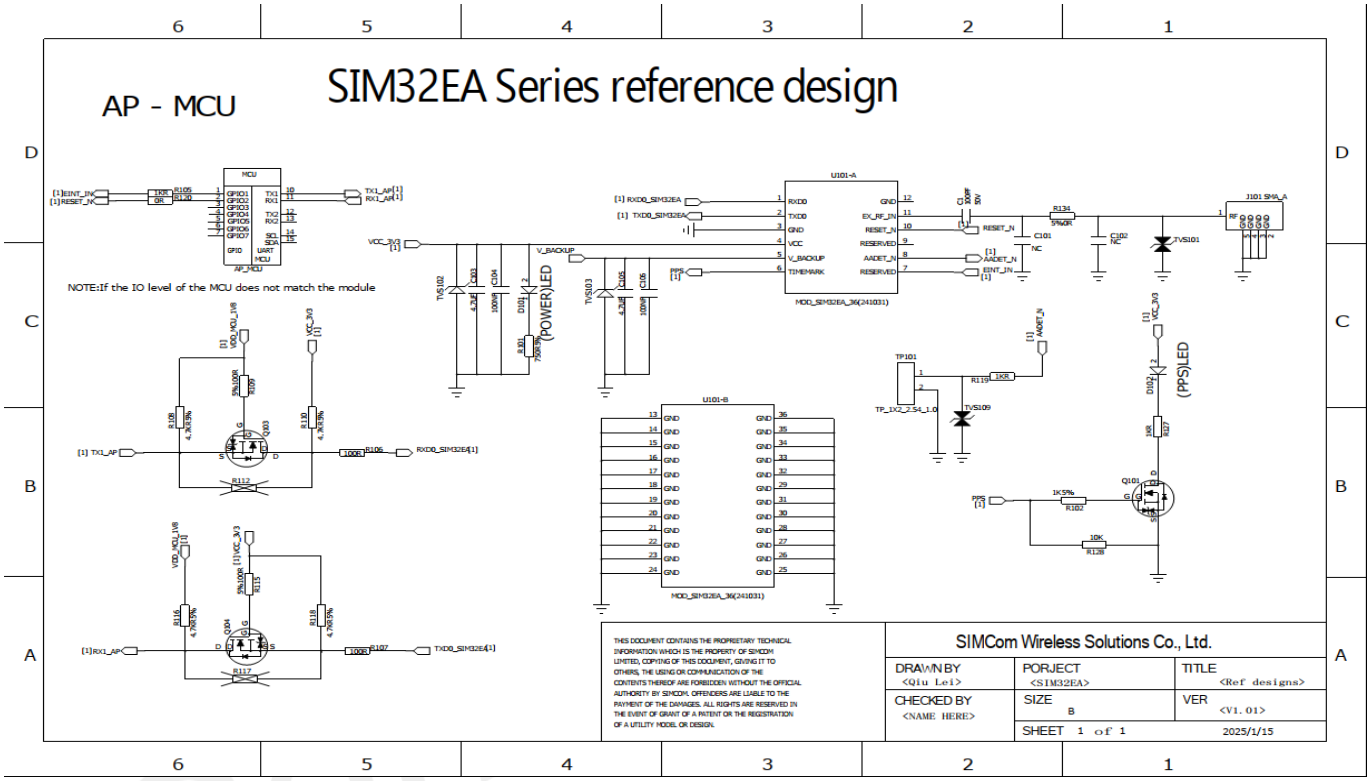


Figure 26: Refer Schematic

NOTE

Please pay attention to the I/O voltage level of SIM32EA. Users should ensure voltage level matching when using it.

9 Appendix

9.1 Related Documents

Table 26: Related documents

SN	Document name	Remark
[1]	SIM32EA Series_Hardware_Design (this document)	It mainly introduces hardware components such as interface functions,recommended circuits, PCB layout guides, packaging, and software instructions
[2]	SIM32EA Series-EVB_User_Guide	Introduction to how to use the SIM32EA with EVB
[3]	SIM32EA_EVB SCH&PCB	SIM32EA-EVB schematic and PCB PDF document
[4]	MOD_SIM32EA_36 SCH&PCB	SIM32EA module reference package
[5]	SIM32 Series_NMEA Message_User Guide	The SIM32EA 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, ref low welding, welding and repair

9.2 Terms and Abbreviations

Table 27: 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
IC	Integrated Circuit
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

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9.3 Safety Caution

Table 28: 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.