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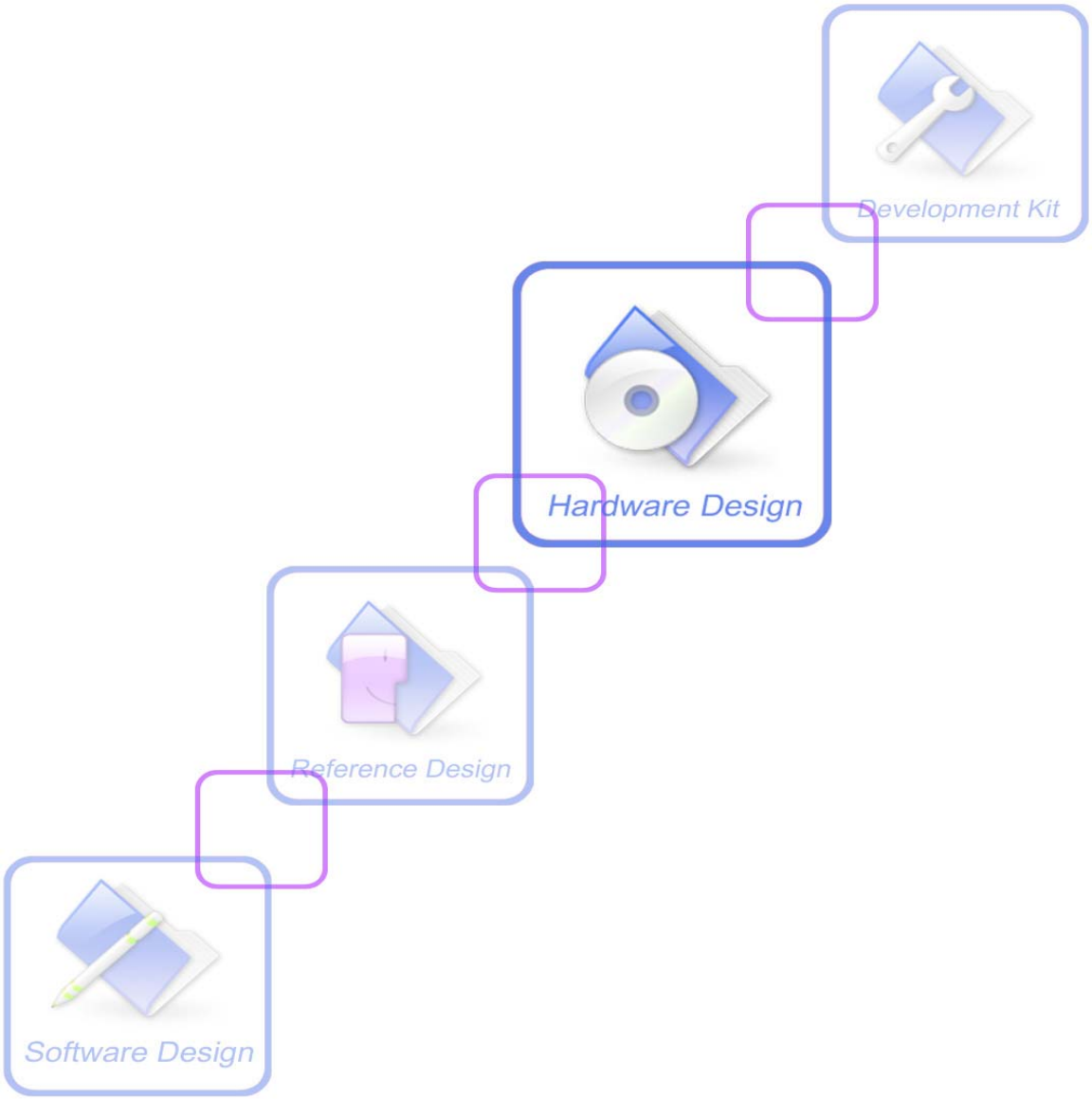
SIM39EAU_Hardware Design_V1.01



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Version History

Date	Version	Description of change	Author
2014-02-26	V1.00	Origin	Shengwu.Sun Lili.Teng
2014-03-17	V1.01	Change Figure 2 and 3	Shengwu.Sun

1 Introduction

This document describes the hardware interface of the SIMCom module SIM39EAU which can be used as a stand alone or A-GPS（Assisted Global Positioning System）receiver with a patch antenna on top of the module. As a wide range of applications can be integrated in SIM39EAU, all functional components of SIM39EAU are described in great detail.

2 SIM39EAU Overview

SIM39EAU is an ultra-compact POT (Patch on Top) GPS module. With built-in LNA and Patch Antenna, SIM39EAU do not need an extra antenna. SIM39EAU can track as low as -165dBm signal even without network assistance. SIM39EAU has excellent low power consumption characteristic (acquisition 32mA, tracking 27mA). SIM39EAU supports various location and navigation applications, including autonomous GPS, QZSS, SBAS ranging (WAAS, EGNOS, GAGAN, MSAS), and A-GPS.

Key Features

- GPS receiver, supports QZSS, SBAS ranging, supports WAAS/EGNOS/MSAS/GAGAN
- 22tracking/66 acquisition-channel, up to 210 PRN channels
- Small footprint: 22 x 22 x 7.5mm, 16-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
- Pulse-per-second (PPS) GPS time reference
    1. Adjustable duty cycle
    2. typical accuracy: ±10ns
- Interface
    UART
- Operating temperature: -40 ~ +85ºC
- 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 SIM39EAU Functional Diagram

The following figure shows a functional diagram of the SIM39EAU and illustrates the mainly functional parts:

- The GPS chip
- SAW filter

- The antenna interface
- The communication interface
- The control signals

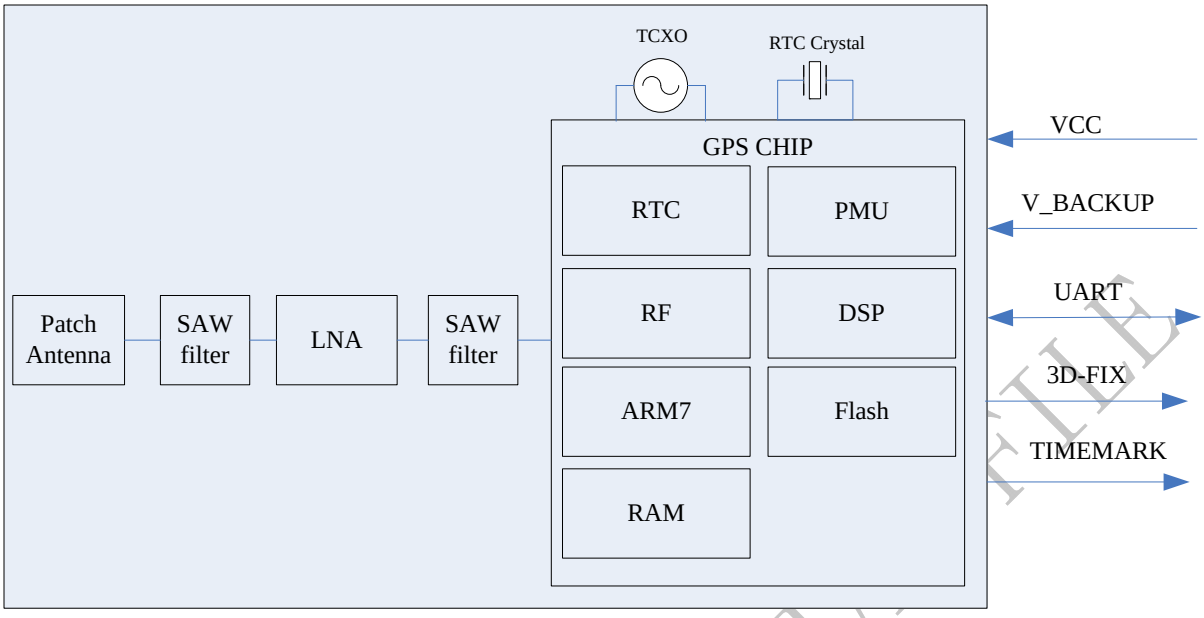


Figure 1: SIM39EAU functional diagram

2.2 GPS Performance

Table 1: GPS performance

Parameter	Description	Performance			
		Min	Type	Max	Unit
Horizontal Position Accuracy(1)	Autonomous		<2.5		m
Velocity Accuracy(2)	Without Aid		0.1		m/s
	DGPS		0.05		m/s
Acceleration Accuracy	Without Aid		0.1		m/s^2
	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		30		s
	Cold start		32		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		-165		dBm
Receiver	Channels		22tracking/66acquisition		
	Update rate			10	Hz
	Tracking L1, CA Code				
	Protocol support NMEA,PMTK				
Power consumption(4)	Acquisition		32		mA
	Continuous tracking		27		mA
	Sleep current		400		uA
	Backup current		8		uA

(1) 50% 24hr static, -130dBm
(2) 50% at 30m/s
(3) GPS signal level: -130dBm
(4) Single Power supply 3.3V

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)		32mA type. @ VCC=3.3 V
Power consumption(sleep)		400uA type. @ VCC=3.3 V
Storage temperature		-40ºC~+85ºC
Operating temperature		-40ºC~+85ºC (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		UART
Other port		3D-FIX
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.

3 Package Information

3.1 Pin out Diagram

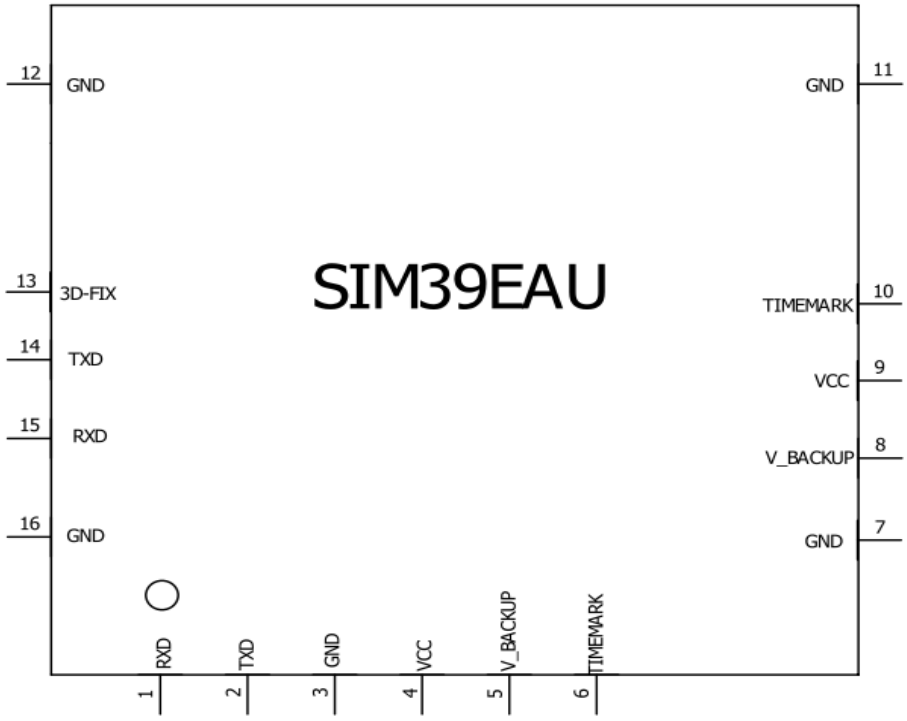


Figure 2: SIM39EAU pin out diagram (Top view)

3.2 Pin Description

Table 3: Pin description

Pin name	Pin number	I/O	Description	Comment
Power supply				
VCC	4,9	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 capacitor to this pin for decoupling.
V_BACKUP	5,8	I	The backup battery input power supply for RTC	If unused, keep open.
GND	7,11,12,16		Ground	GND

Host port interface				
TXD	2,14	O	Serial output	
RXD	1,15	I	Serial input	
GPIOs				
TIMEMARK	6,10	O	Time Mark outputs timing pulse related to receiver time	If unused, keep open.
3D-FIX	13	O	3D-fix indicator	

3.3 Package Dimensions

Following figure shows the Mechanical dimensions of SIM39EAU (top view, side view and bottom view).

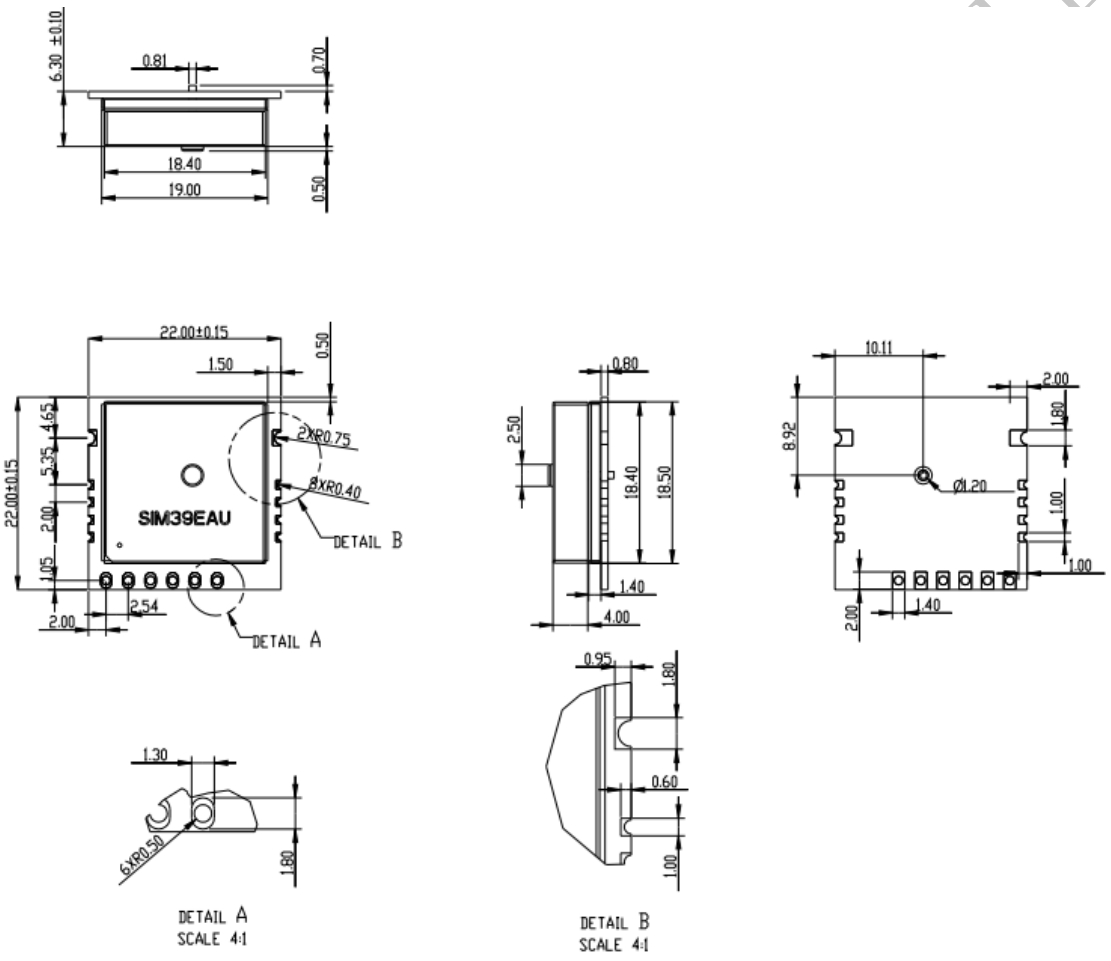


Figure 3: SIM39EAU mechanical dimensions (Unit: mm)

3.4 SIM39EAU Recommended PCB Decal

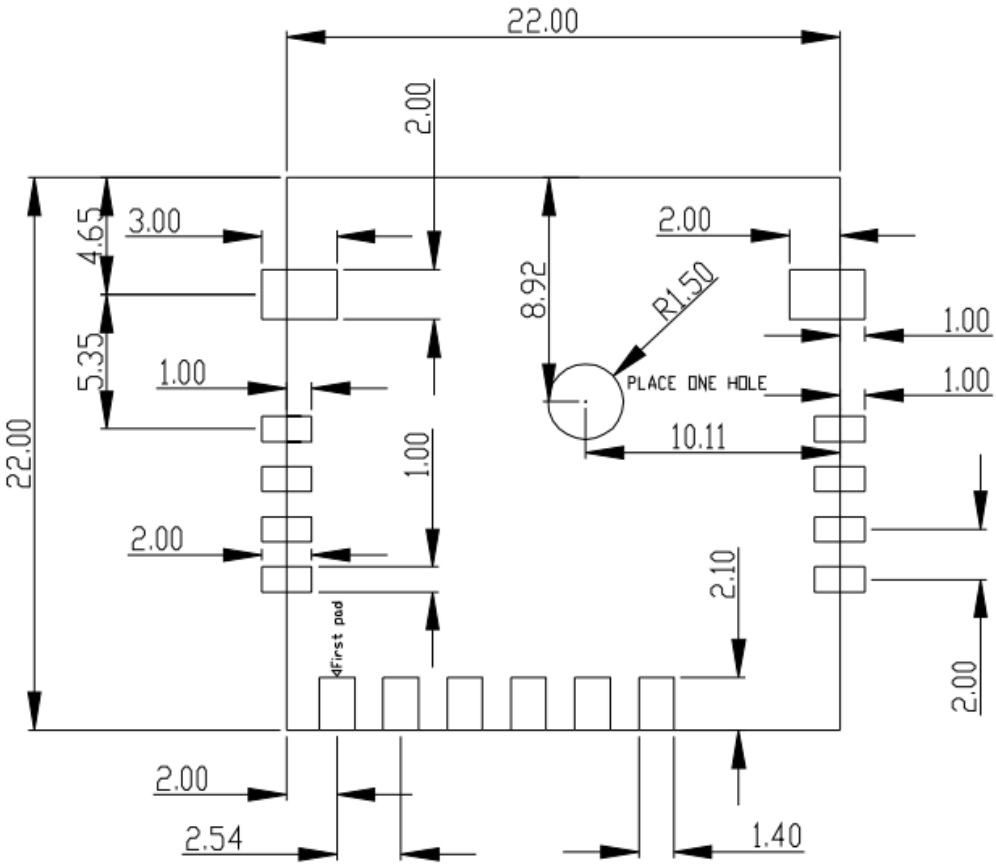


Figure 4: Recommended PCB decal (top view) (Unit: mm)

4 Application Interface

4.1 Power Management

4.1.1 Power Input

The power supply（VCC）range of SIM39EAU is from 2.8V to 4.3V. The power supply should be able to provide sufficient current up to 100mA.

4.1.2 Starting SIM39EAU

When power is first applied, SIM39EAU goes into operation mode.

4.1.3 Verification of SIM39EAU Start

System activity indication depends upon the chosen serial interface:

- When it is activated, SIM39EAU will output messages at the selected UART speed and message types.

4.1.4 Power Saving Modes

SIM39EAU 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 SIM39EAU must be supplied by the backup and it can help to count down the time for backup mode.
- Periodic mode**:** In this mode the SIM39EAU enters tracking modes according to the interval configured by users in the commands.
- AlwaysLocate™ mode: AlwaysLocate™ is an intelligent controller of SIM39EAU periodic mode. Depending on the environment and motion conditions, SIM39EAU 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.

SIM39EAU 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.

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 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 (400uA 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.

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

4.1.6 V_BACKUP

This connects to the backup power of the GPS module. Power source (such as battery or LDO) connected to this pin will help the GPS chipset in keeping its internal RTC running when the main power source is turned off. The voltage should be kept between 2.0~4.3V, Typical 3.0V.
If V_BACKUP power was not reserved, the GPS module will perform a lengthy cold start every time it is power-on. If not used, keep open.

4.2 UART Interface

SIM39EAU includes one UART interface for serial communication. The receiver (RXD) and transmitter (TXD) 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.

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 3D-FIX Output

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

4.4 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, frequency, and active high/low by programming user-defined settings.

4.5 A-GPS

A-GPS is the meaning of Assisted GPS, which is a system that can improve the startup performance, and time-to-first-fix (TTFF) of a GPS satellite-based positioning under certain conditions . SIM39EAU module supports EPO file, EASY MODE and SBAS

4.5.1 EPO

The SIM39EAU 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 SIM39EAU by the HOST side. SIM39EAU has the short cold TTFF and warm TTFF, when the A-GPS is used.

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

4.5.2 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 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 sleep 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 default open and can be closed by PMTK command.

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

5 GPS Antenna

5.1 Antenna specification

As mentioned above, SIM39EAU has integrated a GPS antenna internal, which is a passive patch antenna， with a tiny size of 18.4mm*18.4mm*4mm. Owning to this feature, the user does not need the necessary of choosing and tuning the GPS antenna additionally.
The specifications and performance of the integrated GPS antenna are presented as following table:

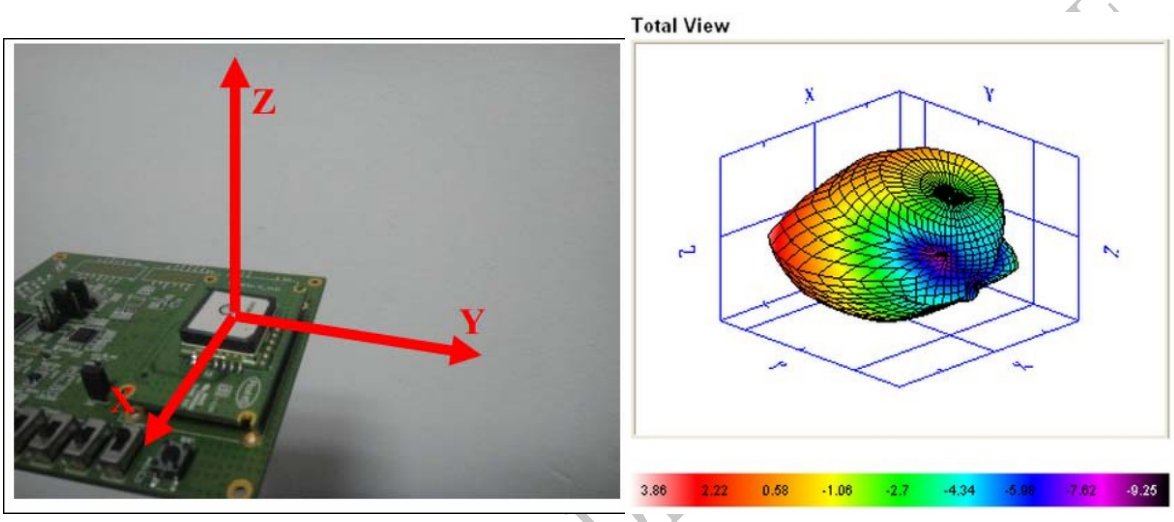


Figure 5: 3D gain pattern

Table 6: Efficiency and Peak Gain

Frequency **(MHz)**	1570	1571	1572	1573	1574	1575	1575.42	1576	1577	1578	1579	1580
Peak Gain (dBic)	3.9	3.92	3.94	3.94	3.96	3.96	3.96	3.95	3.94	3.93	3.93	3.91
Efficiency (%)	64.64	65.27	66.61	67.89	68.77	68.9	69.32	69.48	68.63	67.57	66.72	65.92

Table 7: Antenna Specifications

Parameter	**Specification**	Passive and active antenna
GPS Patch Antenna	Frequency range	1575±2.5MHz
	Polarization	RHCP
	Gain at Zenith	2dBic
	VSWR	<1.5 dB
	Impedance(Ω)	50

5.2 Application Notes

The GPS Patch antenna consists of a radiating patch on one side of a dielectric material substrate backed by a ground plane on the other side, as shown in figure 6:

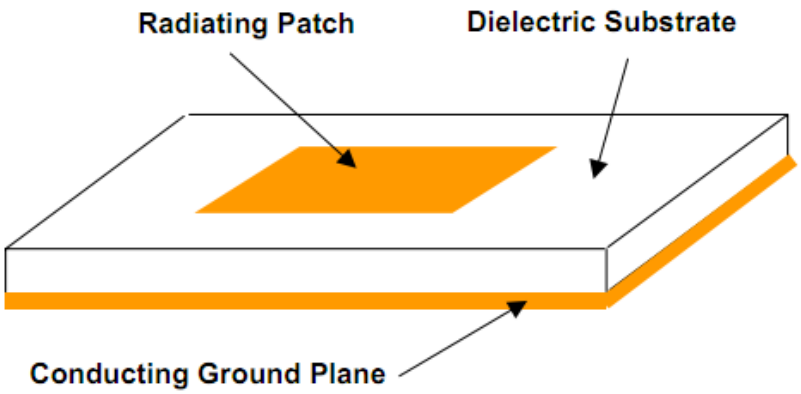
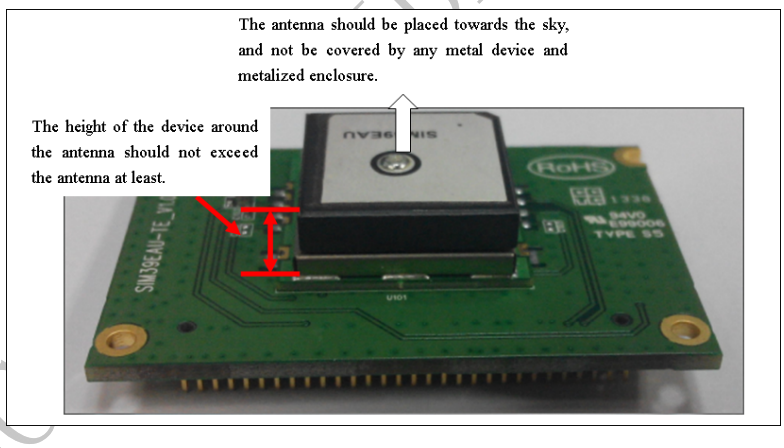


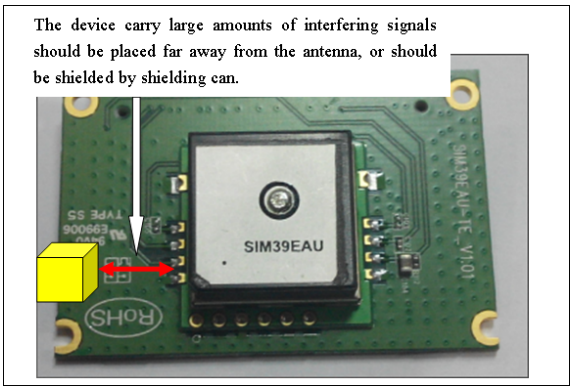
Figure 6: Basic features of GPS patch antenna

When the SIM39EAU is integrated into the customer's product, the following rules should be followed strictly It includes:

1. The SIM39EAU should be placed correctly, and the most important rule is to ensure the antenna towards the sky. It is the best way of using the SIM39EAU module.
2. The antenna should not be covered by any metal device or metalized enclosure. It is because the metal device will block the most GPS signal reach to the antenna.
3. The height of the device around the module, should not exceed the antenna at least. Otherwise, the antenna performance will be affected more or less.
4. The device carry large amounts of interfering signals around the module, should be placed far away from the module, or should be shielded by a shielding can.



(a)



(b)

Figure 7: Illustration of the SIM39EAU module installation

6 Electrical, Reliability and Radio Characteristics

6.1 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 SIM39EAU.

Table 8: 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	℃
Operating Temperature	-40	+85	℃

6.2 Recommended Operating Conditions

Table 9: SIM39EAU 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
Backup battery voltage	V_BACKUP	2	3	4.3	V

Table 10: SIM39EAU standard I/O features

Parameter	Symbol	Min	Typ	Max	Unit
Low level output voltage Test conditions I_{OL} = 2mA and 4.0mA	V_{OL}	-0.3		0.40	V
High level output voltage Test conditions I_{OL} = 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	R_{PU}	40		190	K Ω
Input Pull-dowm resistance	R_{PD}	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

6.3 Electro-Static Discharge

The GPS engine is not protected against Electrostatic Discharge (ESD) in general. Therefore, it is subject to ESD handing precautions that typically apply to ESD sensitive components. Proper ESD handing and packaging procedures must be applied throughout the processing, handing and operation of any application using a SIM39EAU module. The ESD test results are shown in the following table.

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

Pin	Contact discharge	Air discharge
VCC	±5KV	±10KV
Antenna	±5KV	±10KV
V_BACKUP	±5KV	±10KV
GND	±5KV	±10KV
TXD, RXD	±4KV	±8KV
3D-FIX	±4KV	±8KV
TIMEMARK	±4KV	±8KV

7 Manufacturing

7.1 Top and Bottom View of SIM39EAU

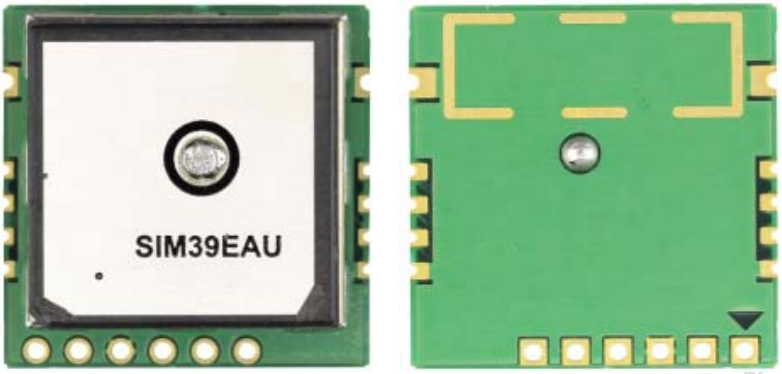


Figure 8: Top and bottom view of SIM39EAU

7.2 Assembly and Soldering

The SIM39EAU 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 SIM39EAU:

Figure 9: The Ramp-Soak-Spike reflow profile of SIM39EAU

SIM39EAU is Moisture Sensitive Devices (MSD), appropriate MSD handling instruction and precautions are summarized in Chapter 7.3.

SIM39EAU modules are also Electrostatic Sensitive Devices (ESD), handling SIM39EAU modules without proper ESD protection may destroy or damage them permanently.

Avoid ultrasonic exposure due to internal crystal and SAW components.

7.3 Moisture sensitivity

SIM39EAU 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 12 lists floor life for different MSL levels in the IPC/JDEC specification:

Table 12: 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, SIM39EAU 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.

7.4 ESD handling precautions

SIM39EAU modules are Electrostatic Sensitive Devices (ESD). Observe precautions for handling!

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

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

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

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

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

7.5 Shipment

SIM39EAU is designed and packaged to be processed in an automatic assembly line, and it is now packaged in SIM39EAU tray.

8 Reference Design

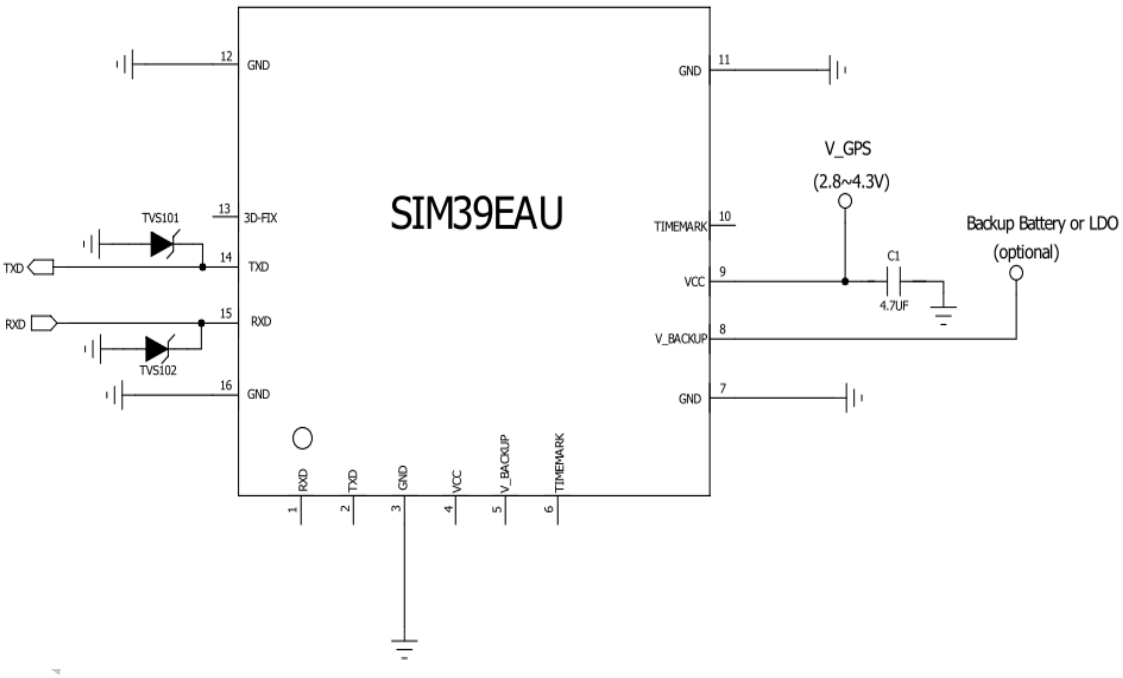


Figure 10: Example application schematic with UART

Appendix

A. Related Documents

Table 7: Related documents

SN	Document name	Remark
[1]	MT3339 Platform NMEA Message Specification_V1.00	
[2]	EPO-II_Format_Protocol_Customer	EPO-II_Format and Protocol

B. Terms and Abbreviations

Table 8: 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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