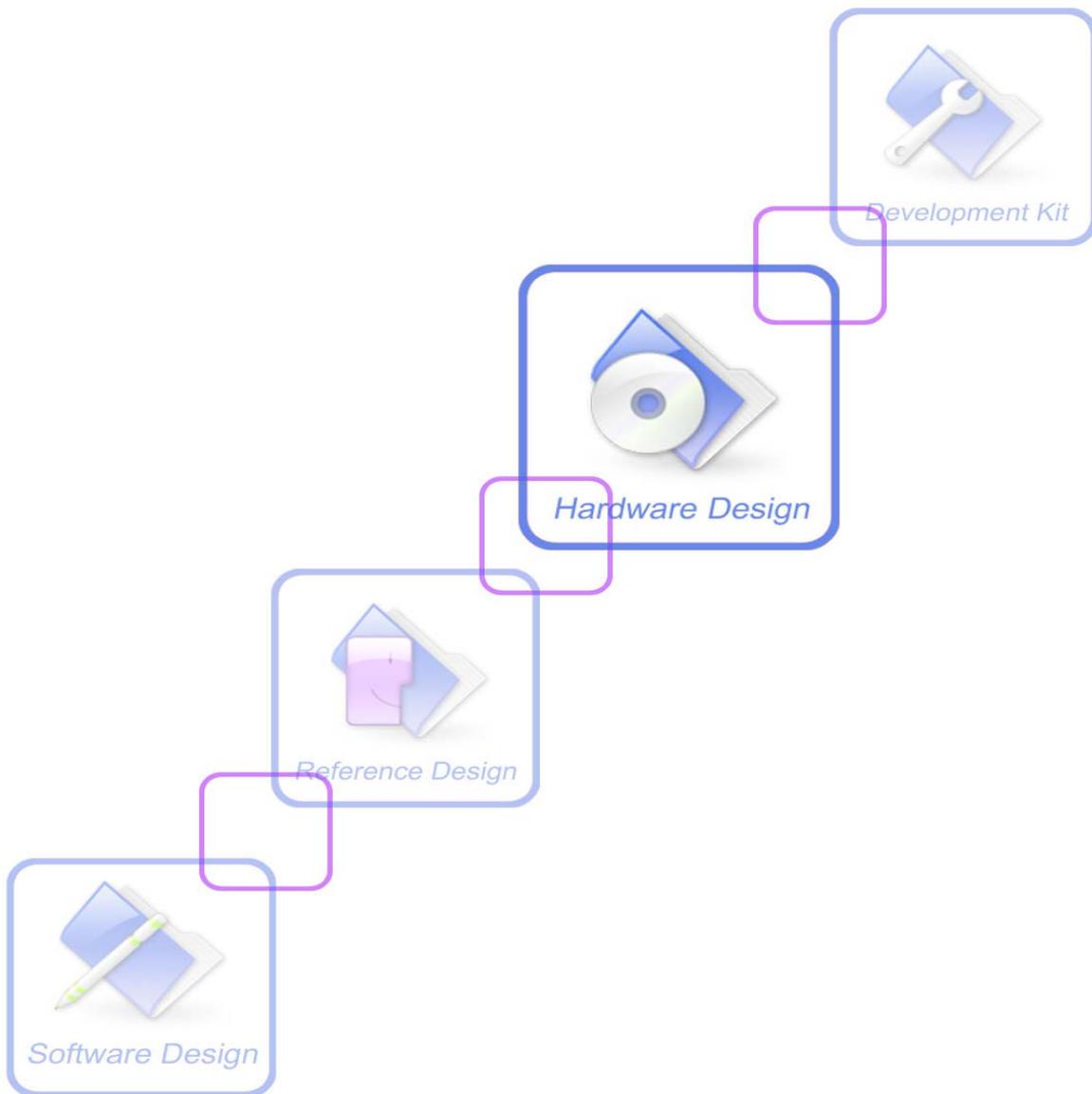




A company of SIM Tech

SIM33ELA_Hardware Design_V1.00



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1 Introduction

This document describes the hardware interface of the SIMCom module SIM33ELA 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 SIM33ELA, all functional components of SIM33ELA are described in great detail.

2 SIM33ELA Overview

SIM33ELA is a stand-alone or A-GPS receiver. With built-in Antenna, SIM33ELA don't need an external Antenna. SIM33ELA can track as low as -165dBm signal even without network assistance. The SIM33ELA has excellent low power consumption characteristic (acquisition 25mA, tracking 20mA). SIM33ELA supports various location and navigation applications, including autonomous GPS, GLONASS, GALILEO, QZSS, SBAS ranging (WAAS, EGNOS, GAGAN, MSAS), DGPS (RTCM) and A-GPS.

Key Features

- GNSS receiver supports GPS, GLONASS, GALILIRO, QZSS, SBAS ranging(WAAS/EGNOS/MSAS/GAGAN),DGPS(RTCM)
- 33tracking/99 acquisition-channel
- Small footprint: 9.6 x 14 x 2.15mm, 31-pin LCC package
- 12 multi-tone active interference cancellers and jamming elimination
- Indoor and outdoor multi-path detection and compensation
- Max NMEA update rate up to 10 HZ
- Advanced software features
 1. EASY self-generated orbit prediction
 2. EPO/HotStill orbit prediction
 3. AlwaysLocate advanced location awareness technology
 4. supports logger function
 5. supports active interference cancellation (AIC)
- Pulse-per-second (PPS) GNSS time reference
 1. Adjustable duty cycle
 2. typical accuracy: $\pm 10\text{ns}$
- Interface
 - UART $\times 2$
- Operating temperature: $-40 \sim +85^{\circ}\text{C}$
- Accuracy 2.5m CEP
- RoHS compliant

The module provides complete signal processing from antenna input to host port in either 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 2.85V CMOS compatible.

2.1 SIM33ELA Functional Diagram

The following figure shows a functional diagram of the SIM33ELA and illustrates the mainly functional parts:

- The GNSS chip
- SAW filter
- The antenna interface
- The communication interface
- The control signals

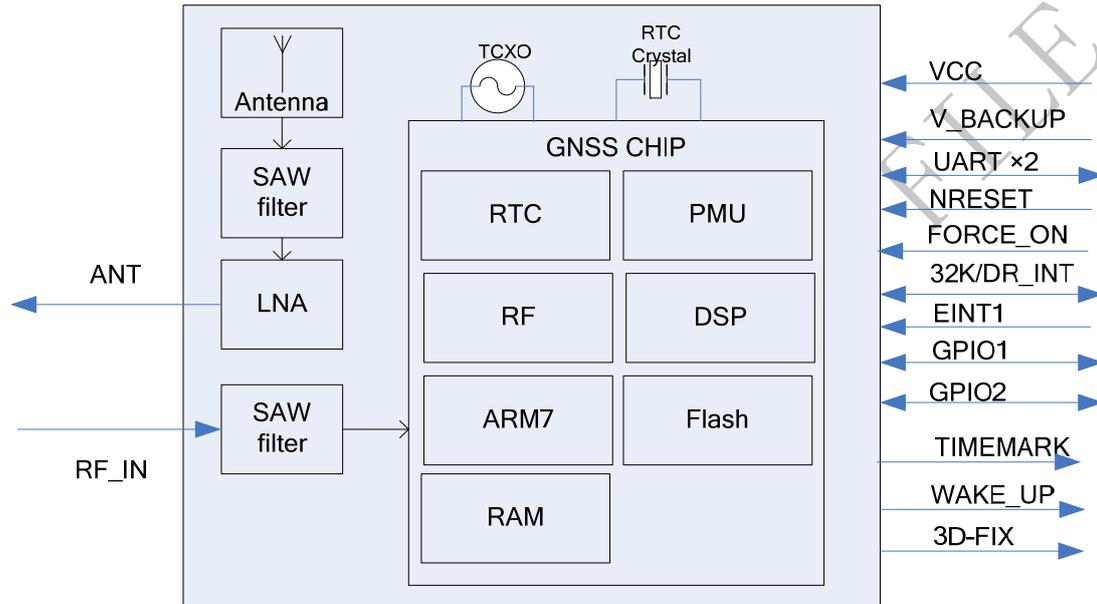


Figure 1: SIM33ELA functional diagram

2.2 GNSS Performance

Table 1: GNSS performance

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy ⁽¹⁾	Autonomous		<2.5		m
Velocity Accuracy ⁽²⁾	Without Aid		0.1		m/s
	DGPS		0.05		m/s
Acceleration Accuracy	Without Aid		0.1		m/s ²
	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
Time To First Fix ⁽³⁾	Hot start		<1		s

	Warm start		26		s
	Cold start		28		s
A-GPS TTFF(EASY mode)	Hot start		0.6		s
	Warm start		1.5		s
	Cold start		14.8		s
Sensitivity ⁽⁷⁾	Autonomous acquisition(cold start)		-147		dBm
	Re-acquisition		-160		dBm
	Tracking		-165		dBm
Receiver	Channels		33tracking/99 acquisition		
	Update rate		1	10	Hz
	Tracking L1, CA Code				
	Protocol support NMEA,PMTK				
Power consumption ⁽⁴⁾	Acquisition		25		mA
	Continuous tracking		20		mA
	Sleep current		320		uA
	Backup current		14		uA
Power consumption ⁽⁵⁾	Acquisition		20		mA
	Continuous tracking		22		mA
	Sleep current		320		uA
	Backup current		14		uA
Power consumption ⁽⁶⁾	Acquisition		20		mA
	Continuous tracking		22		mA
	Sleep current		320		uA
	Backup current		14		uA

(1) 50% 24hr static, -130dBm

(2) 50% at 30m/s

(3) -130 dBm, GPS&GLONASS mode

(4) Single Power supply 3.3V under GPS+GLONASS signal@-130dBm

(5) Single Power supply 3.3V under GPS signal@-130dBm

(6) Single Power supply 3.3V under GLONASS signal@-130dBm

(7) Single Power supply 3.3V under GPS+GLONASS signal

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)		25mA type. @ VCC=3.3 V
Power consumption(sleep)		320uA type. @ VCC=3.3 V
Storage temperature		-40°C~+85°C
Operating temperature		-40°C~+85°C (note 1)
I/O signal levels	VIL	-0.3V~0.8V
	VIH	2.0V~3.3V
	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		UART0,UART1
Serial port protocol (UART)		NMEA; 8 bits, no parity, 1 stop bit; 115200 baud (configurable)
TIMEMARK output (1PPS)		1 pulse per second, synchronized at rising edge, pulse length 100ms

Note 1: Operation in the temperature range -40°C~ -30°C is allowed but Time-to-First-Fix performance and tracking sensitivity may be degraded.

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3 Package Information

3.1 Pin out Diagram

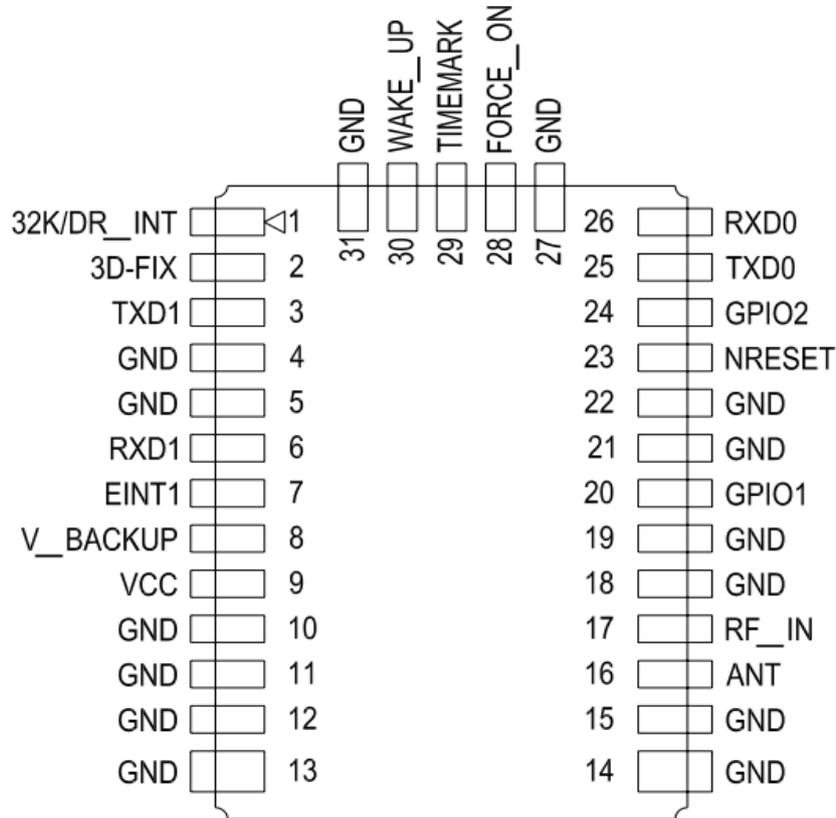


Figure 2: SIM33ELA pin out diagram (Top view)

3.2 Pin Description

Table 3: Pin description

Pin name	Pin number	I/O	Description	Comment
Power supply				
VCC	9	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 and 100nF capacitor to this pin for decoupling.
WAKE_UP	30	O	2.8V power output. High level indicating to host that the module is active.	If unused, keep open.
V_BACKUP	8	I	The backup battery input power supply for RTC	Must keep V_BACKUP active all the time

GND	4,5,10,11,12,13,14,15,18,19,21,22,27,31		Ground	GND
Host port interface				
TXD0	25	O	Serial output as NMEA	
RXD0	26	I	Serial input as NMEA	
TXD1	3	O	Serial output as RTCM	If unused, keep open.
RXD1	6	I	Serial input as RTCM	
GPIOs				
TIMEMARK	29	O	Time Mark outputs timing pulse related to receiver time	If unused, keep open.
NRESET	23	I	Reset input, active low, default pull-up	If unused, keep open.
3D-FIX	2	O	3D-fix indicator	If unused, keep open.
32K/DR_INT	1	I/O	Reserved for wake-up interrupt(DR_INT default) Optionally 32768 Hz RTC clock output	If unused, keep open
EINT1	7	I	This interrupt source could control the module come into or wake up from sleep mode. Low=come into sleep mode High=wake up from sleep mode.	If unused, keep open. default High level.
FORCE_ON	28	I	Power control input used to force wake up from low power modes.	If unused, connect to GND
GPIO1	20	I/O	Reserved	Keep open
GPIO2	24	I/O	Reserved	Keep open
RF interface				
RF_IN	17	I	Antenna signal input	Impedence must be controlled to 50Ω.
ANT	16	O	Embedded antenna output	Impedence must be controlled to 50Ω.

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3.3 Package Dimensions

Following figure shows the Mechanical dimensions of SIM33ELA (top view, side view and bottom view).

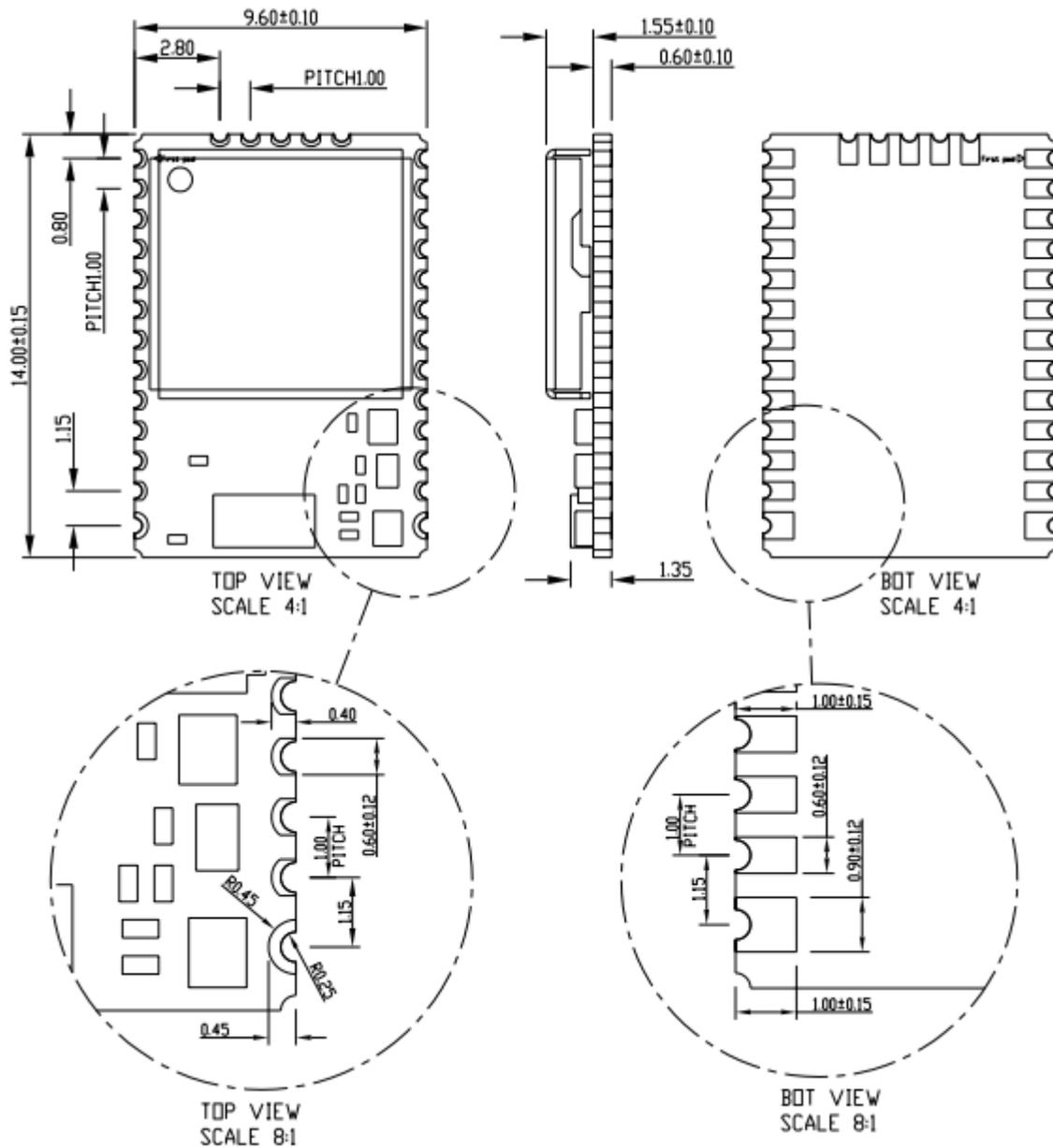


Figure 3: SIM33ELA mechanical dimensions (Unit: mm)

3.4 SIM33ELA Recommended PCB Decal

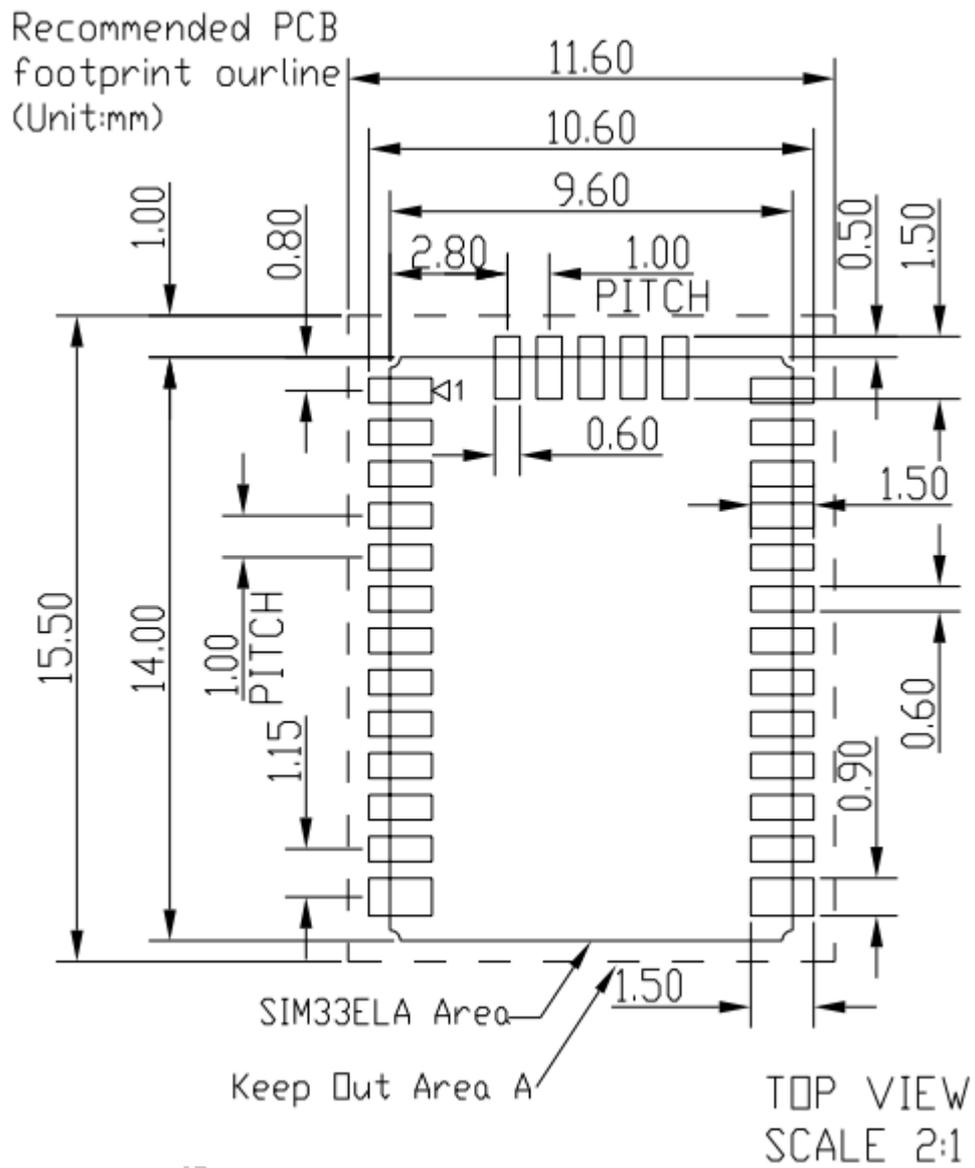


Figure 4: Recommended PCB decal (top view) (Unit: mm)

4 Application Interface

4.1 Power Management

4.1.1 Power Input

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

The power supply range of V_BACKUP is from 2V to 4.3V, customer must keep the V_BACKUP supply active all the time, if not, the module will not start up.

4.1.2 Starting SIM33ELA

When power is first applied, SIM33ELA goes into operation mode.

4.1.3 Verification of SIM33ELA Start

System activity indication depends upon the chosen serial interface:

- When it is activated, SIM33ELA will output messages at the selected UART speed and message types through UART0.

4.1.4 Power Saving Modes

SIM33ELA supports operating modes for reduced average power consumption like standby mode, backup mode, periodic mode, and AlwaysLocate™ mode.

- **Sleep mode:** In this mode the receiver stays at full on power state. When this mode that can be wake up by the host sends the command through the communication interface.
- **Backup mode:** In this mode the SIM33ELA must be supplied by the backup and it can help to count down the time for backup mode. Software on host side to send the command through the communication interface into the backup mode.
- **Periodic mode:** In this mode the SIM33ELA enters tracking or backup mode according to the interval configured by users in the commands.
- **AlwaysLocate™ mode:** AlwaysLocate™ is an intelligent controller of SIM33ELA periodic mode. Depending on the environment and motion conditions, SIM33ELA can adaptive adjust the on/off time to achieve balance of positioning accuracy and power consumption.

Note: the modes mentioned above are operated by PMTK commands, users can refer to document [1] for more information.

SIM33ELA provides very low leakage battery back up memory, which contains all the necessary GNSS information for quick start up and a small amount of user configuration variables. It needs a 3V power supply for V_BACKUP pin.

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	off	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 and V_BACKUP 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 (320uA 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.

Entering into sleep mode is sent PMTK command through the communication interface by host side or pull down EINT1.

Waking up from sleep mode is sent any byte through the communication interface by host side or pull high EINT1.

4.1.6 V_BACKUP Mode

This connects to the backup power of the GNSS module. Power source (such as battery or cap) connected to this pin will help the GNSS chipset in keeping its internal RTC running when the VCC power source is turned off.

The voltage should be kept between 2.0~4.3V, Typical 3.0V.

The V_BACKUP power must be kept active all the time, the GNSS module will perform a quick start every time it is power-on.

4.2 UART Interface

SIM33ELA includes two UART (UART0 and UART1) interface for serial communication. The UART0 is as NMEA output and PMTK command input. The receiver (RXD0) and transmitter (TXD0) side of every port contains a 16-byte FIFO and has 256 bytes URAM. UART can provide the developers signal or message outputs. The baud rates are selectable and ranging from 4.8 to 921.6kbps through PMTK commands, see the following

table for details. UART1 is as RTCM input.

For details about CoreBuilder information, please refer to document [1]

Table 5: PSIMIPR NMEA port data rate

PSIMIPR NMEA port data rate	
Example: \$PSIMIPR,W,115200*1C	
Test Command PSIMIPR,T	Response PSIMIPR,T,(0,4800,9600,14400,19200,38400,57600,115200)
	Parameters See Write Command
Write Command PSIMIPR,W,<baud rate>	Response If success, return : PSIMIPR,W,Ok If error, return : PSIMIPR,W,Error
	Parameters <baud rate> support default baud rate(0) or 4800,9600,14400,19200,38400,57600,115200
Read Command PSIMIPR,R	Response TA returns the current debug information output control PSIMIPR,R,Ok, < baud rate>
	Parameters See Write Command

4.3 NRESET Input

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

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

4.4 FORCE_ON Input

The FORCE_ON signal provides input that can be used to force wakeup from low power modes. The signal is active high.

4.5 WAKE_UP Output

The WAKE_UP output high level indicating to host that the module is active.

WAKE_UP output is intended to drive only CMOS inputs; do not load WAKE_UP signal with current exceeding 10mA. Only loads with steady state current drain is allowed.

4.6 Interrupt input EINT1

This interrupt source could control the module come into or wake up from sleep mode.

Low=come into sleep mode

High=wake up from sleep mode.

4.7 32K/DR_INT signal

The 32K/DR_INT signal is reserved for future usage as wake up interrupting input.

Optionally the signal can be configured to 32.768KHz RTC clock signal output with a custom firmware. The 32K/DR_INT signal has CMOS 1.1V logic levels and when input, the signal is +3.6V tolerable.

4.8 3D-FIX Output

The 3D-FIX is assigned as a fix flag output. This pin will output high after successful positioning.

4.9 Timemark Output

The Timemark pin outputs pulse-per-second (1PPS) pulse signal for precise timing purposes. 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, and active high/low by programming user-defined settings.

4.10 A-GPS and DGPS

A-GPS is the meaning of Assisted GNSS, which is a system that can improve the startup performance, and time-to-first-fix (TTFF) of a GNSS satellite-based positioning under certain conditions . SIM33ELA module supports EPO file, EASY MODE and SBAS

4.10.1 EPO

The SIM33ELA 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 and improve the acquisition sensitivity.

The user should update the EPO files from the EPO server daily through the internet. Then the EPO data should send to the SIM33ELA by the HOST side. SIM33ELA has the short cold TTFF and warm TTFF, when the SIM33ELA_Hardware Design_V1.00

A-GPS is used.

Note: For more information about EPO, please contact SIMCom sales. users can refer to document [2] for more information

4.10.2 EASY MODE

EASY is the abbreviation of Embedded Assist System, it works as embedded firmware 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 GNSS 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 sleep condition. EASY assistance is going to be engaged when the GNSS 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 default open and can be closed by PMTK command.

4.10.3 DGPS

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 GNSS and GEO Augmented Navigation (GAGAN) to cover the Indian subcontinent.

SIM33ELA module supports SBAS and RTCM, but only one mode can be applied at one time, and SBAS is the default feature, customers who want to apply RTCM in the design can contact SIMCom sales for supporting.

4.11 GNSS Antenna

SIM33ELA has an embedded GNSS Antenna and the signal is further amplified by internal Low Noise Amplifier (LNA), which is available at ANT output. The antenna signal ANT shall be connected externally to RF_IN Antenna Input signal via a short trace between pad ANT and pad RF_IN.

4.11.1 Reference Design for Antenna Embedded

If using the embedded antenna, make sure the pad ANT be connected externally to RF_IN pad via a short trace with 50Ω impedance. The RF input signal path contains a first SAW band-pass filter before LNA, which provides excellent protection against out-of-band GNSS blocking caused by possible near-by wireless transmitters.

Figure 5 shows the reference design circuit for embedded antenna.

Note keepout 5x7.2mm under the embedded antenna. Follow also GND via hole suggestive locations. Routing signals directly under the module should be avoided. This area should be dedicated to keep-out to both traces and assigned to ground plane (copper plane), except for via holes, which can be placed close to the pad under the module. If possible, the amount of via holes underneath the module should be minimized. Note that the embedded GNSS antenna requires a small ground plane clearance and void area (keep out 5x7.2mm) for copper plane & trace for all layers under the antenna. Placement of other components is not allowed under the keep out on opposite side.

5 Electrical, Reliability and Radio Characteristics

5.1 Absolute Maximum Ratings

The absolute maximum ratings stated in Table 6 are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to SIM33ELA.

Table 6: Absolute maximum ratings

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

5.2 Recommended Operating Conditions

Table 7: SIM33ELA operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
Operating temperature range		-40	+25	+85	°C
Main supply voltage	VCC	2.8	3.3	4.3	V
module active indicate	WAKE_UP	-	2.8	-	V
Backup battery voltage	V_BACKUP	2	3	4.3	V

Table 8: SIM33ELA 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	K Ω
Input Pull-down resistance	RPD	40		190	K Ω
Input capacitance	C _{IN}		5		pF
Load capacitance	C _{load}			8	pF
Tri-state leakage current	I _{OZ}	-10		10	uA

5.3 Electro-Static Discharge

The GNSS engine is not protected against Electrostatic Discharge (ESD) in general. Therefore, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application using a SIM33ELA module. The ESD test results are shown in the following table.

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

Pin	Contact discharge	Air discharge
VCC	±5KV	±10KV
V_BAKUP	±5KV	±10KV
GND	±5KV	±10KV
RXD0, TXD0	±4KV	±8KV
TXD1, RXD1	±4KV	±8KV
NRESET	±4KV	±8KV
TIMEMARK	±4KV	±8KV
3D-FIX	±4KV	±8KV

6 Manufacturing

6.1 Top and Bottom View of SIM33ELA

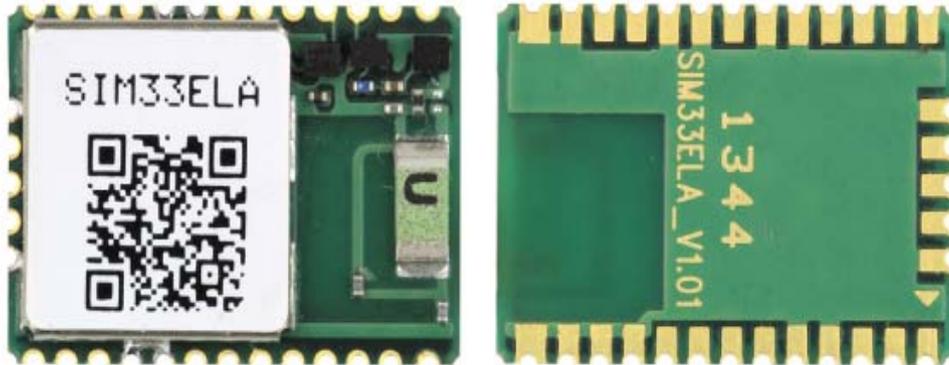


Figure 7: Top and bottom view of SIM33ELA

6.2 Assembly and Soldering

The SIM33ELA 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 SIM33ELA:



Figure 8: The Ramp-Soak-Spike reflow profile of SIM33ELA

SIM33ELA is Moisture Sensitive Devices (MSD), appropriate MSD handling instruction and precautions are summarized in Chapter 6.3.

SIM33ELA modules are also Electrostatic Sensitive Devices (ESD), handling SIM33ELA 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

SIM33ELA module is moisture sensitive at MSL level 3, dry packed according to IPC/JEDEC specification J-STD-020C. The calculated shelf life for dry packed SMD packages is a minimum of 6 months from the bag seal date, when stored in a non condensing atmospheric environment of <math><40^{\circ}\text{C}/90\% \text{RH}</math>.

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

Table 10: Moisture Classification Level and Floor Life

Level	Floor Life(out of bag)at factory ambient $\leq +30^{\circ}\text{C}/60\% \text{RH}$ or as stated
1	Unlimited at $\leq +30^{\circ}\text{C}/85\% \text{RH}$
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, SIM33ELA must be processed and soldered within the time. If this time is exceeded, the devices need to be pre-baked before the reflow solder process.

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

- Floor life or environmental requirements after opening the seal have been exceeded, e.g. exposure to excessive seasonal humidity.

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

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

SIM33ELA modules are Electrostatic Sensitive Devices (ESD). Observe precautions for handling!

Failure to observe these precautions can result in severe damage to the GNSS receiver!



GNSS 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 pins, 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).

7 Reference Design

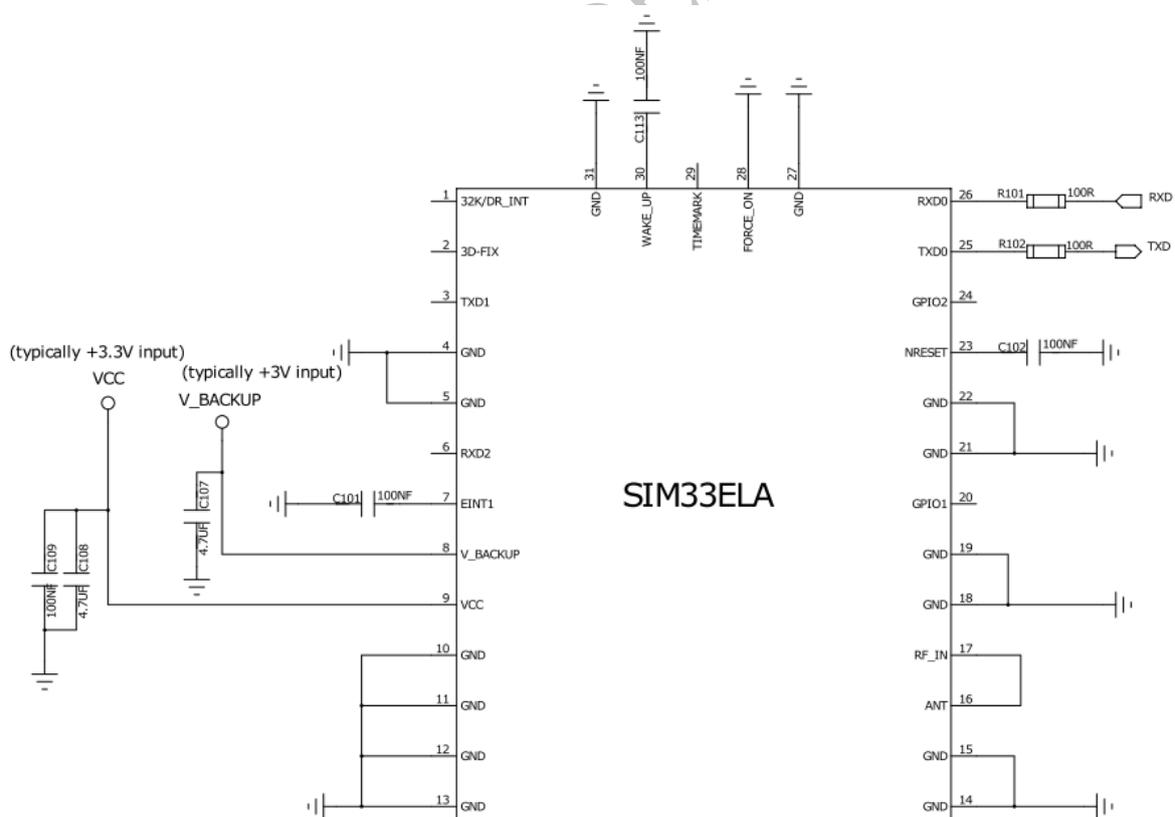


Figure 9: Example application schematic with UART

Appendix

A. Related Documents

Table 11: Related documents

SN	Document name	Remark
[1]	MT3333 Platform NMEA Message Specification_V1.00	
[2]	EPO-II_Format_Protocol_Customer	EPO-II_Format and Protocol

B. Terms and Abbreviations

Table 12: Terms and abbreviations

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

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