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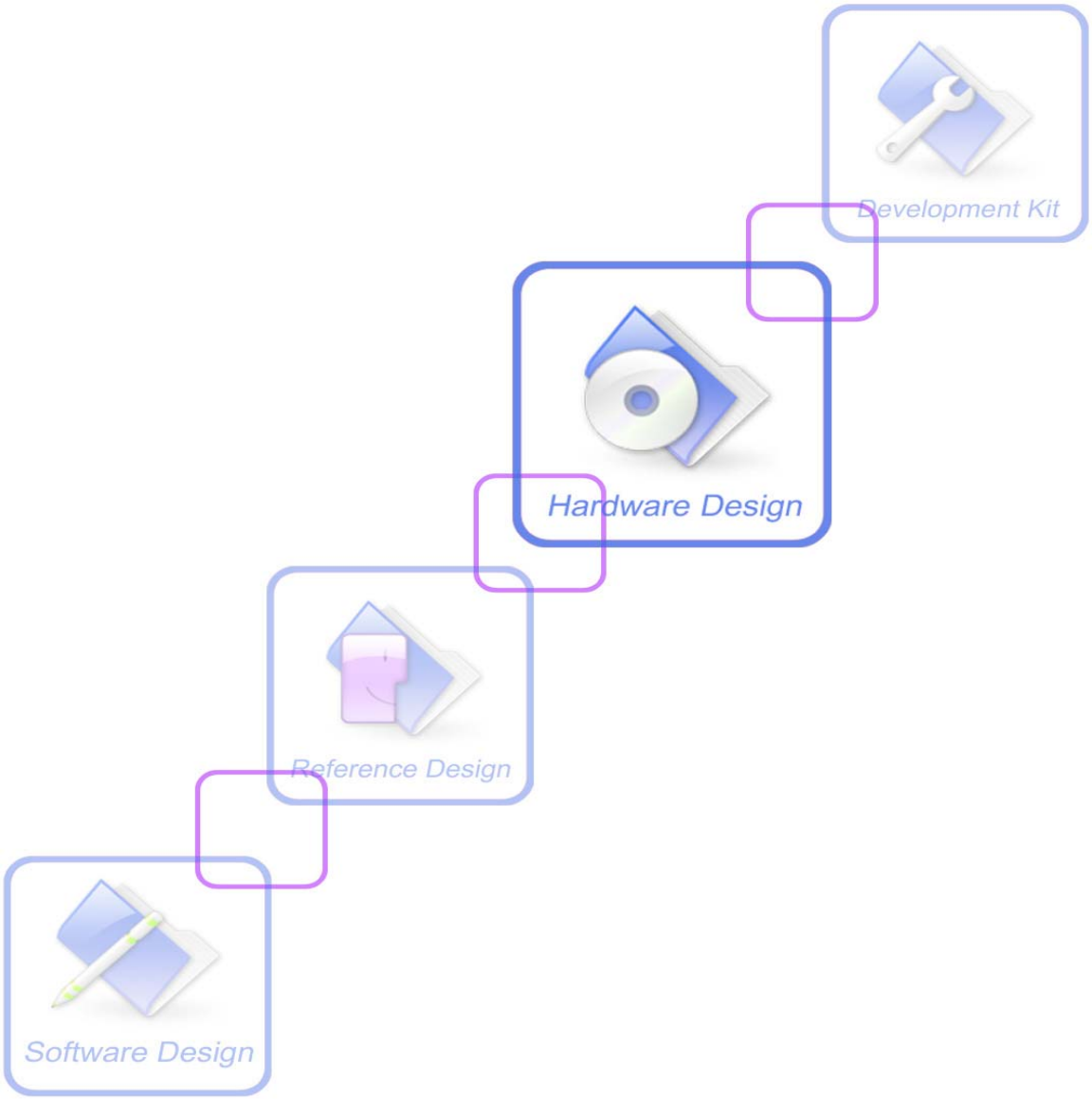
SIM28_Hardware Design_V1.06



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Version History

Date	Version	Description of change	Author
2011-06-25	V1.00	Origin	Jing.zhou jianmei.zhou
2011-09-19	V1.01	Delete internal LNA	Honggang ma
2011-09-22	V1.02	Add LNA, and correct RF parameter	Honggang ma Jing zhou
2013-01-23	V1.03	Update figure 4	Honggang ma
2013-03-22	V1.04	Update the document	Honggang ma Xiaohan Jin
2013-04-17	V1.05	Update the operating temperature to -40 ~ +85ºC	Honggang ma
2013-05-22	V1.06	Add baudrate 38400 software version	Honggang ma

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1 Introduction

This document describes the hardware interface of the SIMCom module SIM28 which can be used as a stand alone or A-GPS (Assisted Global Positioning System) receiver. As a wide range of applications can be integrated in SIM28, all functional components of SIM28 are described in great detail.

2 SIM28 Overview

SIM28 is a stand-alone or A-GPS receiver. With built-in LNA, SIM28 can relax antenna requirement and do not need external LNA. SIM28 can track as low as -167dBm signal even without network assistance. SIM28 has excellent low power consumption characteristic (acquisition 24mA, tracking 19mA). SIM28 supports various location and navigation applications, including autonomous GPS, SBAS ranging (WAAS, EGNOS, GAGAN, and MSAS) and A-GPS.

Key Features

The module provides complete signal processing from antenna input to host port output in NMEA messages. The module requires 2.8V~4.3V power supply. The host port is configurable to UART. Host data and I/O signal levels are 2.8V CMOS compatible.

- GPS receiver, supports multi-GNSS include QZSS, SBAS ranging, supports WAAS/EGNOS/MSAS/GAGAN
- 22tracking/66 acquisition-channel GNSS receiver, up to 210 PRN channels
- Small footprint: 16 x 12.2 x 2.4mm, 24-pin LCC package
- 12 multi-tone active interference cancellers and jamming elimination(1)
- Indoor and outdoor multi-path detection and compensation
- Max NMEA update rate up to 10 HZ(2)
- Advanced software features
  1. EASY self-generated orbit prediction
  2. EPO/HotStill orbit prediction
  3. AlwaysLocate advanced location awareness technology
- Pulse-per-second (PPS) GPS time reference
  1. Adjustable duty cycle
  2. typical accuracy: ±10ns
- Interface
  1. UART
  2. SPI/I2C(3)
- Operating temperature: -40 ~ +85ºC
- Accuracy 2.5m CEP
- RoHS compliant

(1) AIC can be controlled by PMTK command, see *document [2]* for details.
(2) Default is 1 HZ. And EASY function can be activated only at 1 HZ update rate.
(3) SPI and I2C can not be applied synchronously.

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2.1 SIM28 Functional Diagram

The following figure shows a functional diagram of the SIM28 and illustrates the mainly functional parts:

- The main chip
- SAW filter
- Low noise amplifier
- The antenna interface
- The communication interfaces
- The control interfaces

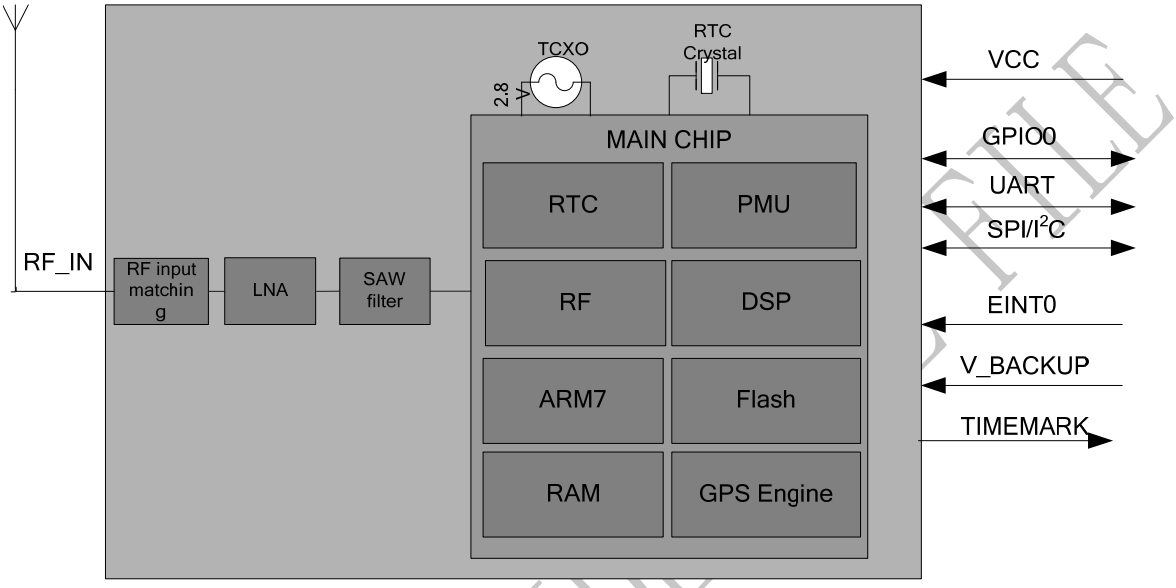

Figure 1: SIM28 functional diagram

2.2 GPS Performance

Table 1: GPS performance

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy(1)	Autonomous		2.5m CEP		m
Velocity Accuracy(2)	Without Aid		0.1		m/s
	DGPS		0.05		m/s
Acceleration Accuracy	Without Aid		0.1		m/s^2
	DGPS		0.05		m/s^2
Timing Accuracy			10		nS
Dynamic Performance	Maximum Altitude			18000	m
	Maximum Velocity			515	m/s
	Maximum Acceleration			4	G
TTFF(3)	Hot start		<1		s

	Warm start		30		s
	Cold start		32		s
TTFF with EASY(5)	Hot start		0.3		s
	Warm start		1.4		s
	Cold start		13.8		s
A-GPS TTFF(EPO in flash mode)	Hot start		0.7		s
	Warm start		1.5		s
	Cold start		12.5		s
Sensitivity	Autonomous acquisition(cold start)		-147		dBm
	Re-acquisition		-160		dBm
	Tracking		-167		dBm
Receiver	Channels		66		
	Update rate		1	10	Hz
	Tracking L1, CA Code				
	Protocol support NMEA,PMTK				
Power consumption(4)	Continuous tracking		19		mA
	Sleep current		200		uA

(1) 50% 24hr static, -130dBm
(2) 50% at 30m/s
(3) GPS signal level: -130dBm
(4) Single Power supply 3.3V
(5) EASY can not work at the simulation environment, this test implemented at a good test condition.

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2.3 General Features

Table 2: General features

Parameters		Value
Supply voltage VCC		+2.8V~4.3V
Supply voltage ripple VCC		54 mV(RMS) max @ f = 0~3MHz 15 mV(RMS) max @ f > 3 MHz
Power consumption(acquisition)		24mA type. @ VCC=3.3 V
Power consumption(sleep)		200uA type. @ VCC=3.3 V
Storage temperature		-40ºC~+85ºC
Operating temperature		-40ºC~+85ºC
I/O signal levels	VIL	-0.3V~0.8V
	VIH	2.0V~3.6V
	VOL	-0.3V~0.4V

	VOH	2.4V~3.1V
I/O output sink/source capability		+/- 3mA max
I/O input leakage		+/- 10 uA max
Host port		UART
Other port		I^2C/SPI
Serial port protocol (UART)		NMEA; 8 bits, no parity, 1 stop bit; 115200 baud (configurable)
TM output (1PPS)		1 pulse per second, synchronized at rising edge, pulse length 300ms

3 Package Information

3.1 Pin Out Diagram

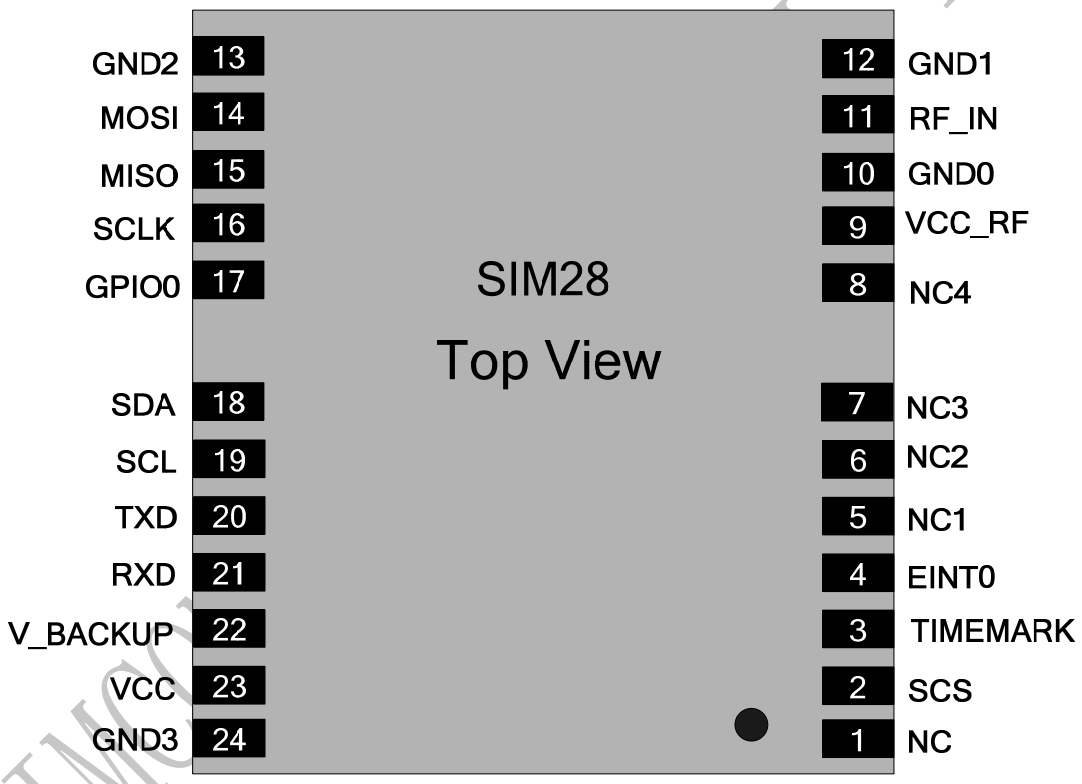

Figure 2: SIM28 pin out diagram (Top view)

3.2 Pin Description

Table 3: Pin description

Pin name	Pin number	I/O	Description	Comment
Power supply				
VCC	23	I	Main power input, which will be used to power the baseband and RF section internally.	Provide clean and stable power source to this pin. Add a 4.7uF capacitor to

				this pin for decoupling.
VCC_RF	9	O	2.8V output power supply for active antenna	If unused, keep open.
V_BACKUP	22	I	The backup battery input power supply for RTC	If unused, keep open. Do not support battery charge function.
GND	10,12,13,24		Ground	GND
Host port interface				
MISO	15	I	SPI MISO	If unused, keep open.
MOSI	14	O	SPI MOSI	
SCLK	16	O	SPI clock	
SCS	2	O	SPI slave select	
SDA	18	I/O	I^2C data	If unused, keep open.
SCL	19	I/O	I^2C C Clock	
TXD	20	O	Serial output	
RXD	21	I	Serial input	
GPIOs				
EINT0	4	I	This interrupt source could act as wake up event during power saving mode. Provide an interrupt on either high or low logic level or edge-sensitive interrupt	If unused, keep open.
TIMEMARK	3	O	Time Mark outputs timing pulse related to receiver time	If unused, keep open.
GPIO0	17	I/O	GPIO can provide the developers signal or message outputs. GPIO supports a simple control interface.	If unused, keep open.
RF interface				
RF_IN	11	I	Radio antenna connection	Impendence must be controlled to 50Ω.
Other interface				
NC	1,5,6,7,8		Not Connected	

3.3 Package Dimensions

Following figure shows the Mechanical dimensions of SIM28 (top view, side view and bottom view).

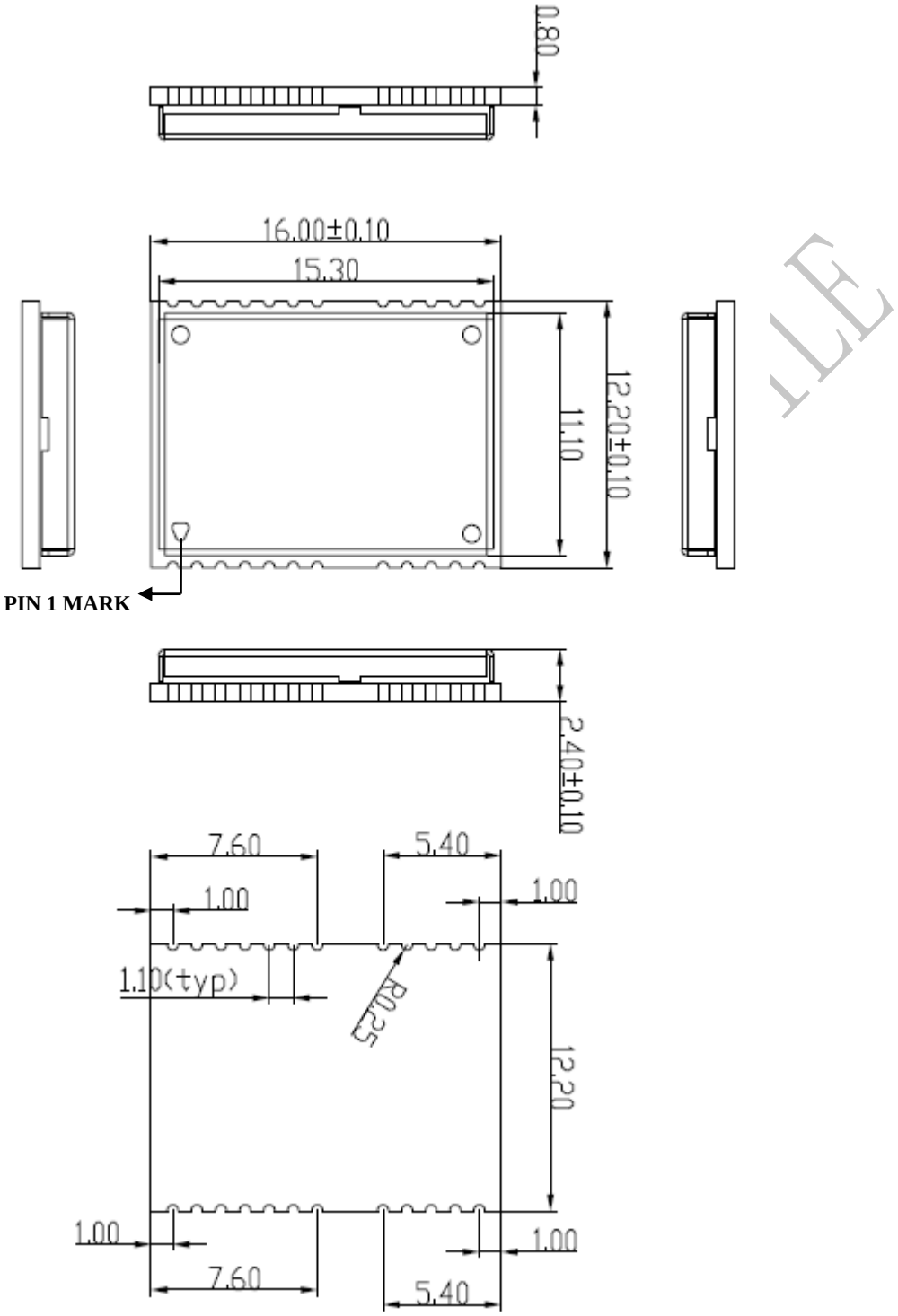

Figure 3: SIM28 mechanical dimensions (Unit: mm)

3.4 SIM28 Recommended PCB Decal

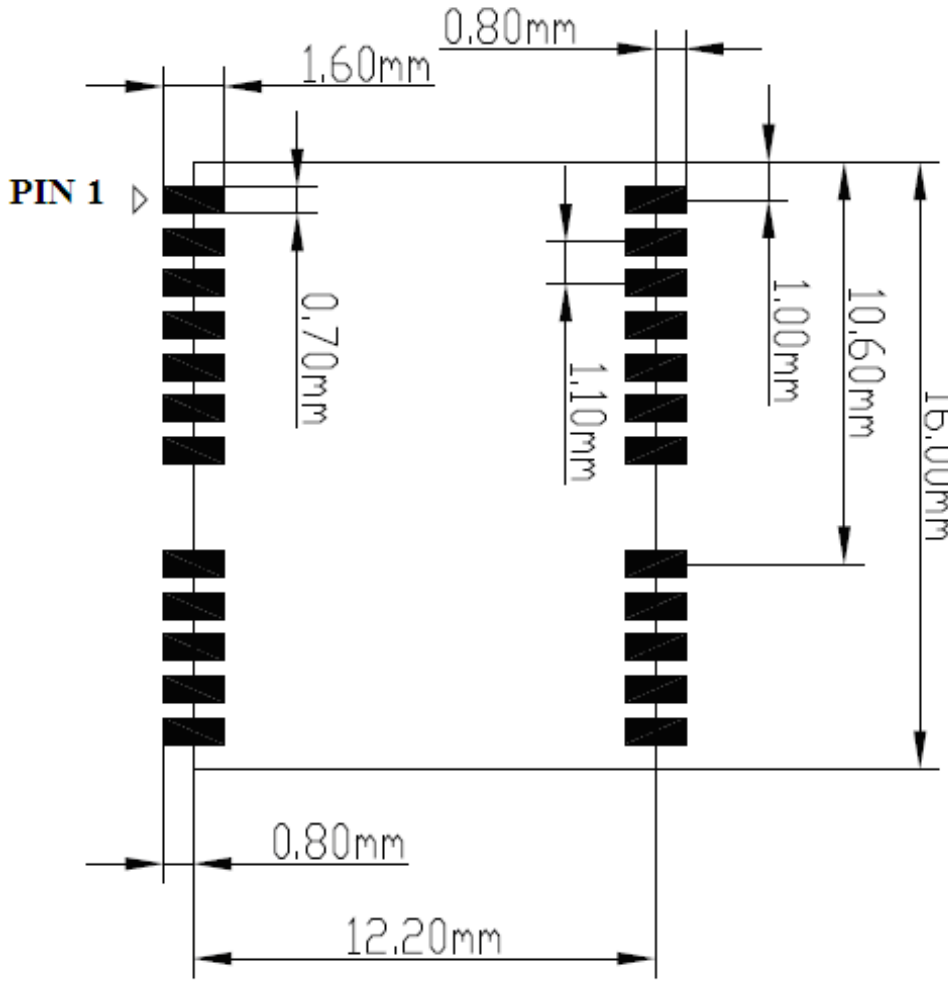

Figure 4: Recommended PCB decal (top view) (Unit: mm)

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4 Application Interface

4.1 Power Management

4.1.1 Power Input

The power supply range of SIM28 is from 2.8V to 4.3V. The power supply should be able to provide sufficient current up to 100mA.

4.1.2 Starting SIM28

For initial power up, the RTC must start oscillating to sequence the Finite State Machine. RTC startup time may vary. When power is first applied, SIM28 goes into operation mode.

4.1.3 Verification of SIM28 Start

System activity indication depends upon the chosen serial interface, When it is activated, SIM28 will output messages at the selected UART speed, and message types. The default baud rate is 115200bps.

4.1.4 Power Saving Modes

SIM28 provides very low leakage battery back up memory, which contains all the necessary GPS information for quick start up and a small amount of user configuration variables. It needs a 3V power supply for V_BACKUP pin, and the stable operation region ranges from very light load to about 3mA.

SIM28 supports operating modes for reducing average power consumption like sleep mode and AlwayLocate™ mode.

- Sleep mode**:** In this mode the receiver stays at full on power state. This mode can be waken up by the host sending the command through the communication interface or external interrupt.
- AlwayLocate™ mode: AlwayLocate™ is an intelligent controller of SIM28 periodic mode. Depending on the environment and motion conditions, SIM28 can adapt to adjust the on/off time to achieve balance of positioning accuracy and power consumption.

Note: all the operation to the SIM28 module are applied by PMTK commands, customer can refer to document [2] for more information.

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4.1.5 Operating Mode

Table 4: 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	on	on	on	off	on
Backup	on	on	off	off	on

4.1.5.1 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.

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.

4.1.5.2 Sleep Mode

Sleep mode means a low quiescent (200uA type.) power state, non-volatile RTC, and backup RAM block is powered on. Other internal blocks like digital baseband and RF are internally powered off. The power supply input VCC shall be kept active all the time, even during sleep mode. Waking up from and entering into sleep mode is controlled by UART interface, any byte typing-in will drag SIM28 out of sleep mode.

4.2 VCC_RF

VCC_RF is a 2.8V output for external antenna, for the detail usage of VCC_RF; customer can refer to *document [3]* for more application example.

4.3 UART Interface

SIM28 includes one configurable UART interface for serial communication. This UART can be as NEMA output and PMTK command input. The bit rates are selectable and ranging from 4.8 to 921.6kbps. UART can provide the developers signal or message outputs.

Note: The baud rate is 115200, if other baud rate required please contact SIMCom FAE.

Table 5: Host port multiplexed function pins

Pin name	Pin number	UART function
TXD	20	data transmit
RXD	21	data receive

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4.4 SPI Interface

The SPI interface is for connection of external serial flash to save configuration and A-GPS data. The SCS chip select signal is available to select external slaves. External SPI serial flash up to 128Mbits is supported.

Table 6 : SPI function pins

Pin name	Pin number	SPI function
MISO	15	Master input
MOSI	14	Master output
SCLK	16	Clock output
SCS	2	Chip select

4.5 I²C Interface

The SCL and SDA can be connected to an external I2C interface EEPROM up to 1 Mbits for reading and writing data into EEPROM. This can be used to store configurations permanently.

Note: The EEPROM and flash can not be supported at the same time.

4.6 Timemark Output

The Timemark pin outputs pulse-per-second (1PPS) pulse signal for precise timing purpose. 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.

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

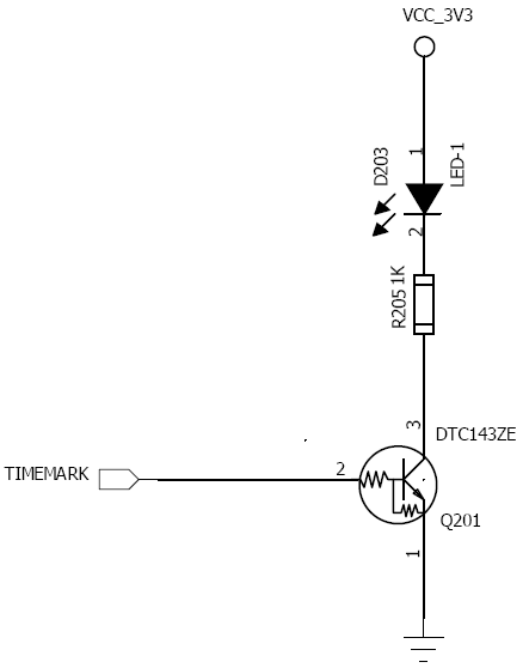

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Figure 5: TIMEMARK application circuit

4.7 A-GPS

A-GPS is the meaning of Assisted GPS, which is a system that can improve the startup performance under certain conditions, or time-to-first-fix (TTFF) of a GPS satellite-based positioning system. SIM28 module supports EPO file, EASY mode.

4.7.1 EPO

SIM28 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 be sent to the SIM28 by the HOST side. SIM28 has the shorter cold TTFF and warm TTFF when the A-GPS is used.

Note: For more information about EPO please reefer to document [4].

4.7.2 EASY Mode

EASY is the abbreviation of Embedded Assist System, it works as embedded software which accelerates TTFF by predicting satellite navigation messages from received ephemeris.

No additional computing interval for EASY task. EASY is efficiently scheduled and computed in free time of every second after GPS navigation solution.

EASY function is conceptually designed to automatically engage for predicting after first receiving the broadcast ephemeris. After a while (generally tens of seconds), 3-day extensions will be completely generated then all EASY functions will be maintained at a standby condition. EASY assistance is going to be engaged when the GPS requests in new TTFF condition or re-generates again with another new received ephemeris. Meanwhile, TTFF will be benefited by EASY assistance.

Note: EASY function is open by default and can be closed by PMTK command.

4.8 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

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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.

4.9 GPS Antenna

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

It is recommended to use an active GPS antenna. In a typical application, SIM28 with an active antenna can get a tracking sensitivity about 3dB better than SIM28 with a passive antenna.

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

Table 7: Antenna Specifications

Parameter	**Specification**	Passive and active antenna
Active Antenna Recommendations	Frequency range	1575±3MHz
	Polarization	RHCP
	Gain	>20dB (max 40 dB)
	Noise Figure	<1.5 dB

4.9.1 Antenna Interface

The SIM28 receives L1 band signals from GPS satellites at a nominal frequency of 1575.42 MHz. The RF signal is connected to the RF_IN pin. And the trace from RF_IN to antenna should be 50Ω controlled.

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

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

4.9.2 Antenna Choice and RF Design Consideration

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

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4.9.2.1 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 i mpedance.

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

Figure 5 shows a minimal setup for a GPS receiver with SIM28 module.

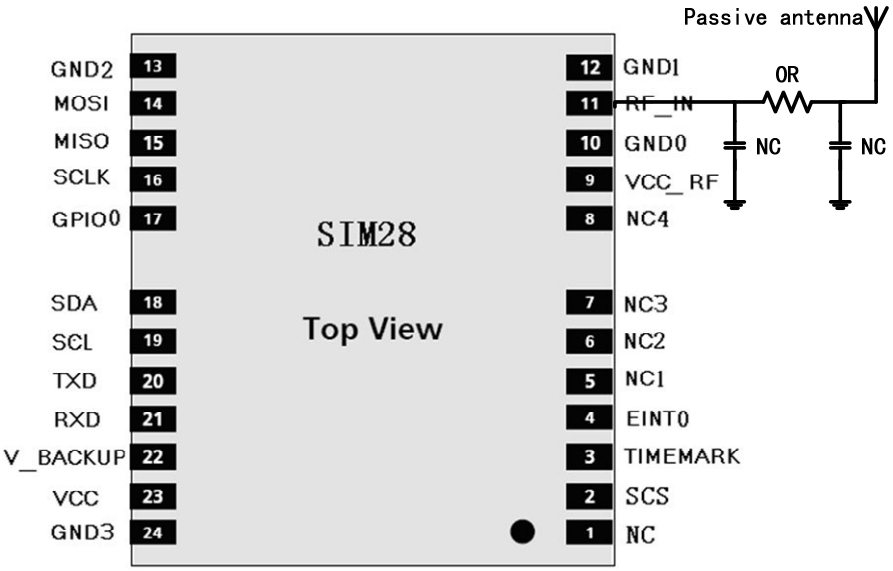

Figure 6: SIM28 passive antenna design

For best performance with passive antenna designs user can use an external LNA to increase the sensitivity up 3~4 dB. Please see Figure 6 and Figure 7, Figure 8? 没有解释？.

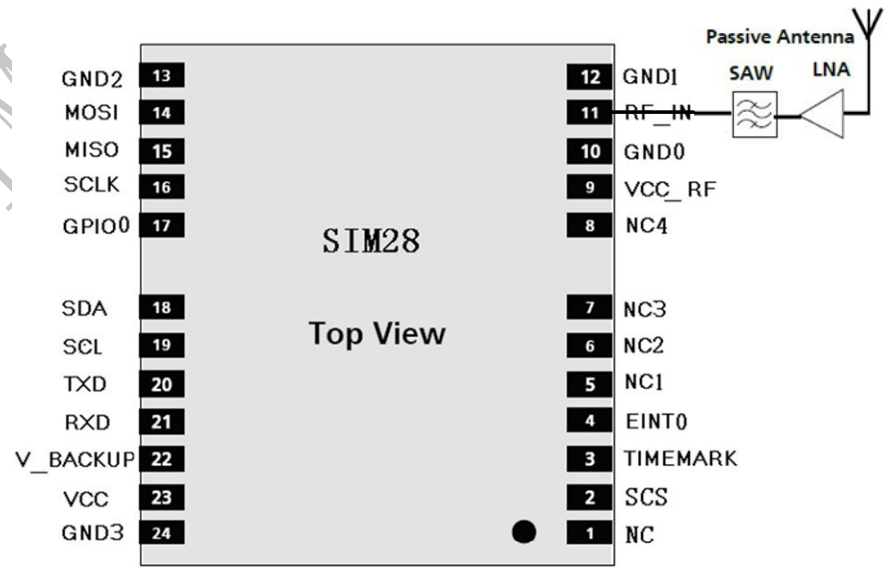

Figure 7: SIM28 passive antenna design (with external LNA and SAW)

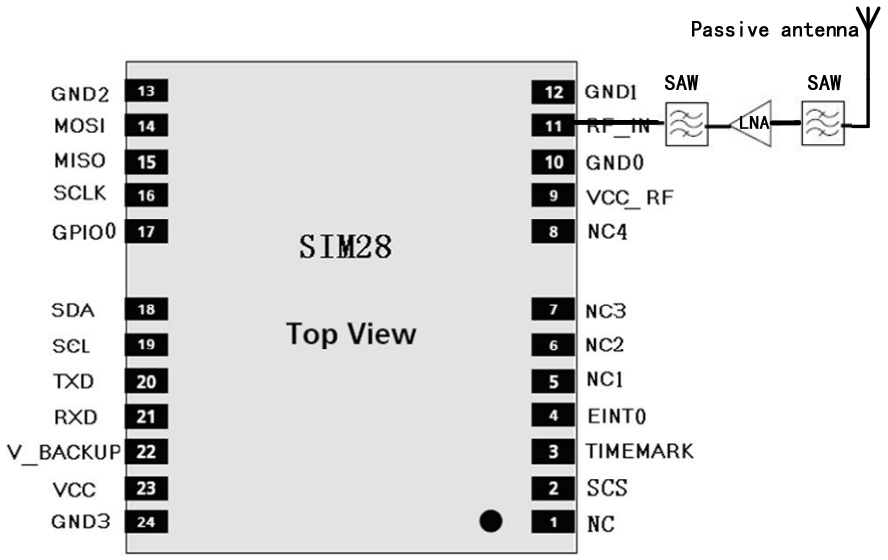

Figure 8: SIM28 passive antenna design for best performance and increased immunity

4.9.2.2 Active Antennas

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

Usually, the supply voltage is fed to the antenna through the coaxial RF cable shown as Figure 9. The output voltage of PIN 9 is 2.8V. If the supply voltage of active antenna is 2.8V, PIN 9 **VCC_RF** can be used as **V_ANT**. If the active antenna is less than 2.8V, other power should be connected to **RF_IN**.

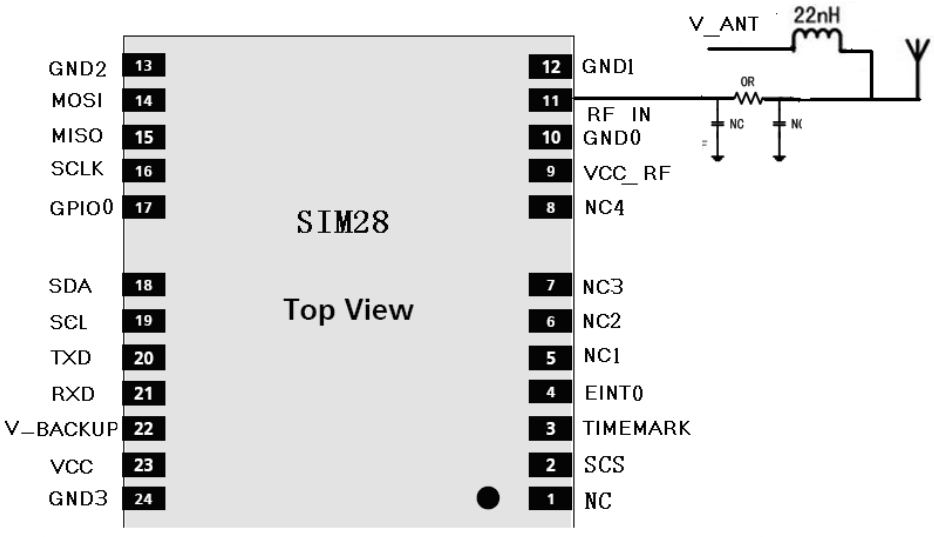

Figure 9: SIM28 Active antenna design

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.

GPS antenna choice should base on the designing product and other conditions. For detailed Antenna designing consideration, please refer to related antenna vendor's design recommendation. The antenna vendor will offer further technical support and tune their antenna characteristic to achieve successful GPS reception performance depending on the customer's design.

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5 Electrical, Reliability and Radio Characteristics

5.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 8 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to SIM28.

Table 8: Absolute maximum ratings

Parameter	Min	Max	Unit
VCC	-	4.3	V
Input Power at RF_IN	-	-12	dbm
V_BACKUP	-	4.6	V
I/O pin voltage	-	3.6	V
Storage temperature	-45	+125	℃
Operating Temperature	-40	+85	℃

5.2 Recommended Operating Conditions

Table 9: SIM28 operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature range		-40	+25	+85	℃
Main supply voltage	VCC	2.8	3.3	4.3	V
Active antenna supply voltage output	VCC_RF	2.7	2.8	2.9	V
	Imax			10	mA
Backup battery voltage	V_BACKUP	2.3		4.3	V

Table 10: SIM28 standard IO features

Parameter	Symbol	Min	Typ	Max	Unit
Low level output voltage Test conditions IOL = 2mA and 4.0mA	V_{ol}	-0.3		0.40	V
High level output voltage Test conditions IOL = 2mA and 4.0mA	V_{oh}	2.4		3.1	V
Low level input voltage	V_{il}	-0.3		0.8	V
High level input voltage	V_{ih}	2.0		3.6	V
Input Pull-up resistance	RPU	40		190	KΩ
Input Pull-dowm resistance	RPD	40		190	KΩ
Input capacitance	C_{in}		5		pF
Load capacitance	C_{load}			8	pF

Tri-state leakage current	IOZ	-10		10	uA

5.3 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 SIM28 module.

Table 11: The ESD characteristics (Temperature: 25℃, Humidity: 45 %)

Pin	Contact discharge（KV)	Air discharge（KV)
VCC	±5	±10
GND	±5	±10
VCC_RF	±5	±10
RF_IN	±5	±10

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6 Manufacturing

6.1 Label information

Figure 10: Label of SIM28

Table 12: illustration of module information

Item	Description
A	**Logo of SIMCom**
B	**Module name**
C	**Module part number** Hardware number and software number included; ex.S2-10488 is hardware number Z0X02 is software number
D	**Module serial number** The first number stands for factory code; The second number stands for year code; The third to eighth numbers is the SN number in hexadecimal numeric; The last two numbers stands for MNEA sentence baud rate, “11” stands for 115200, “96” stands for 9600; “38” stands for 38400;
E	**Module bar code** Stands for the first 6 numbers of SN number
F	**PIN 1 Mark**

6.2 Assembly and Soldering

The SIM28 module is intended for SMT assembly and soldering in a Pb-free reflow process on the top side of the PCB. Suggested solder paste stencil height is 150um minimum to ensure sufficient solder volume. If required paste mask pad openings can be increased to ensure proper soldering and solder wetting over pads.
The following figure is the Ramp-Soak-Spike Reflow Profile of SIM28:

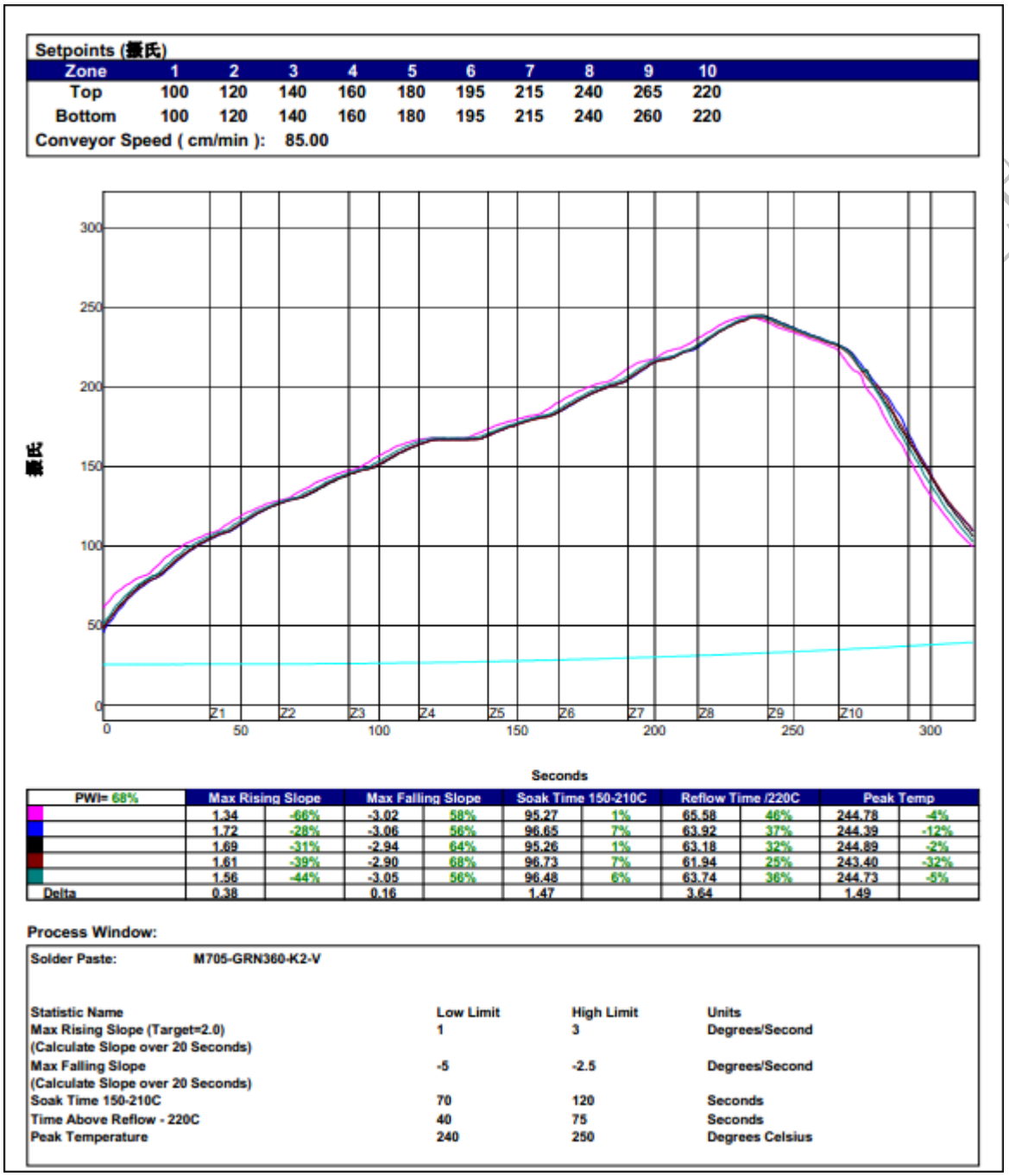

Figure 11: The Ramp-Soak-Spike reflow profile of SIM28

SIM28 is Moisture Sensitive Devices (MSD), appropriate MSD handling instruction and precautions are summarized in Chapter 6.2.

SIM28 modules are also Electrostatic Sensitive Devices (ESD), handling SIM28 modules without proper ESD protection may destroy or damage them permanently.

Avoid ultrasonic exposure due to internal crystal and SAW components.

6.3 Moisture Sensitivity

SIM28 module is moisture sensitive at MSL level 3, dry packed according to IPC/JEDEC specification J-STD-020C. The calculated shelf life for dry packed SMD packages is a minimum of 12 months from the bag seal date, when stored in a non condensing atmospheric environment of <40°C/90% RH.

Table 10 lists floor life for different MSL levels in the IPC/JDEC specification:

Table 13: Moisture Classification Level and Floor Life

Level	Floor Life(out of bag)at factory ambient≦+30℃/60%RH or as stated
1	Unlimited at ≦+30℃/85% RH
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, module must be reflowed within the time limit specified on the label.

Factory floor life is 1 week for MSL 3, SIM28 must be processed and soldered within the time. If this time is exceeded, or the humidity indicator card in the sealed package indicates that they have been exposed to moisture, the devices need to be pre-baked before the reflow solder process.

Both encapsulate and substrate materials absorb moisture. IPC/JEDEC specification J-STD-020 must be observed to prevent cracking and delamination associated with the "popcorn" effect during reflow soldering. The popcorn effect can be described as miniature explosions of evaporating moisture. Baking before processing is required in the following cases:

- Humidity indicator card: At least one circular indicator is no longer blue
- Floor life or environmental requirements after opening the seal have been exceeded, e.g. exposure to excessive seasonal humidity.

Refer to Section 4 of IPC/JEDEC J-STD-033 for recommended baking procedures.

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

6.4 ESD Handling Precautions

SIM28 modules are Electrostatic Sensitive Devices (ESD). Observe precautions for handling! Failure to observe these precautions can result in severe damage to the GPS receiver!

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

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

When handling the RF pin, do not come into contact with any charged capacitors and be careful when contacting materials that can develop charges (e.g. patch antenna ~10pF, coax cable ~50-80pF/m, soldering iron, …)
To prevent electrostatic discharge through the RF input, do not touch the mounted patch antenna.

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

6.5 Shipment

SIM28 is designed and packaged to be processed in an automatic assembly line, and it is now packaged in SIM28 tray.

7 Reference Design

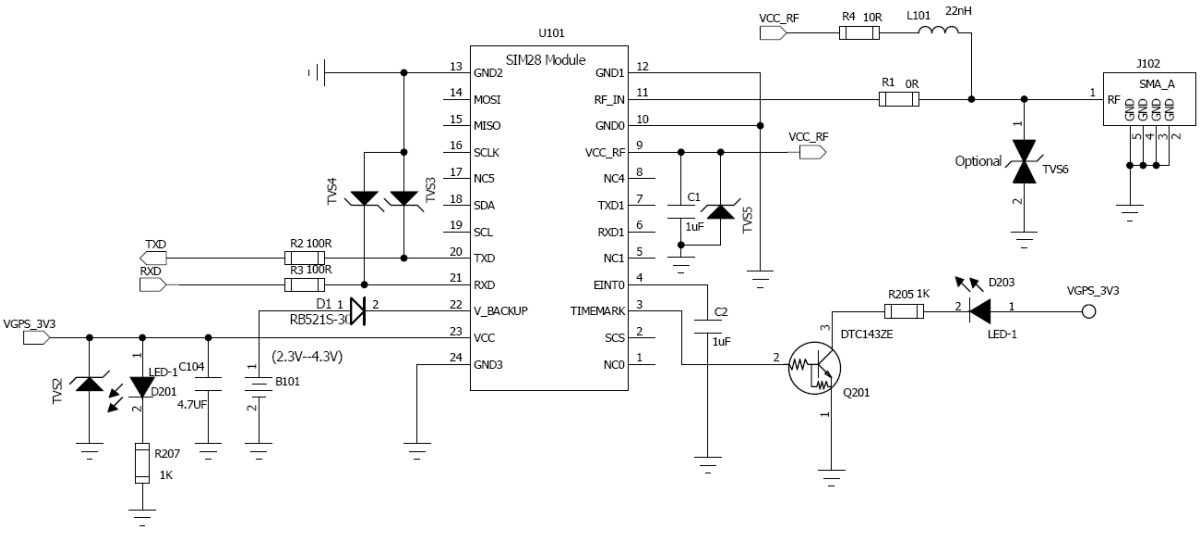

Figure 12: Example application schematic

Note: I/Os of SIM28V are 2.8V CMOS voltage level, attentions should be paid if the voltage level of the host controller not compatible; B101 is an un-rechargeable battery, if rechargeable backup battery used in the design, customer should design a charge circuit; To get the best performance on ESD testing, please take appropriate measures as the reference design shows; Please contact FAE to get more reference designs.

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Appendix

A. Related Documents

Table 14: Related documents

SN	Document name	Remark
[1]	SIM28_EVB kit_User Guide_V1 02	
[2]	SIM28/68R/68V NMEA Messages SpecificationV1.01	
[3]	SIM28 REFERENCE DESIGN PACKAGE	
[4]	SIM28 /68R /68V EPO-II_ProtocolV1.00	

B. Terms and Abbreviations

Table 15: Terms and abbreviations

Abbreviation	Description
A-GPS	
CMOS	Complementary Metal Oxide Semiconductor
EEPROM	Electrically Erasable Programmable Read Only Memory
EPO	Extended Prediction Orbit
ESD	Electrostatic Sensitive Devices
FSM	Finite State Machine
GPS	Global Positioning System
I/O	Input/Output
IC	Integrated Circuit
Inorm	Normal Current
Imax	Maximum Load Current
kbps	Kilo bits per second
KA	Keep alive
MSL	moisture sensitive level
NEMA	National Marine Electronics Association
SGEE	server-generated extended ephemeris

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