SE868Kx-Ax Family Product User Guide

1VV0301201 Rev. 2

2017-04-03

TELIT
TECHNICAL
DOCUMENTATION

SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

NOTICES

While reasonable efforts have been made to ensure the accuracy of this document, Telit assumes no liability resulting from any inaccuracies or omissions in this document, or from use of the information obtained herein. The information in this document has been carefully checked and is believed to be reliable, however no responsibility is assumed for inaccuracies or omissions. Telit reserves the right to make changes to any products described herein and reserves the right to revise this document and to make changes from time to time in content hereof with no obligation to notify any person of revisions or changes. Telit does not assume any liability arising out of the application or use of any product, software, or circuit described herein; neither does it convey license under its patent rights or the rights of others.

It is possible that this publication may contain references to, or information about Telit products (machines and programs), programming, or services that are not announced in your country. Such references or information must not be construed to mean that Telit intends to announce such Telit products, programming, or services in your country.

COPYRIGHTS

This manual and the Telit products described herein may be, include or describe copyrighted Telit material, such as computer programs stored in semiconductor memories or other media. Laws in the Italy and other countries preserve for Telit and its licensors certain exclusive rights for copyrighted material, including the exclusive right to copy, reproduce in any form, distribute and make derivative works of the copyrighted material. Accordingly, any copyrighted material of Telit and its licensors contained herein or in the Telit products described in this manual may not be copied, reproduced, distributed, merged or modified in any manner without the express written permission of Telit. Furthermore, the purchase of Telit products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Telit, as arises by operation of law in the sale of a product.

COMPUTER SOFTWARE COPYRIGHTS

The Telit and Third Party supplied Software (SW) products described in this instruction manual may include copyrighted Telit and other Third Party supplied computer programs stored in semiconductor memories or other media. Laws in the Italy and other countries preserve for Telit and other Third Party supplied SW certain exclusive rights for copyrighted computer programs, including the exclusive right to copy or reproduce in any form the copyrighted computer program. Accordingly, any copyrighted Telit or other Third Party supplied SW computer programs contained in the Telit products described in this manual may not be copied (reverse engineered) or reproduced in any manner without the express written permission of Telit or the Third Party SW supplier. Furthermore, the purchase of Telit products shall not be deemed to grant either directly or by implication, estoppel, or otherwise, any license under the copyrights, patents or patent applications of Telit or other Third Party supplied SW, except for the normal non-exclusive, royalty-free license to use that arises by operation of law in the sale of a product.

USAGE AND DISCLOSURE RESTRICTIONS

I. License Agreements

The software described in this document is the property of Telit and its licensors. It is furnished by express license agreement only and may be used only in accordance with the terms of such an agreement.

II. Copyrighted Materials

Software and documentation are copyrighted materials. Making unauthorized copies is prohibited by law. No part of the software or documentation may be reproduced, transmitted, transcribed, stored in a retrieval system, or translated into any language or computer language, in any form or by any means, without prior written permission of Telit

III. High Risk Materials

Components, units, or third-party products used in the product described herein are NOT fault-tolerant and are NOT designed, manufactured, or intended for use as on-line control equipment in the following hazardous environments requiring fail-safe controls: the operation of Nuclear Facilities, Aircraft Navigation or Aircraft Communication Systems, Air Traffic Control, Life Support, or Weapons Systems (High Risk Activities"). Telit and its supplier(s) specifically disclaim any expressed or implied warranty of fitness for such High Risk Activities.

IV. Trademarks

TELIT and the Stylized T Logo are registered in the Trademark Office. All other product or service names are the property of their respective owners.

V. Third Party Rights

The software may include Third Party Right software. In this case you agree to comply with all terms and conditions imposed on you in respect of such separate software. In addition to Third Party Terms, the disclaimer of warranty and limitation of liability provisions in this License shall apply to the Third Party Right software.

TELIT HEREBY DISCLAIMS ANY AND ALL WARRANTIES EXPRESS OR IMPLIED FROM ANY THIRD PARTIES REGARDING ANY SEPARATE FILES, ANY THIRD PARTY MATERIALS INCLUDED IN THE SOFTWARE, ANY THIRD PARTY MATERIALS FROM WHICH THE SOFTWARE IS DERIVED (COLLECTIVELY “OTHER CODE”), AND THE USE OF ANY OR ALL THE OTHER CODE IN CONNECTION WITH THE SOFTWARE, INCLUDING (WITHOUT LIMITATION) ANY WARRANTIES OF SATISFACTORY QUALITY OR FITNESS FOR A PARTICULAR PURPOSE.

NO THIRD PARTY LICENSORS OF OTHER CODE SHALL HAVE ANY LIABILITY FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING WITHOUT LIMITATION LOST PROFITS), HOWEVER CAUSED AND WHETHER MADE UNDER CONTRACT, TORT OR OTHER LEGAL THEORY, ARISING IN ANY WAY OUT OF THE USE OR DISTRIBUTION OF THE OTHER CODE OR THE EXERCISE OF ANY RIGHTS GRANTED UNDER EITHER OR BOTH THIS LICENSE AND THE LEGAL TERMS APPLICABLE TO ANY SEPARATE FILES, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

PRODUCT APPLICABILITY

PRODUCT
SE868-A
SE868-AS
SE868K3-A
SE868K3-AL
SE868K7-A
SE868K7-AL

Table 0-1 Product Applicability Table

CONTENTS

TABLES

FIGURES

1 INTRODUCTION

1.1 Purpose

The purpose of this document is to provide information regarding the function, features, and usage of the Telit products listed in **Section 2.3 Product Variants**.
Please refer to that section for details of the members of the product family.

1.2 Audience

This document is intended for customer personnel who are responsible for design and implementation of a GNSS receiver system.

1.3 Contact and Support Information

For general contact, technical support services, technical questions, and to report documentation errors contact Telit Technical Support at:

- TS-EMEA@telit.com
- TS-AMERICAS@telit.com
- TS-APAC@telit.com

Alternatively, use:
http://www.telit.com/support

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:
http://www.telit.com

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

1.4 Text Conventions

Dates are in ISO 8601 format, i.e. YYYY-MM-DD.

Symbol	Description
	Danger – This information MUST be followed or catastrophic equipment failure and/or bodily injury may occur.
	Caution or Warning – This is an important point about integrating the product into a system. If this information is disregarded, the product or system may malfunction or fail.
	Tip – This is advice or suggestion that may be useful when integrating the product.

1.5 Related Documents

- Telit Jupiter SE868-A Datasheet
- Telit Jupiter SE868-AS Datasheet
- SE868-A/AS Evaluation Kit User Guide
- Telit MT-GNSS Software User Guide

1.5.1 Related Documents Requiring a Non-Disclosure Agreement

- Telit MT-GNSS Authorized Software User Guide

2 PRODUCT DESCRIPTION

The SE868Kx-A GNSS antenna module family provides complete multi-constellation position, velocity, and time (PVT) engines featuring high performance, high sensitivity, and low power consumption.

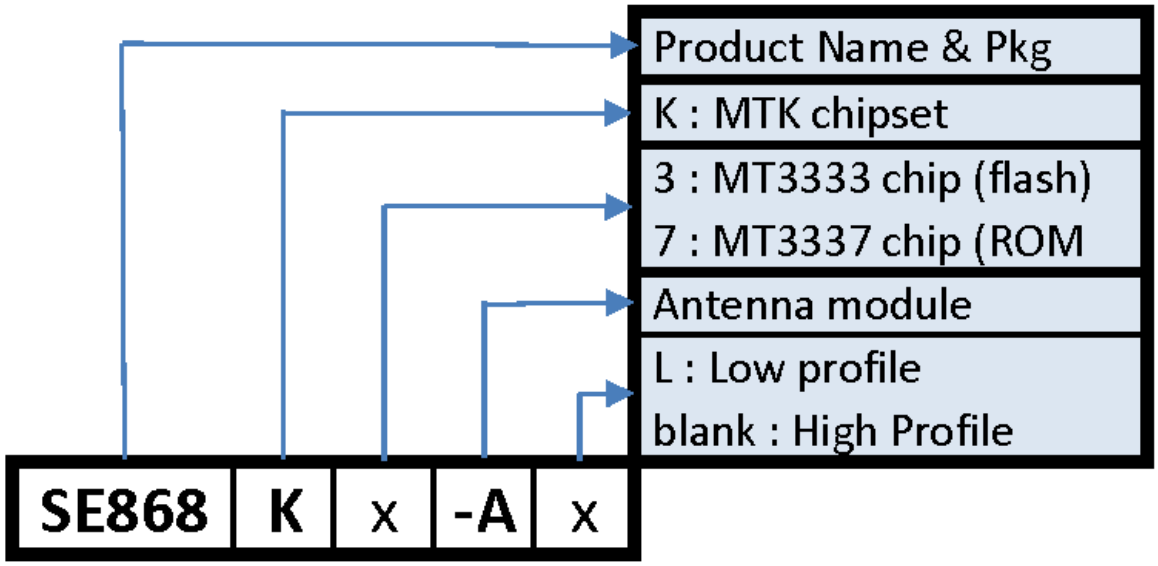
The inclusion of the GLONASS constellation (on selected models) yields better coverage, greater accuracy, and improved availability.

- These modules include a built-in SMT patch antenna
- These modules are based on the MediaTek MT3333 (SE868-A and SE868K3-A/AL) series) or MT3337 (SE868-AS and SE868K7-A/AL) chipset.

2.1 Product Overview

- Complete GNSS receiver module including memory, LNA, TCXO, and RTC plus a built-in patch antenna
- SE868-A and SE868K3-A series: GPS (L1), QZSS, and Glonass (L1) simultaneous ranging with 99 search and 33 tracking channels
- SE868-AS and SE868K7-A series: GPS(L1) ranging with 66 search and 22 tracking channels
- SE868-A and SE868K3-A series: Galileo ready
- SE868-A and SE868K3-A series: SBAS capable (WAAS, EGNOS, MSAS, GAGAN), including ranging
- AGPS support for extended ephemeris using local or server-based solutions:
  - Local: Embedded Assist System (EASY)
  - Server: Extended Prediction Orbit (EPO)
- DGPS capable using the RTCM SC-104 protocol
- Jamming Rejection: Active Interference Cancellation (AIC)
- Fix reporting at 1 Hz (default). Maximum: 10Hz
- NMEA v3.1 command input and data output
- Two serial ports (UART) for input commands and output messages
- SE868-A and SE868K3-A series: The secondary serial port is configurable for UART or I^2C interface
- SE868-A and SE868K3-A series: 8 Megabit built-in flash memory
- SE868-AS and SE868K7-A series: ROM memory
- 1PPS output
- Less than 100 mW total power consumption (Full Power mode – typical, GNSS)
- Power management modes for extended battery life
- Supported by evaluation kits
- -40°C to +85°C industrial temperature range
- 11 x 11 x 6.1 mm (nominal) 32-pad LGA package.
  - Low (-AL) module height is 4.1 mm.
- Surface mountable by standard SMT equipment
- RoHS compliant design

2.2 SE868xx-A Product Naming



Note - Early production modules :

- The ”K x x” fields are not present,
- The “–A” was replaced by “-AS” on SE868-AS and SE868K7-A series (ROM) GPS-only modules

2.3 Product Variants

Module	Chipset	Constellations	Memory	Antenna	Notes
SE868-A	MT3333	Multi	Flash	High	Early production
SE868-AS	MT3337E	GPS only	ROM	High	Early production
SE868K3-A	MT3333	Multi	Flash	High	
SE868K3-AL	MT3333	Multi	Flash	Low	
SE868K7-A	MT3337E	GPS only	ROM	High	
SE868K7-AL	MT3337E	GPS only	ROM	Low	

Table 2-1 Product Variants

See **Section 8.4 SE868-Ax to SE868Kx-Ax Comparison and Migration** for detailed pinout differences.

2.3.1 Multi-constellation modules (SE868-A and SE868K3-A series) features

- MediaTek MT3333 engine
- GPS, QZSS, and GLONASS satellite signals
- Flash memory with Upgradable firmware
- AGPS: Local (EASY) and server-based (EPO)
- Force-On pin
- I^2C on the 2nd port

Feature	SE868-A	SE868K3-A	SE868K3-AL
Additional LNA	No	Yes	Yes
Antenna Profile	High	High	Low

Table 2-2 Multi-constellation (SE868-A and SE868K3-A series) variants

2.3.2 GPS-only modules (SE868-AS and SE868K7-A series) features

- MediaTek MT3337 (early production) or MT333E (enhanced) engine
- GPS and QZSS satellite signals
- ROM memory
- AGPS: Local (EASY) and server-based (EPO)
  - EASY requires MT3337E ROM
  - EPO is host-based
- No Force-On pin
- UART only on the 2nd port

Feature	SE868-AS	SE868K7-A	SE868K7-AL
GNSS chip	MT3337 or MT3337E	MT3337E	MT3337E
Antenna Profile	High	High	Low
AGPS (EASY)	MT33337E only		

Table 2-3 GPS-only (SE868-AS and SE868K7-A series) variants

2.3.2.1 ROM Features (SE868-AS and SE868K7-A series modules)

Feature	SE868-AS (early production) P/N SE868ASA210Rxxx	SE868-AS P/N SE868ASA232Rxxx	SE868K3-Ax
ROM version	3337	3337E (enhanced)	3337E (enhanced)
EASY	No	Yes	Yes
SBAS	Yes	No	No
AlwaysLocate	Yes	No	No
LOCUS	Yes	No	No

2.4 Block Diagrams

2.4.1 Early Production

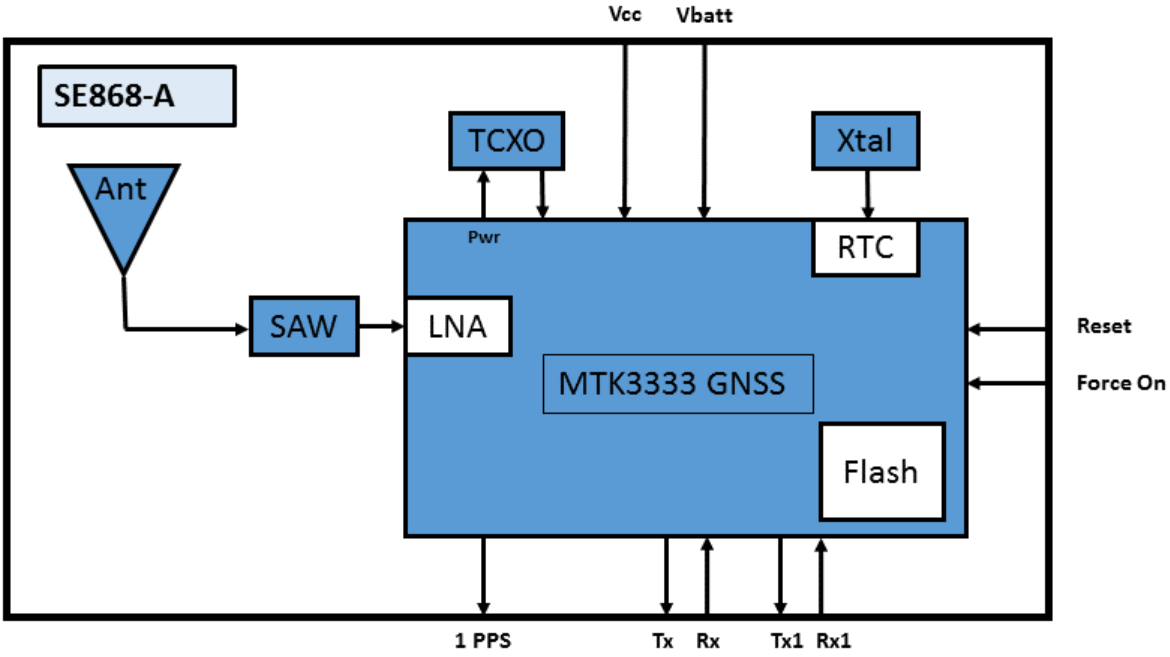


Figure 2-2 SE868-A Block Diagram

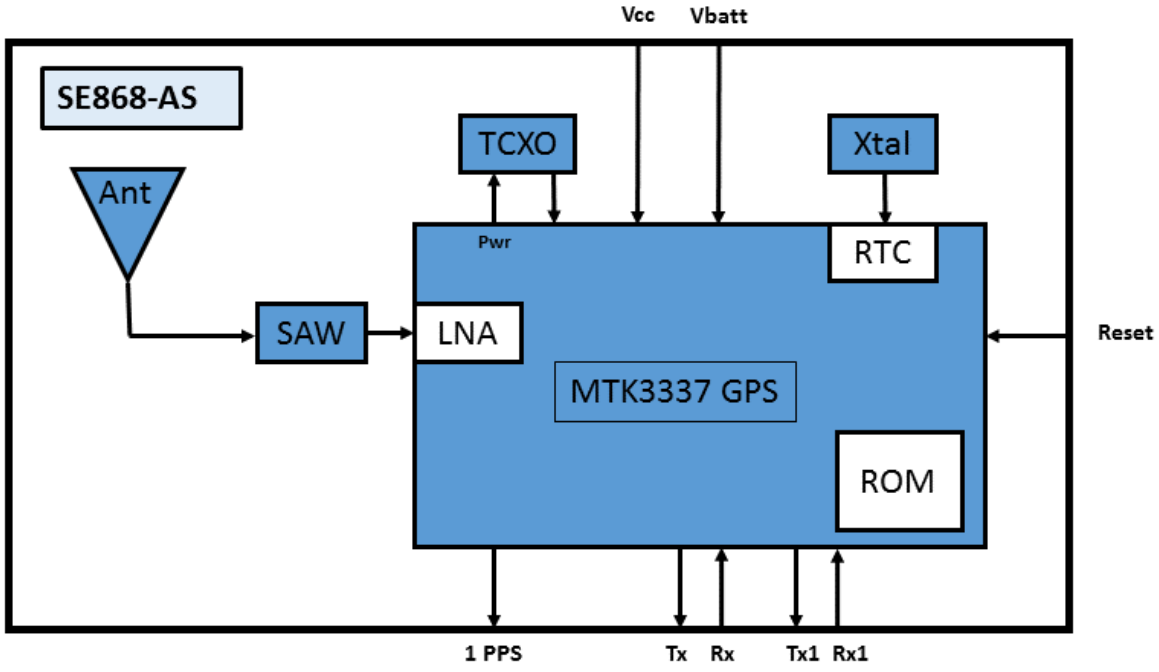


Figure 2-3 SE868-AS Block Diagram

2.4.2 Current Production

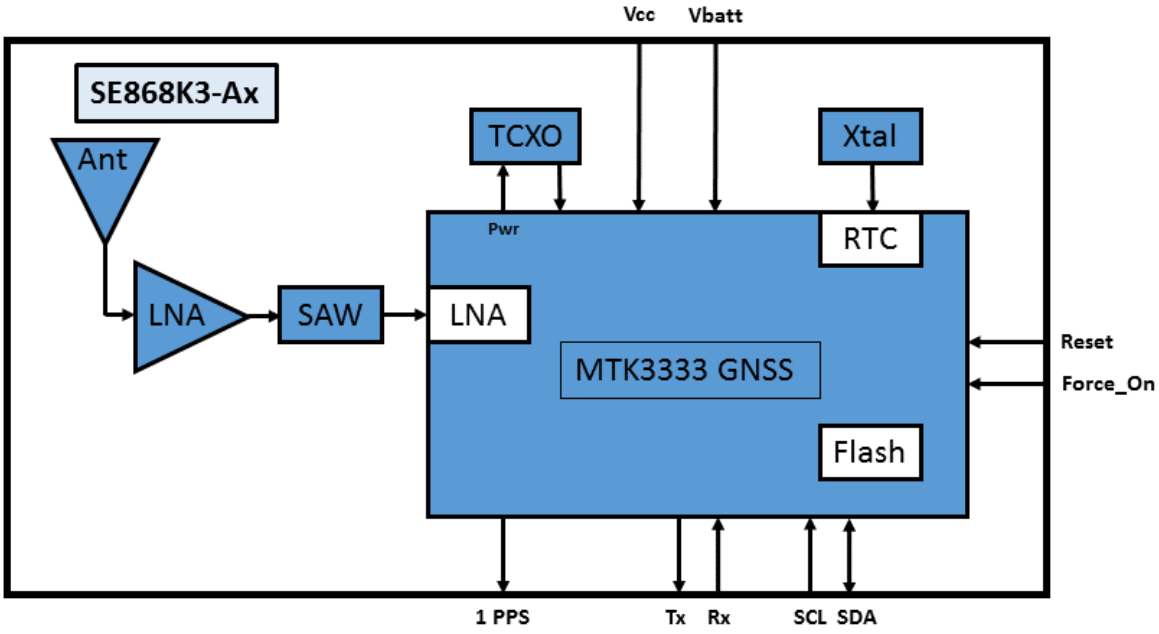


Figure 2-4 SE868K3-Ax Block Diagram

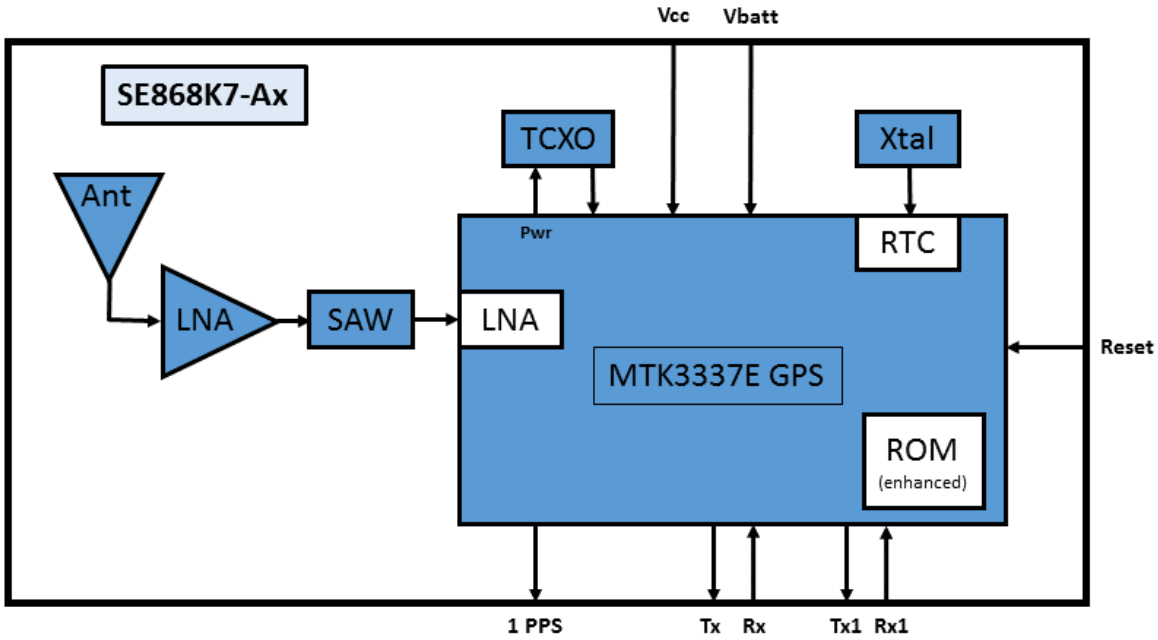


Figure 2-5 SE868K7-Ax Block Diagram

2.5 Module Photos

Figure 2-6 SE868xx-Ax Top View

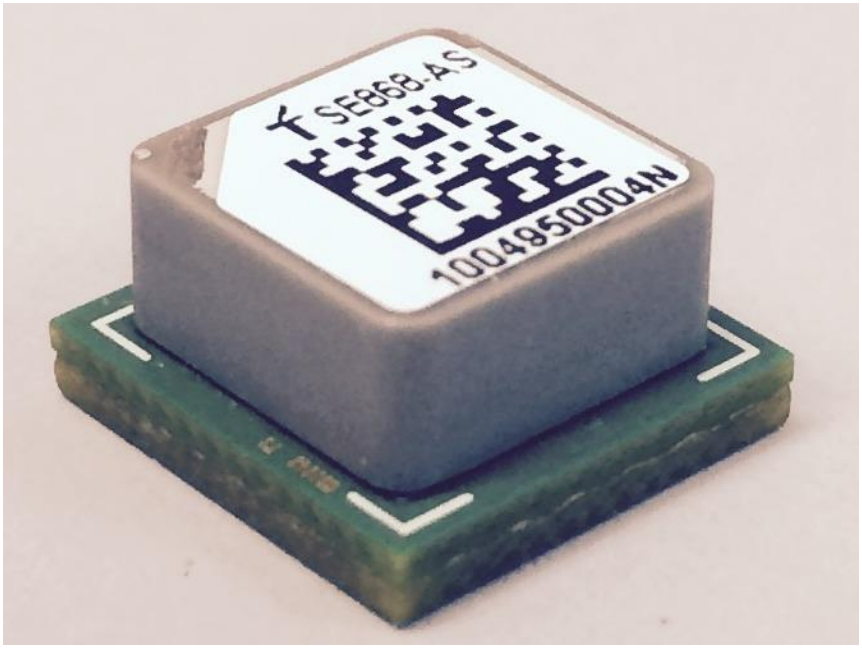


Figure 2-7 SE868xx-Ax Side View

Note: All modules in the applicability table have a similar appearance.

- The SE868Kx-AL module is 2 mm shorter that the SE868-AS shown.

3 EVALUATION BOARD (EVB)

The EVB contains the module mounted on a PC Board to facilitate testing.

Please refer to the product Evaluation Board User Guide for detailed information.

Figure 3-1 SE868xx-Ax Evaluation Board

4 PRODUCT FEATURES

4.1 Multi-Constellation Navigation (SE868-A and SE868K3-A series only)

GPS and GLONASS constellations are enabled by default.
The user may enable or disable GPS and/or GLONASS constellations via command. Using GLONASS alone may not give optimum positioning results depending on the region where the receiver is located.

4.2 Quasi-Zenith Satellite System (QZSS)

The satellites of the Japanese SBAS are in a highly-inclined, elliptical geosynchronous orbit, allowing continuous coverage over Japan using only three satellites. Their primary purpose is to provide augmentation to the GPS system, but the signals may also be used for ranging.
NMEA reporting for QZSS may be enabled/disabled by the user.

4.3 Satellite-Based Augmentation System (SBAS)

SBAS is not supported on the current production SE868-AS and SE868K7-A series modules (with the enhanced ROM).
The receiver is capable of using SBAS satellites as a source of both differential corrections and satellite ranging measurements. These systems (WAAS, EGNOS, GAGAN and MSAS) use geostationary satellites to transmit signals similar to that of GPS and in the same L1 band.
The SBAS feature limits the maximum fix rate to 5 Hz. If disabled, the maximum is 10 Hz.
The module is enabled for SBAS by default, but can be disabled by command **PTMK313**.
Either SBAS or DGPS corrections can be used and are set by the **PMTK301** command.

4.3.1 SBAS Corrections

The SBAS satellites transmit a set of differential corrections to their respective regions. The use of SBAS corrections can improve positioning accuracy

4.3.2 SBAS Ranging

The use of SBAS satellites can augment the number of measurements available for the navigation solution, thus improving availability and accuracy.

4.4 Assisted GPS (AGPS)

Assisted GPS (or Aided GPS) is a method by which information from a source other than broadcast GPS signals is used to improve (i.e. reduce) TTFF.
The necessary ephemeris data is calculated either by the receiver itself (locally-generated ephemeris) or a server (server-generated ephemeris) and is then stored in the module.
See **Section 2.3 Product Variants** for applicability.

4.4.1 Locally-generated AGPS - Embedded Assist System (EASY)

Proprietary algorithms within the module perform GPS ephemeris prediction locally from stored broadcast ephemeris data (received from tracked satellites). The algorithms predict orbital parameters for up to three days. The module must operate in Full Power mode for at least 5 minutes to collect ephemeris data from visible satellites, or 12 hours for the full constellation.
EASY is on by default, but can be disabled by command **PMTK869**.

See **Section 2.3 Product Variants** for applicability.

4.4.2 Server-generated AGPS - Extended Prediction Orbit (EPO)

(SE868-A and SE868K3-A series only)

Server-generated ephemeris predictions are maintained on Telit AGPS servers. The predicted ephemeris file is obtained from the AGPS server and is transmitted to the module over serial port 1 (RX). These predictions do not require local broadcast ephemeris collection, and are valid for up to 14 days.
The SE868-A and SE868K3-A series modules support server-based AGPS as a standard feature.
Please refer to the Telit EPO Application Note for details. Example source code is available under NDA.
Contact TELIT for support regarding this service.
See the next section regarding EPO support (Host EPO) on the SE868-AS and SE868K7-A series modules.

4.4.3 Host EPO (SE868-AS and SE868K7-A series only)

The SE868-AS and SE868K7-A series modules do not have flash memory. However, they can still make use of Assisted GPS. If the system design includes a host processor, it can access server-generated EPO data and send it to the module over the primary serial port (which must be temporarily changed to binary mode). This data is valid for six hours.
Please refer to the MT333x Host EPO Application Note.
Contact Telit support for further details.

4.5 Differential GPS (DGPS)

DGPS is a Ground-Based Augmentation System (GBAS) for reducing position errors by applying corrections from a set of accurately-surveyed ground stations located over a wide area. These reference stations measure the range to each satellite and compare it to the known-good range. The differences can then be used to compute a set of corrections which are transmitted to a DGPS receiver, either by radio or over the internet.
The DGPS receiver can then send them to the module 2nd serial port (RX2) using the RTCM SC-104 message protocol. The corrections can significantly improve the accuracy of the position reported to the user.
The receiver can accept either the RTCM SC-104 messages or SBAS differential data via command **PMTK501**.
RTCM is not supported if the 2nd port is configured for I^2C.

4.6 Elevation Mask Angle

The default elevation mask angle is 5°. It can be changed via the **PMTK311** command.

4.7 Static Navigation

Static Navigation is an operating mode in which the receiver will freeze the position fix when the speed falls below a set threshold (indicating that the receiver is stationary).
The course and altitude are also frozen, and the speed is reported as “0”.
The navigation solution is unfrozen when the speed increases above a threshold or when the computed position exceeds a set distance from the frozen position (indicating that the receiver is again in motion). The speed threshold can be set via the **PMTK386** command.
Set the threshold to zero to disable static navigation.

This feature is useful for applications in which very low dynamics are not expected, the classic example being an automotive application.
Static Navigation is disabled by default.

4.8 Jamming Rejection – Active Interference Cancellation (AIC)

The receiver module detects and removes narrow-band interfering signals (jamming signals) without the need for external components or tuning. It rejects up to 12 CW (Continuous Wave) type signals of up to –80 dBm (total power signal levels). This feature is useful both in the design stage and during the production stage for uncovering issues related to unexpected jamming. When enabled, Jamming Rejection will increase current drain by about 1 mA, and impact on GNSS performance is low at modest jamming levels. However, at high jamming levels (e. g. –90 to –80 dBm), the RF signal sampling ADC starts to become saturated after which the GNSS signal levels start to diminish.
Jamming rejection is enabled by default, but can be disabled with the **PMTK286** command.

4.9 Internal LNA (SE868Kx-A/AL modules only)

The current-production modules include a built-in LNA to improve sensitivity.

4.10 10 Hz Navigation

The default rate of 1 Hz can be changed by command **PMTK500** to a maximum of 10 Hz.
Enabling the SBAS feature limits the maximum fix rate to 5 Hz.

4.11 1PPS

1PPS is a one pulse per second signal with approximately 100 ms duration which is active when the receiver is in 3D navigation (4 satellites used in the navigation solution).
Please refer to the Telit MT Software User Guide information of the **MTK285** command to enable/disable this output.
The 1PPS pulse may vary 30 ns (1 σ).
The relationship between the 1PPS signal and UTC is unspecified.

4.12 Serial I/O Port

All modules include a primary UART serial port.
The SE868-A and SE868K3-A series modules include two serial ports – the primary UART and a secondary I^2C port. Refer to the pinouts for port assignments
The SE868-AS and SE868K7-A series modules include two UART ports.

4.12.1 UART

UART ports are full-duplex and support configurable baud rates. The signal input and output levels are LVTTL compatible (see **Section 8.7 I/O Ports**). Note that the idle state of the interface lines is logic high.
Care must be used to prevent backdriving the RX line(s) when the module is powered down or in a low-power state.

4.12.2 I2C (SE868-A and SE868K3-A series only)

The SE868-AS and SE868K7-A series modules do not support I^2C interface.

The SE868-A and SE868K3-A series modules 2nd serial port is configured to use the I^2C interface by default.
The module operates in the polled mode with the host as the master.

Transmit
The TX buffer is 256 bytes, and the host must read several packets each report cycle. A minimum pause of 2 ms is required between reads. For example, if the report cycle is 1 second, set the polling sleep time to 500 ms for the next output interval to start.
The buffer will contain up to 254 data bytes plus an <LF> (x'0A") character.
Each NMEA sentence will be terminated by the (standard) <CR-LF> (x'0D, x'0A') characters, and a NMEA sentence can span buffers.
If necessary, a buffer is padded with x'0A' characters. x'0A' is also used for idle characters.

Receive
The RX buffer is 255 bytes, which is the maximum length for commands sent to the module.
A minimum of 10 ms is required between packets.

Further details and sample code are available under NDA from the **MediaTek MT3339/MT3333 I^2C Application Note**.

4.13 Power Management Modes

The receiver supports operating modes that reduce overall current consumption with less frequent position fixes. Availability of GNSS signals in the operating environment will be a factor in choosing power management modes. The designer can choose a mode that provides the best trade-off of navigation performance versus power consumption.
The various power management modes can be enabled by sending the desired command using the host serial port (RX).

4.13.1 Full Power Continuous Mode

The receiver starts in full power continuous mode when powered up. This mode uses the acquisition engine to search for all possible satellites at full performance, resulting in the highest sensitivity and the shortest possible TTFF.
The receiver then switches to the tracking engine to lower the power consumption when:

- A valid GPS/GNSS position is obtained
- The ephemeris for each satellite in view is valid

To return to Full Power mode from a low power mode, send the NMEA command: **$PMTK225,0*2B** just after the module wakes up from its previous sleep cycle.
If power is removed from both Vcc and Vbatt, then Time, Ephemeris, Almanac, EASY, EPO data, and PMTK configuration data will be lost. If Vbatt is maintained, no data will be lost.

4.13.2 Standby Mode

In this mode the receiver stops navigation, the internal processor enters the standby state, and the current drain at main supply VCC_IN is substantially reduced.
Standby mode is entered by sending the following NMEA command:
$PMTK161,0*28 (STOP Mode)
$PMTK161,1*28 (SLEEP Mode)
The host can then wake up the module from Standby mode to Full Power mode by sending any byte to the host port (RX).

4.13.3 Backup Mode (SE868-A and SE868K3-A series only)

In the backup mode, the internal Power Management Unit is turned off, leaving only BBRAM and the RTC powered up. This reduces power consumption to the minimum that still provides data retention to enable hot and warm starts. To enter the Backup mode, use the NMEA command: **$PMTK225,1** and specify the desired sleep time.

4.13.4 Periodic Mode

This mode allows autonomous power on/off control with reduced fix rate to decrease average power consumption. The main power supply pin VCC_ON is still powered, but power distribution to internal circuits is internally controlled by the receiver.
Periodic mode is entered by sending the following NMEA command:
$PMTK225,<Type>,<Run_time>,<Sleep_time>,<2nd_run_time>,<2nd_sleep_time>*<checksum>
Where:

Type = 1 for Periodic (backup) mode or 2 for Periodic (standby) mode
Run_time = Full Power period (ms)
Sleep_time = Standby period (ms)
2nd_run_time = Full Power period (ms) for extended acquisition if GNSS acquisition fails during Run_time
2nd_sleep_time = Standby period (ms) for extended sleep if GNSS acquisition fails during Run_time

Example: **$PMTK225,1,3000,12000,18000,72000*16**
for periodic mode with 3 s navigation and 12 s sleep in backup state.
The acknowledgement response for the command is:
$PMTK001,225,3*35
Periodic mode is exited by sending the NMEA command
$PMTK225,0*2B
just after the module wakes up from a previous sleep cycle.

4.13.5 AlwaysLocate™ Mode (SE868-A and SE868K3-A series only)

AlwaysLocate™ is an intelligent controller of the Periodic mode where the main supply pin VCC_IN is still powered, but power distribution is controlled internally. Depending on the environment and motion conditions, the module can autonomously and adaptively adjust the parameters of the Periodic mode (e.g. RF on/off ratio and fix rate) to achieve a balance in positioning accuracy and power consumption. The average current drain will vary based on conditions.
AlwaysLocate™ mode is entered by sending the following NMEA command:
$PMTK225,<mode>*<checksum><CR><LF>
Where mode = 8 for AlwaysLocate (standby) mode or 9 for AlwaysLocate (backup) mode
Example: **$PMTK225,9*22**
The acknowledgement response for the command is:
$PMTK001,225,3*35
AlwaysLocate™ mode is exited by sending the NMEA command:
$PMTK225,0*2B
just after the module wakes up from its previous sleep cycle.

5 PRODUCT PERFORMANCE

5.1 Horizontal Position Accuracy

Constellation	CEP (m)
GPS	≤ 2.5
GLONASS	2.6
GPS + Glonass	≤ 2.5
Test Conditions: 24-hr Static, Live signals, Full Power mode	
Note: SE868-AS and SE868K7-A series modules support GPS only	

Table 5-1 SE868xx-A Horizontal Position Accuracy

5.2 Time to First Fix

Constellations(s)	Start Type	Max TTFF (s)
GPS	Hot	≤ 1.0
	Warm	32
	Cold	33
Glonass	Hot	1.4
	Warm	32
	Cold	33
GPS + GLO	Hot	≤ 1.0
	Warm	28
	Cold	31
Test Conditions: Static scenario, -130 dBm, Full Power mode		
Note: SE868-AS and SE868K7-A series modules support GPS only		

Table 5-2 SE868xx-A Time to First Fix

5.3 Sensitivity

Constellations	State	Minimum Signal Level (dBm) SE868-A
GPS	Acquisition	-145
	Navigation	-158
	Tracking	-160
GLO	Acquisition	-145
	Navigation	-158
	Tracking	-159
GPS + GLO	Acquisition	-145
	Navigation	-158
	Tracking	-160

Table 5-3 SE868-A Sensitivity

Const	State	Minimum Signal Level (dBm)			
		SE868K3-A	SE868K3-AL	SE868K7-A	SE868K7-AL
GPS	Acquisition			-148	-146
	Navigation			-163	-159
	Tracking			-164	-160
GPS + GLO	Acquisition	-148	-146		
	Navigation	-161	-157		
	Tracking	-164	-160		

Table 5-4 SE868Kx-Ax Sensitivity

6 SOFTWARE INTERFACE

Serial I/O port (RX and TX pins) supports full duplex communication between the receiver and the user.
The default serial configuration is: NMEA, 9600 bps, 8 data bits, no parity, and 1 stop bit.

More information regarding the software interface can be found in the **Telit MT Software User Guide.**

Customers that have executed a Non-Disclosure Agreement (NDA) with Telit Wireless may obtain the **Telit MT-GNSS Authorized Software User Guide**, which contains additional proprietary information.

6.1 NMEA Output Messages

NMEA-0183 v3.10 is the default protocol.
Some sentences may exceed the NMEA length limitation of 80 characters.

Default: GPS and QZSS constellations enabled.
GLONASS is also enabled for SE868-A and SE868K3-A series modules.
Default fix rate: 1 Hz. Maximum rate is 10 Hz.
Note: Multiple GSA and GSV messages may be output on each cycle.

6.1.1 Standard Messages

Message ID	Description
RMC	GNSS Recommended minimum navigation data
GGA	GNSS position fix data
VTG	Course Over Ground & Ground Speed
GSA	GNSS Dilution of Precision (DOP) and active satellites
GSV	GNSS satellites in view.

Table 6-1 Default NMEA output messages

The following messages can be enabled by command:

Message ID	Description
GLL	Geographic Position – Latitude & Longitude
ZDA	Time & Date

Table 6-2 Available Messages

The following table shows the Talker IDs used:

Talker ID	Constellation
BD	BeiDou
GA	Galileo
GL	GLONASS
GP	GPS
QZ	QZSS

Table 6-3 NMEA Talker IDs

6.1.2 Proprietary Output Messages

The receivers support several proprietary NMEA output messages which contain additional receiver data and status information.

Message ID	Description
$PMTK010	System messages (e.g. to report startup, etc.)

6.2 NMEA Input Commands

The modules use NMEA proprietary messages for commands and command responses. This interface provides configuration and control over selected firmware features and operational properties of the module. Wait time is about 50 to 100 ms.

The format of a command is: **$<command-ID>[,<parameters>]*<cr><lf>**

Commands are NMEA proprietary format and begin with **"$PMTKxxx**".
Parameters, if present, are comma-delimited as specified in the NMEA protocol.

Unless otherwise noted in the Software User Guide, commands are echoed back to the user after the command is executed.

6.2.1 NMEA Commands List

Command ID	Description
$PMTK000	Test. This command will be echoed back to the sender (for testing the communications link).
$PMTK101	Perform a HOT start
$PMTK102	Perform a WARM start
$PMTK103	Perform a COLD start
$PMTK104	Perform a system reset (erasing any stored almanac data) and then a COLD start
$PMTK120	Erase aiding data stored in flash memory
$PMTK127	Erase EPO data stored in flash memory
$PMTK161,0	Standby - Stop mode
$PMTK161,1	Standby - Sleep mode
$PMTK251,Baudrate	Set NMEA Baud rate
$PMTK313,0	Disable SBAS feature
$PMTK313,1	Enable SBAS feature
$PMTK353,1,0,0,0,0	Enable GPS only mode
$PMTK353,0,1,0,0,0	Enable GLO only mode
$PMTK353,1,1,0,0,0	Enable GPS and GLO mode

NOTE: Multi-constellation commands are not supported by the MT3337-baased modules

Table 6-4 NMEA Input commands

7 FLASH UPGRADABILITY

(SE868-A and SE868K3-A series only)

Note: The SE868-AS and SE868K7-A series modules use ROM memory and therefore are not upgradable.
Please refer to the product EVK User Guide for more detailed information.

The firmware stored in the internal Flash memory may be upgraded via the serial port TX/RX pins. In order to update the FW, the following steps should be performed to re-program the module.

1. Remove all power to the module.
2. Connect serial port USB cable to a PC.
3. Apply main power.
4. Clearing the entire flash memory is strongly recommended prior to programming.
5. Run the software utility to re-flash the module.
6. Upon successful completion of re-flashing, remove main power to the module for a minimum of 10 seconds.
7. Apply main power to the module.
8. Verify the module has returned to the normal operating state.

8 ELECTRICAL INTERFACE

8.1 SE868-A Family Pinout Diagram

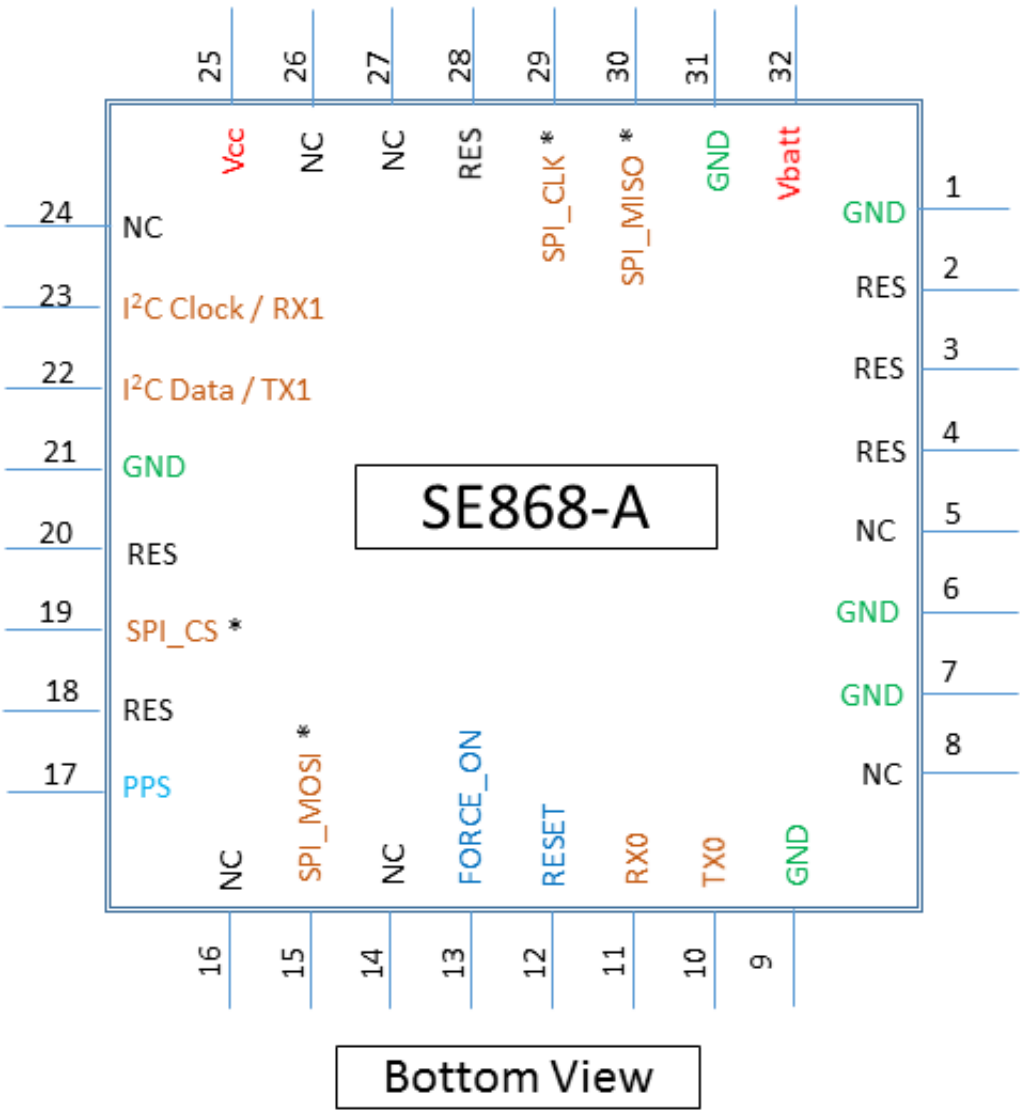


Figure 8-1 SE868-A Family Pinout Diagram

Notes (See the detailed pinout tables below):

1. All Ground (GND) pins are to be grounded
2. Reserved pins (RES) are to be left floating
3. FORCE_ON is connected only on the SE868-A and SE868K3-A series modules. See **Section 8.6.1.2 FORCE_ON** for details.
4. SPI pins (marked with "*") require a special Firmware build and therefore are not available on the SE868-AS and SE868K7-A series modules.
5. I²C pins are implemented only on the SE868K3-Ax. They are UART on the SE868K7-Ax.
6. See the detailed pinout tables below.

8.2 Signal Levels

Several distinct logic levels are utilized by the digital signal interfaces of the module:

8.2.1 Logic Levels – Inputs

RX, RX2, Reset-N, Force_On					
Signal	**Symbol**	**Min**	**Typ**	**Max**	**Units**
Input Voltage (L)	V_{il}	0		0.5	V
Input Voltage (H)	V_{ih}	1.9		3.4	V
Note: These inputs have an internal pullup of 40 kΩ to 190 kΩ. Do not drive the Reset-N line high.					

Table 8-1 Input Logic Levels: RX and Reset-N

8.2.2 Logic Levels – Outputs

TX, TX2, and 1PPS					
Signal	**Symbol**	**Min**	**Typ**	**Max**	**Units**
Output Voltage (L)	V_{ol}			0.4	V
Output Voltage (H)	V_{oh}	2.14		2.89	V
Normal Current (L)	I_{ol}		-2		mA
Output Current (H)	I_{oh}		-2		mA

Table 8-2 Output Logic Levels: TX and 1PPS

8.3 SE868-A Module Pinout Tables

8.3.1 SE868-A Pinout Table

PIN	SIGNAL	TYPE	DESCRIPTION	LOGIC LEVEL
1	Ground	GND	Ground	-
2	Reserved	RES	Reserved. Do not connect	-
3	Reserved	RES	Reserved. Do not connect	-
4	Reserved	RES	Reserved. Do not connect	-
5	No Connection	NC	Not connected	-
6	Ground	GND	Ground	-
7	Ground	GND	Ground	-
8	No Connection	NC	Not connected	-
9	Ground	GND	Ground	-
10	TX0	O	Serial_Output_UART0	2V8
11	RX0	I	Serial_Input_UART0	2V8
12	HRST_B	I	System Reset – Active Low	2V8
13	FORCE_ON	I	Force full-power mode (Note 3)	1V2
14	No Connection	NC	Not connected	-
15	No Connection	NC	Not connected	-
16	No Connection	NC	Not connected	-
17	PPS	O	Pulse Per Second signal	2V8
18	Reserved	RES	Reserved. Do not connect	-
19	Reserved	RES	Reserved. Do not connect	-
20	Reserved	RES	Reserved. Do not connect	-
21	Ground	GND	Ground	-
22	I^2C Data / TX1	I/O	I2C Data / UART1_Tx	2V8
23	I^2C Clock / RX1	I/O	I2C Clock / UART1_Rx	2V8
24	No Connection	NC	Not connected	-
25	VCC	PWR	Main power supply	3.0 to 3.6 V
26	No Connection	NC	Not connected	-
27	No Connection	NC	Not connected	-
28	Reserved	RES	Reserved. Do not connect	-
29	No Connection	NC	Not connected	-
30	No Connection	NC	Not connected	-
31	Ground	GND	Ground	-
32	VBATT	PWR	Backup Power supply	3.0 to 3.6 V

Table 8-3 SE868-A Pinout Table

8.3.2 SE868-AS Pinout Table

PIN	SIGNAL	TYPE	DESCRIPTION	LOGIC LEVEL
1	Ground	GND	Ground	-
2	Reserved	RES	Reserved. Do not connect	-
3	Reserved	RES	Reserved. Do not connect	-
4	Reserved	RES	Reserved. Do not connect	-
5	No Connection	NC	Not connected	-
6	Ground	GND	Ground	-
7	Ground	GND	Ground	-
8	No Connection	NC	Not connected	-
9	Ground	GND	Ground	-
10	TX0	O	Serial_Output_UART0	2V8
11	RX0	I	Serial_Input_UART0	2V8
12	HRST_B	I	System Reset – Active Low	2V8
13	No Connection	NC	No Connection (Note 3)	-
14	No Connection	NC	Not connected	-
15	No Connection	NC	Not connected	-
16	No Connection	NC	Not connected	-
17	PPS	O	Pulse Per Second signal	2V8
18	Reserved	RES	Reserved. Do not connect	-
19	Reserved	RES	Reserved. Do not connect	-
20	Reserved	RES	Reserved. Do not connect	-
21	Ground	GND	Ground	-
22	TX1	O	Serial_Output_UART1	2V8
23	RX1	I	Serial_Input_UART1	2V8
24	No Connection	NC	Not connected	-
25	VCC	PWR	Main power supply	3.0 to 3.6 V
26	No Connection	NC	Not connected	-
27	No Connection	NC	Not connected	-
28	Reserved	RES	Reserved. Do not connect	-
29	No Connection	NC	Not connected	-
30	No Connection	NC	Not connected	-
31	Ground	GND	Ground	-
32	VBATT	PWR	Backup Power supply	3.0 to 3.6 V

Table 8-4 SE868-AS Pinout Table

8.3.3 SE868K3-A Pinout Table

PIN	SIGNAL	TYPE	DESCRIPTION	LOGIC LEVEL
1	Ground	GND	Ground	-
2	Reserved	RES	EIT0 / GPIO12	-
3	Reserved	RES	GPIO9	-
4	Reserved	RES	Reserved. Do not connect	-
5	No Connection	NC	Not connected	-
6	Ground	GND	Ground	-
7	Ground	GND	Ground	-
8	No Connection	NC	Not connected	-
9	Ground	GND	Ground	-
10	TX0	O	UART0 Serial Output (Transmit)	2V8
11	RX0	I	UART0 Serial Input (Receive)	2V8
12	S_RESET	I	System Reset – Active Low	2V8
13	FORCE_ON	I	Force full-power mode (Note 3)	1V2
14	No Connection	NC	Not connected	-
15	SPI_MOSI	I/O	SPI Data MOSI (Note 4)	2V8
16	No Connection	NC	Not connected	-
17	PPS	O	Pulse Per Second signal	2V8
18	No Connection	NC	Not connected	-
19	SPI_CS	I/O	SPI Chip Select (Note 4)	2V8
20	Reserved	RES	GPIO10	-
21	Ground	GND	Ground	-
22	I^2C Data / TX1	I/O	I2C Data / UART1 Tx (Note 5)	2V8
23	I^2C Clock / RX1	I/O	I2C Clock / UART1 Rx (Note 5)	2V8
24	No Connection	NC	Not connected	-
25	VCC	PWR	Main power supply	3.0 to 3.6 V
26	No Connection	NC	Not connected	-
27	No Connection	NC	Not connected	-
28	Reserved	RES	EIT1 / GPIO13	-
29	SPI_CLK	I/O	SPI Clock (Note 4)	2V8
30	SPI_MISO	I/O	SPI Data MISO (Note 4)	2V8
31	Ground	GND	Ground	-
32	VBATT	PWR	Backup Power supply	3.0 to 3.6 V
Note 4: SPI interface requires a special FW build				

Table 8-5 SE868K3-A Pinout Table

8.3.4 SE868K7-A Pinout Table

PIN	SIGNAL	TYPE	DESCRIPTION	LOGIC LEVEL
1	Ground	GND	Ground	-
2	Reserved	RES	EIT0 / GPIO 12 on MT3333	-
3	Reserved	RES	GPIO9 on MT3333.	-
4	Reserved	RES	Reserved. Do not connect	-
5	No Connection	NC	Not connected	-
6	Ground	GND	Ground	-
7	Ground	GND	Ground	-
8	No Connection	NC	Not connected	-
9	Ground	GND	Ground	-
10	TX0	O	UART0 Serial Output (Transmit)	2V8
11	RX0	I	UART0 Serial Input (Receive)	2V8
12	S_RESET	I	System Reset – Active Low	2V8
13	Reserved	RES	Reserved. Do not connect (Note 3)	-
14	No Connection	NC	Not connected	-
15	Reserved	RES	Reserved. SPI on MT3333.	-
16	No Connection	NC	Not connected	-
17	PPS	O	Pulse Per Second signal	2V8
18	No Connection	NC	Not connected	-
19	Reserved	RES	Reserved. SPI on MT3333.	-
20	Reserved	RES	GPIO10 on MT3333.	-
21	Ground	GND	Ground	-
22	TX1	I/O	UART1 Tx (Note 5)	2V8
23	RX1	I/O	UART1 Rx (Note 5)	2V8
24	No Connection	NC	Not connected	-
25	VCC	PWR	Main power supply	3.0 to 3.6 V
26	No Connection	NC	Not connected	-
27	No Connection	NC	Not connected	-
28	Reserved	RES	EIT1 / GPIO13 on MT3333.	-
29	Reserved	RES	Reserved. SPI on MT3333.	-
30	Reserved	RES	Reserved. SPI on MT3333.	-
31	Ground	GND	Ground	-
32	VBATT	PWR	Backup Power supply	3.0 to 3.6 V

Note 3: Force-On is not implemented in the MT3337
Note 5: TX1/RX1 are UART-only on the MT3337

Table 8-6 SE868K7-A Pinout Table

8.4 SE868-Ax to SE868Kx-Ax Comparison and Migration

This section contains information relating to migrating from the early production modules to current production as follows:

- MTK3333-based: SE868-A to SE868K3-Ax
- MTK3337-based: SE868-AS to SE868K7-Ax

As shown in the following tables, the main differences for the SE868-A and SE868K3-A series SE868K3-Ax are the addition of SPI pins (which require a custom FW build) and the change of pin 18 from Reserved to No Connection.

For the SE868-AS and SE868K7-A series SE868K7, the main differences are the change from “No Connection” to “Reserved” for the FORCE_ON and SPI pins that are used on the SE868K3-Ax. This is to allow a compatible board design for the two modules as long as FORCE_ON, I^2C and SPI are not required.

Of course, there are also differences in the firmware (in flash memory for the SE868K3-Ax or ROM for the SE868K7-Ax).

8.4.1 SE868-A and SE868K3-Ax Pinout Comparison

PIN	SE868-A Signal	SE868K3-Ax Signal	Comparison
1	Ground	Ground	=
2	Reserved	Reserved	=
3	Reserved	Reserved	=
4	Reserved (DR-IN)	Reserved	=
5	No Connection	No Connection	=
6	Ground	Ground	=
7	Ground	Ground	=
8	No Connection	No Connection	=
9	Ground	Ground	=
10	TX0	TX0	=
11	RX0	RX0	=
12	HRST_B	S_RESET	=
13	FORCE_ON	FORCE_ON	= (Note 3)
14	No Connection	No Connection	=
15	No Connection	SPI_MOSI	SPI MOSI (Note 4)
16	No Connection	No Connection	=
17	PPS	PPS	=
18	Reserved (ECLK)	No Connection	NC
19	Reserved (SYNC_PULSE)	SPI_CS	SPI CS (Note 4)
20	Reserved (GIO10)	Reserved	=
21	Ground	Ground	=
22	I^2C Data / TX1	I^2C Data / TX1	= (Note 5)
23	I^2C Clock / RX1	I^2C Clock / RX1	= (Note 5)
24	No Connection	No Connection	=
25	VCC	VCC	=
26	No Connection	No Connection	=
27	No Connection	No Connection	=
28	Reserved (MM_I2CD)	Reserved	=
29	No Connection	SPI_CLK	SPI CLK (Note 4)
30	No Connection	SPI_MISO	SPI MISO (Note 4)
31	Ground	Ground	=
32	VBATT	VBATT	=

Notes are under ***Figure 8-1 SE868-A Family Pinout Diagram***

Table 8-7 SE868-AS and SE868K3-A Pinout Comparison

8.4.2 SE868-AS and SE868K7-Ax Pinout Comparison

PIN	SE868-AS Signal	SE868K7-Ax Signal	Comparison
1	Ground	Ground	=
2	Reserved	Reserved	=
3	Reserved	Reserved	=
4	Reserved (DR_IN)	Reserved	=
5	No Connection	No Connection	=
6	Ground	Ground	=
7	Ground	Ground	=
8	No Connection	No Connection	=
9	Ground	Ground	=
10	TX0	TX0	=
11	RX0	RX0	=
12	HRST_B	S_RESET	=
13	No Connection	Reserved	Reserved (Note 3)
14	No Connection	No Connection	=
15	No Connection	Reserved	Reserved (Note 4)
16	No Connection	No Connection	=
17	PPS	PPS	=
18	Reserved (NC)	No Connection	NC
19	Reserved (SYNC_PULSE)	Reserved	= (Note 4)
20	Reserved (NC)	Reserved	=
21	Ground	Ground	=
22	TX1	TX1	= (Note 5)
23	RX1	RX1	= (Note 5)
24	No Connection	No Connection	=
25	VCC	VCC	=
26	No Connection	No Connection	=
27	No Connection	No Connection	=
28	Reserved (NC)	Reserved	=
29	No Connection	Reserved	Reserved (Note 4)
30	No Connection	Reserved	Reserved (Note 4)
31	Ground	Ground	=
32	VBATT	VBATT	=

Notes are under ***Figure 8-1 SE868-A Family Pinout Diagram***

Table 8-8 SE868-AS and SE868K3-A Pinout Comparison

8.5 DC Power Supply

The modules have two power supply pins V_{CC} and V_{BATT}.

8.5.1 VCC

This is the main power input. The supply voltage must be in the range specified in **Table 8-9 DC Supply Voltage** below.
When power is first applied, the module will start up in full power continuous operation mode. During operation, the current drawn by the module can vary greatly, especially if enabling low-power operation modes. The supply must be able to handle the current fluctuation including any inrush surge current.
GPS/GNSS receiver modules require a clean and stable power supply. In designing such a supply, any resistance in the VCC line can negatively influence performance. Consider the following points: All supplies should be within the rated requirements. At the module input, use low ESR capacitors that can deliver the required current for switching from backup mode to normal operation. Keep the rail short and away from any noisy data lines or switching supplies, etc. Wide power lines and power planes are preferred.

8.5.2 VBATT

The battery backup power input range is specified in the table below.
In case of a power failure on VCC, VBATT supplies power to the following:

- real-time clock (RTC)
- battery backed RAM (BBRAM)
- EASY data
- Default configuration options (not commanded options)

This allows the module to retain time and ephemeris information, thus enabling hot and warm starts, which will shorten TTFF.
For the SE868-A and SE868K3-A series modules, if VBATT is removed EPO data is also retained in flash memory.

8.5.3 DC Power Requirements

Main Supply Voltage & Backup Voltage					
Supply	**Name**	**Min**	**Typ**	**Max**	**Units**
Main Voltage	VCC	3.0	3.3	3.6	V
Backup Voltage	VBATT	3.0	3.3	3.6	V

Table 8-9 DC Supply Voltage

8.5.4 DC Power Consumption: SE868-A

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	84	123	mW
GPS and Glonass	103	146	mW
Navigation/Tracking			
GPS Only	74	120	mW
GPS and Glonass	81	139	mW
Low Power Mode			
GPS Only	19		mW
GPS and Glonass	25		mW
Battery Backup	54		µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: 500 ms duty cycle SBAS: enabled 1PPS sync: enabled			

Table 8-10 SE868-A Power Consumption

8.5.5 DC Power Consumption: SE868-AS

State (GPS only)	Typ	Max	Units
Acquisition	79	102	mW
Navigation/Tracking	74	102	mW
Low Power - Periodic	24		mW
Low Power – AlwaysLocate Standby	16		mW
Low Power - Backup	22		µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: 500 ms duty cycle SBAS: disabled 1PPS sync: disabled			

Table 8-11 SE868-AS Power Consumption

8.5.6 DC Power Consumption: SE868K3-Ax

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	107	151	mW
GPS and Glonass	111	163	mW
Navigation/Tracking			
GPS Only	73	93	mW
GPS and Glonass	99	132	mW
Low Power Mode			
GPS Only			mW
GPS and Glonass			mW
Battery Backup	56		µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: 500 ms duty cycle SBAS: enabled 1PPS sync: enabled			

Table 8-12 SE868K3-Ax Power Consumption

8.5.7 DC Power Consumption: SE868K7-Ax

State (GPS only)	Typ	Max	Units
Acquisition	85	119	mW
Navigation/Tracking	71	89	mW
Low Power - Periodic			mW
Low Power – AlwaysLocate Standby			mW
Low Power - Backup	22		µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: 500 ms duty cycle SBAS: disabled 1PPS sync: disabled			

Table 8-13 SE868K7-Ax Power Consumption

8.6 Control Signals

8.6.1 Input Signals

8.6.1.1 RESET-N

The Reset-N input is a low true input to reset the receiver to the default starting state. This signal is not required for the module to operate properly, so this pin may be left unconnected. However, if used, the signal can only be driven low, never high since it has an internal pullup, for example, using an open-collector circuit.

8.6.1.2 FORCE_ON (SE868-A and SE868K3-Ax only)

Connect this pin through a 10 KΩ resistor to ground to create a pulldown.

Upon command, the module will enter the backup (low power) state.
To exit this state, drive the Force-on signal high (true) to force the module to return to the full power state.

Force-on should be held high until the PMTK101 message is received (about 1 second), then released to logic low.

If Force-on is high when a low-power command is received, the module will enter the Standby (stop) state rather than the Backup state, since the PMU is still on.

This signal is only available on the SE868-A and SE868K3-A series modules.

8.6.2 Output Signals

8.6.2.1 1PPS

1PPS is a one pulse per second signal with approximately 100 ms duration which is active when the receiver is in 3D navigation. The 1PPS pulse may vary 30 ns (1 σ).
The relationship between the 1PPS signal and UTC is unspecified.

8.7 I/O Ports

8.7.1 UART

8.7.1.1 TX0

The TX serial data line outputs NMEA messages from the receiver to the host at a default rate of 9600 bps. When no serial data is being output, the TX data line idles high.

When the module is powered down, do not back drive this or any other GPIO line.

8.7.1.2 RX0

The RX serial data line accepts proprietary NMEA commands at a default rate of 9600 bps from the host to the receiver. When the module is powered down, do not back drive this (or any other) GPIO line. The idle state from the host computer must be high.

8.7.1.3 TX1

The TX2 data line is currently unused by the firmware.

8.7.1.4 RX1

The RX2 (UART) data line accepts DGPS data using the RTCM SC-104 protocol from the host CPU or other source at a default bit rate of 9600 bps.
When the module is powered down, do not back drive this or any other GPIO line. The idle state for serial data from the host computer must be logic 1.

8.7.2 I2C

The 2nd serial port on the SE868-A and SE868K3-A series modules is configured to use the I^2C interface.
It does not accept DGPS corrections.
The SE868-AS and SE868K7-A series modules do not support I^2C interface.
For details, please refer to the **MediaTek MT3339/MT3333 I^2C Application Note**.

9 REFERENCE DESIGN

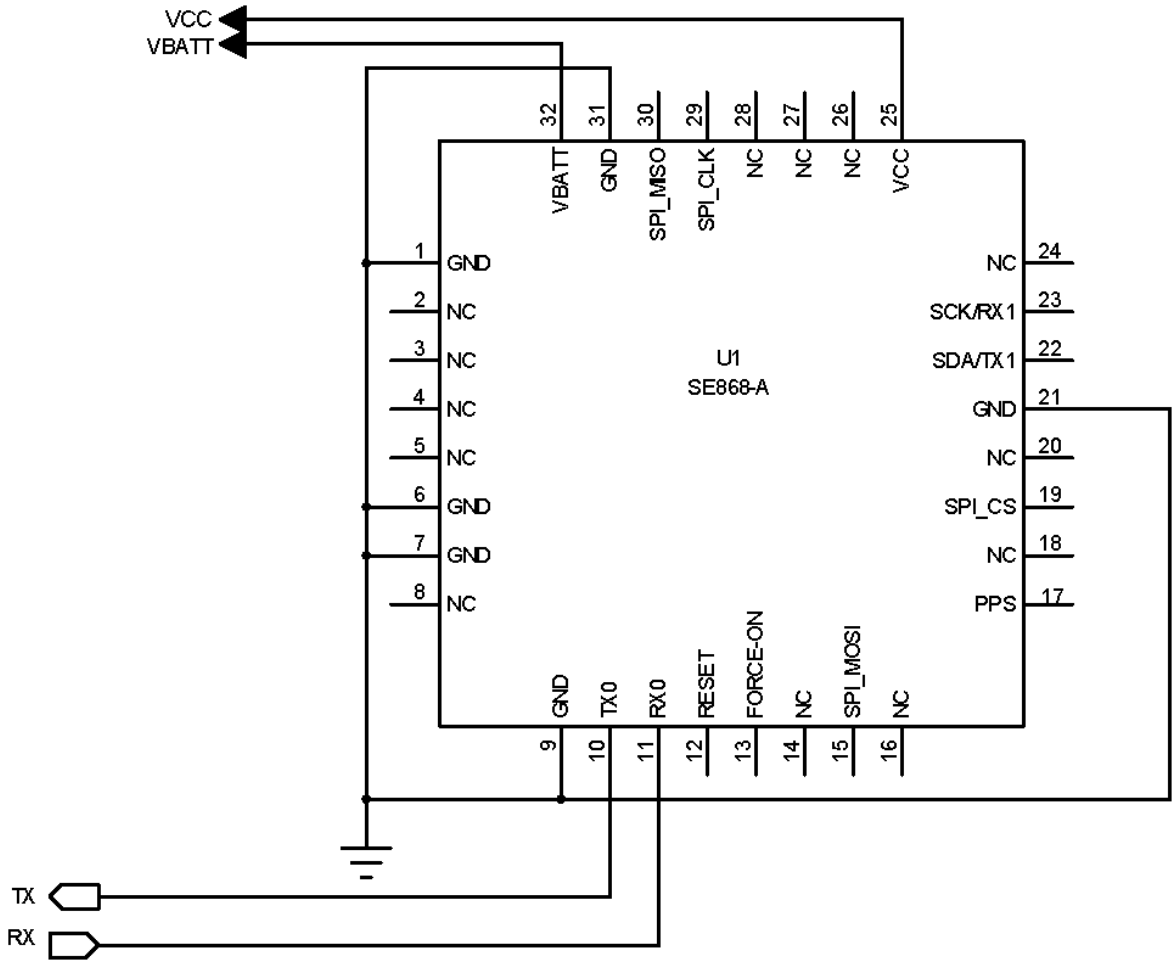


Figure 9-1 Reference Design

Along with power and grounds, the minimum signals required to operate the receiver properly are the RF input signal and two digital I/O signals (TX and RX).

TX and RX are UART lines with a default of 9600-8-N-1. They are used for message output and command input. Be careful not to drive the RX line if the module is turned off.

See **Section 8 Electrical Interface** for important details.

10 RF FRONT-END DESIGN

10.1 RF Signal Requirements

The receiver can achieve Cold Start acquisition with a signal level above the specified minimum at its input. This means that it can acquire and track visible satellites, download the necessary navigation data (e.g. time and ephemeris) and compute its position within a period of 5 minutes. In the GNSS signal acquisition process, decoding the navigation message data is the most difficult task, which is why Cold Start acquisition requires a higher signal level than navigation or tracking. For the purposes of this discussion, autonomous operation is assumed, which makes the Cold Start acquisition level the dominant design constraint. If assistance data in the form of time and/or ephemeris aiding is available, lower signal levels may be used for acquisition.

The GPS signal is defined by IS-GPS-200. This document states that the signal level received by a linearly polarized antenna having 3 dBi gain will be a minimum of -130 dBm when the antenna is in the worst-case orientation and the satellite is 5 degrees or more above the horizon.
In actual practice, the GPS satellites transmit slightly more power than specified by IS-GPS-200, and the signal level typically increases if a satellite has higher elevation angles.

The GLONASS signal is defined by GLONASS ICD (currently 2008 Version 5.1). This document states that the power level of the received RF signal from a GLONASS satellite at the output of a 3dBi linearly polarized antenna is not less than -131dBm for L1 sub-band provided that the satellite is observed at an angle 5 degrees or more above the horizon.

The receiver will display a reported C/No of 40 dB-Hz for a GPS signal level of -130 dBm at the RF input. This assumes a SEN (system equivalent noise) of the receiver of 4dB. System Equivalent Noise includes the Noise Figure of the receiver plus signal processing or digital noise. For an equivalent GLONASS signal level, the GLONASS signal will report a C/No of approximately 39 dB-Hz. This is due to the receiver's higher losses (NF) for GLONASS signals and a higher signal processing noise for GLONASS signals.

Each GNSS satellite presents its own signal to the receiver, and best performance is obtained when the signal levels are between -130 dBm and -125 dBm. These received signal levels are determined by:

- Satellite transmit power
- Satellite elevation angle
- Free space path loss
- Extraneous path loss (e.g. rain)
- Partial or total path blockage (such as foliage or buildings)
- Multipath interference (caused by signal reflection)
- GNSS antenna characteristics
- Signal path after the GNSS antenna

The satellite transmit power is specified in each constellation's reference documentation, which is readily available online.

The GNSS signal is relatively immune to attenuation from rainfall.
However, the GNSS signal is heavily influenced by attenuation due to foliage (such as tree canopies, etc.) as well as outright blockage caused by buildings, terrain or other items near the line of sight to the specific GNSS satellite. This variable attenuation is highly dependent upon satellite location. If enough satellites are blocked, say at a lower elevation, or all in one general direction, the geometry of the remaining satellites will be worse (higher DOP) and will

result is a lower position accuracy. The receiver reports this geometry effect in the form of PDOP, HDOP and VDOP numbers.
For example, in a vehicular application, the GNSS antenna may be placed on the dashboard or rear package tray of an automobile. The metal roof of the vehicle will cause significant blockage. Also, any thermal coating applied to the vehicle glass can attenuate the GNSS signal by as much as 15 dB. Again, both of these factors will affect the performance of the receiver.

Multipath interference results when the signal from a particular satellite is reflected from a surface (e.g. a building or the roof of a car) and is received by the GNSS antenna either in addition to or in place of the line of sight signal. The reflected signal has a path length that is longer than the line of sight path so it can either attenuate the original signal, or if received in place of the original signal, can add error in determining a solution because the distance to the particular satellite is actually shorter than measured. It is this phenomenon that makes GNSS navigation in urban canyons (narrow roads surrounded by high-rise buildings) so challenging. In general, the reflection of a GNSS signal causes its polarization to reverse. The implications of this are covered in the next section.

10.2 GNSS Antenna (included in the module)

The SE868xx-Ax modules include a SMT 9 x 9 mm ceramic patch antenna shown in the following table:

Module	Antenna	Constellations supported
SE868K3-A	9x9x4 mm	GPS, Galileo, GLONASS
SE868K3-AL	9x9x2 mm	GPS, Galileo, GLONASS
SE868K7-A	9x9x4 mm	GPS
SE868K7-AL	9x9x2 mm	GPS

See **Section 10.6 Ground Plane** for the Ground Plane drawing.

In order to optimize antenna performance, it is strongly recommended to design a 30mm by 30mm ground plane under the module on the application PCB.

If the ground plane size is smaller than 30x30mm, center frequency detuning may occur.

10.3 System Noise Floor

The receiver will display a reported C/No of 40 dB-Hz for an input signal level of -130 dBm. The C/No number means the carrier (or signal) is 40 dB greater than the noise floor measured in a one Hz bandwidth. This is a standard method of measuring GNSS receiver performance.

The simplified formula is:

C/No = GNSS Signal level – Thermal Noise – System NF

Equation 10-1 Carrier to Noise Ratio

Thermal noise is -174 dBm/Hz at 290 K.

We can estimate a typical system noise figure of 4 dB for the module, consisting of the pre-select SAW filter loss, the LNA noise figure, and implementation losses within the digital signal processing unit. The DSP noise is typically 1.0 to 1.5 dB.

However, if a good quality external LNA is used, the noise figure of that LNA (typically better than 1dB) could reduce the overall system noise figure from 4 dB to approximately 2 dB.

10.4 RF Interference

RF interference into the GNSS receiver tends to be the biggest problem when determining why the system performance is not meeting expectations. As mentioned earlier, the GNSS signals are at -130 dBm and lower. If signals higher than this are presented to the receiver, the RF front end can be overdriven. The receiver can reject CW jamming signals in each band (GPS and GLONASS), but would still be affected by non-CW signals.

The most common source of interference is digital noise, often created by the fast rise and fall times and high clock speeds of modern digital circuitry. For example, a popular netbook computer uses an Atom processor clocked at 1.6 GHz. This is only 25 MHz away from the GNSS signal, and depending upon temperature of the SAW filter, can be within its passband. Because of the nature of the address and data lines, this would be broadband digital noise at a relatively high level.

Such devices are required to adhere to a regulatory standard for emissions such as FCC Part 15 Subpart J Class B or CISPR 22. However, these regulatory emission levels are far higher than the GNSS signal.

10.5 Shielding

Shielding the RF circuitry generally is ineffective because the interference is received by the GNSS antenna itself, which is the most sensitive portion of the RF path. The antenna cannot be shielded because it could not then receive the GNSS signals.

There are two solutions, one is to move the antenna away from the source of interference, and the other is to shield the digital interference source to prevent it from getting to the antenna.

10.6 Ground Plane

It is recommended to include a 30 mm by 30 mm ground plane around the module in the PCB design as shown below in order to optimize antenna performance.

The ground plane should be on the top layer of the PCB (directly under the module) with the module centered on it.

See **Section 10.2 GNSS Antenna (included in the module)** for details.

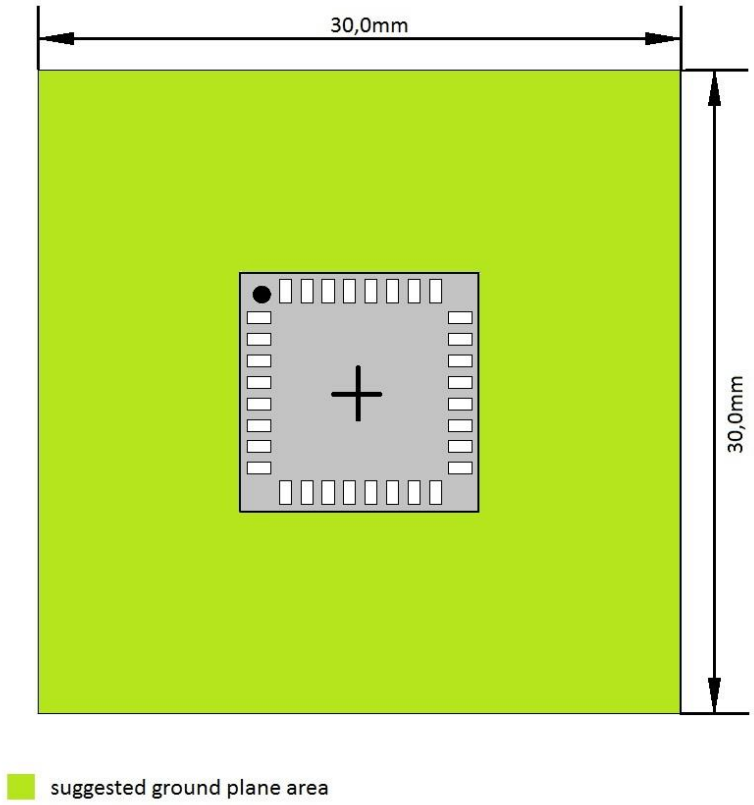


Figure 10-1 SE868xx-Ax Ground Plane

11 MECHANICAL DRAWINGS

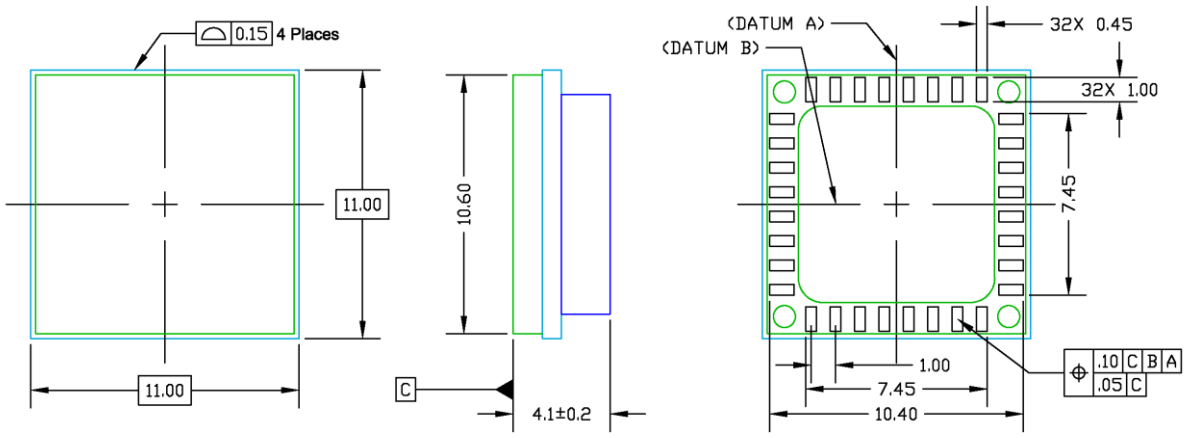


Figure 11-1 SE868Kx-AL (low profile) Mechanical Drawing

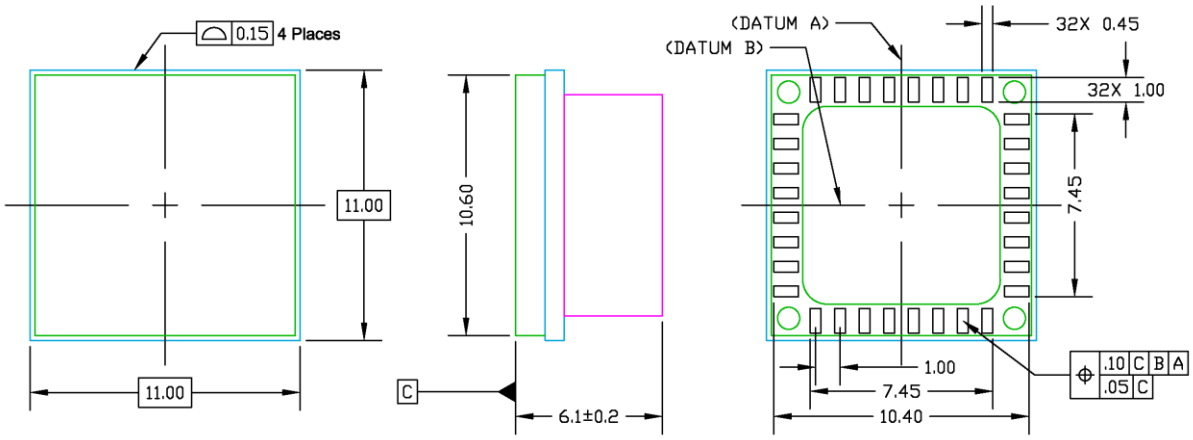


Figure 11-2 SE868Kx-A (high profile) Mechanical Drawing

12 PCB FOOTPRINT

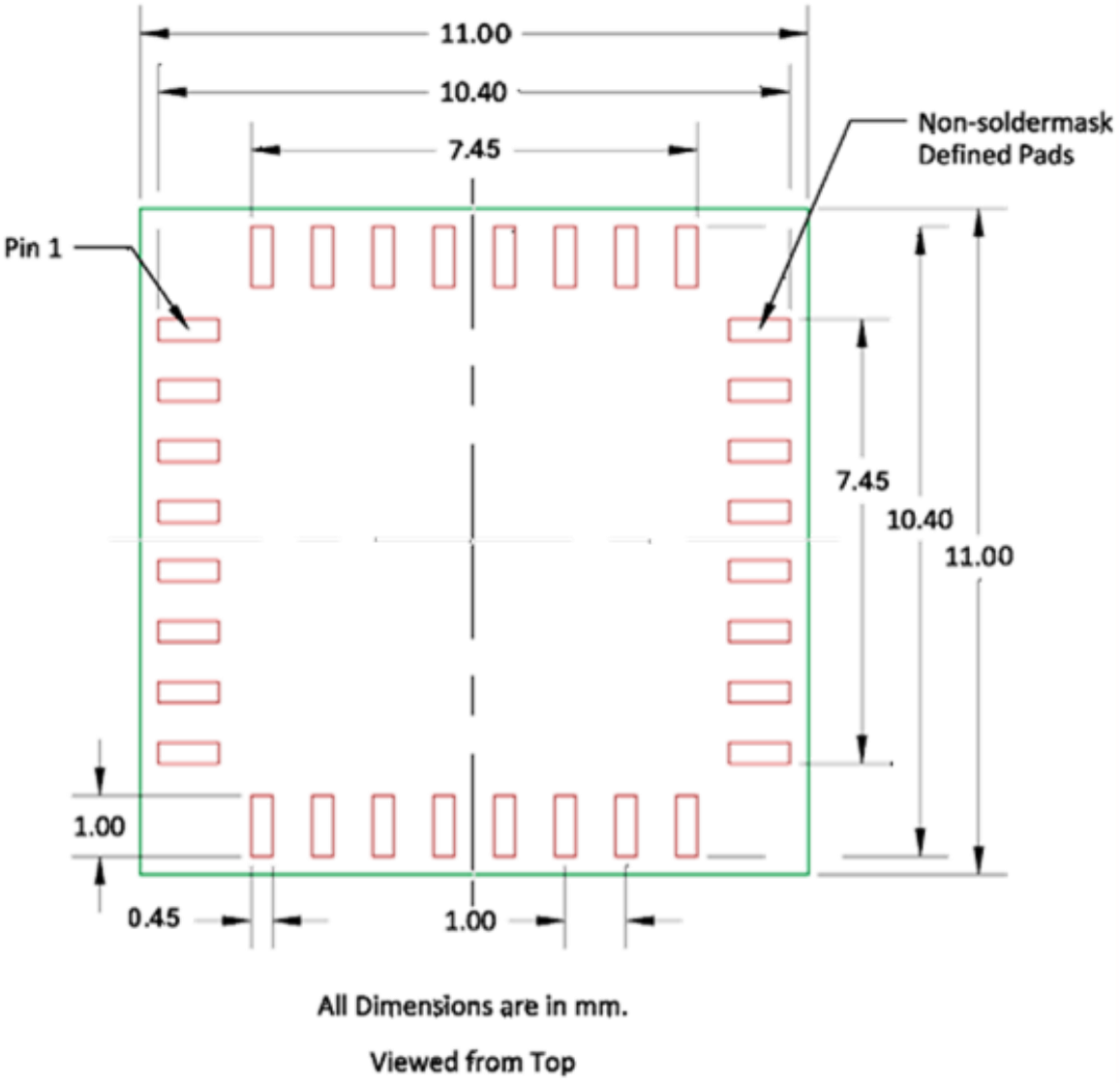


Figure 12-1 SE868xx-Ax Footprint

13 PACKAGING AND HANDLING

13.1 Product Marking and Serialization

The SE868xx-A module label has a 2D Barcode identifying the module and its serial number. Contact a Telit representative for information on specific module serial numbers.

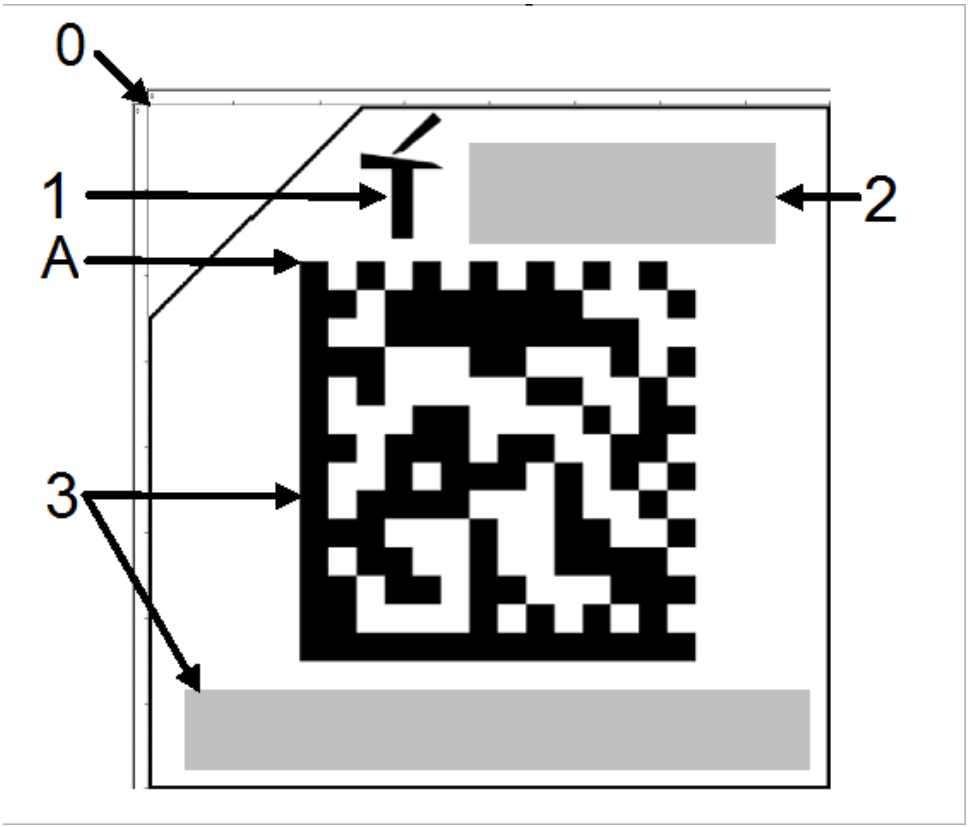


Figure 13-1 Product Label

Key	Description
1	Telit logo
2	Product Name
3	Telit Serial Number barcode (type 2D datamatrix) 11 digit (base 36 – 0 to 9 followed by A to Z)

Figure 13-2 Product Label Description

13.2 Product Packaging

SE868xx-Ax modules are shipped in Tape and Reel form. The reeled modules are shipped in 24mm reels with 250 units per reel. Each reel is 'dry' packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and placed in a carton.

The minimum order quantity for shipping is 250 units.

All packaging is ESD protective lined.

The SE868-A/AS receivers are Moisture Sensitive Devices (MSD). Please follow the MSD and ESD handling instructions on the labels of the MBB and exterior carton.

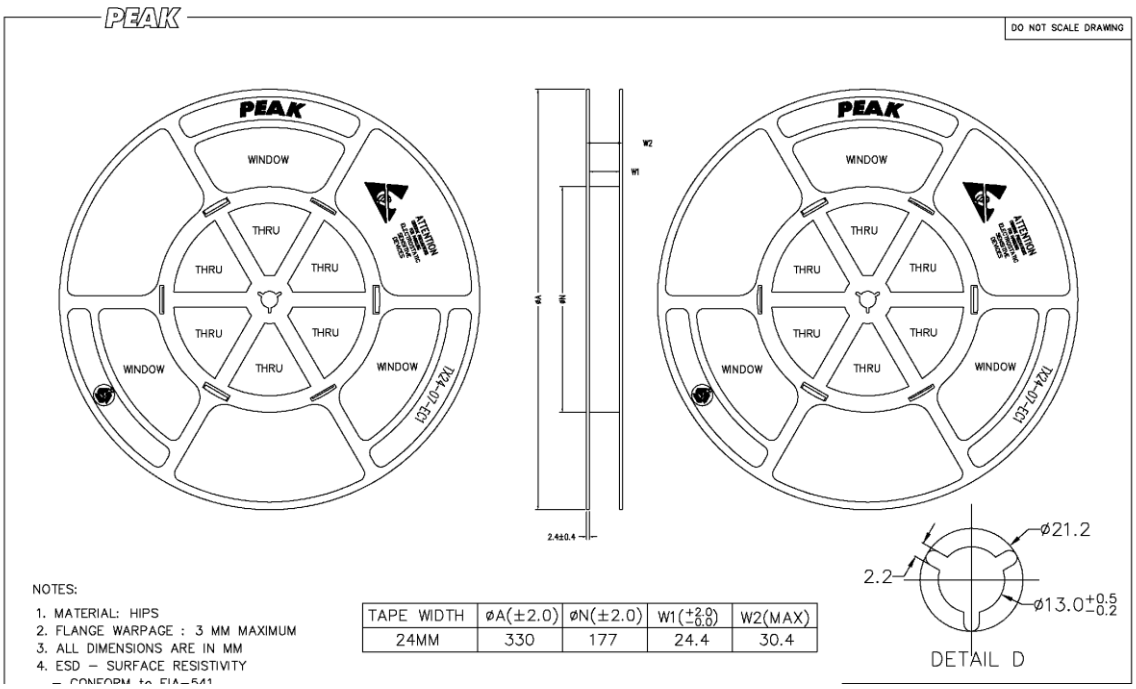


Figure 13-3 SE868xx-Ax Reel

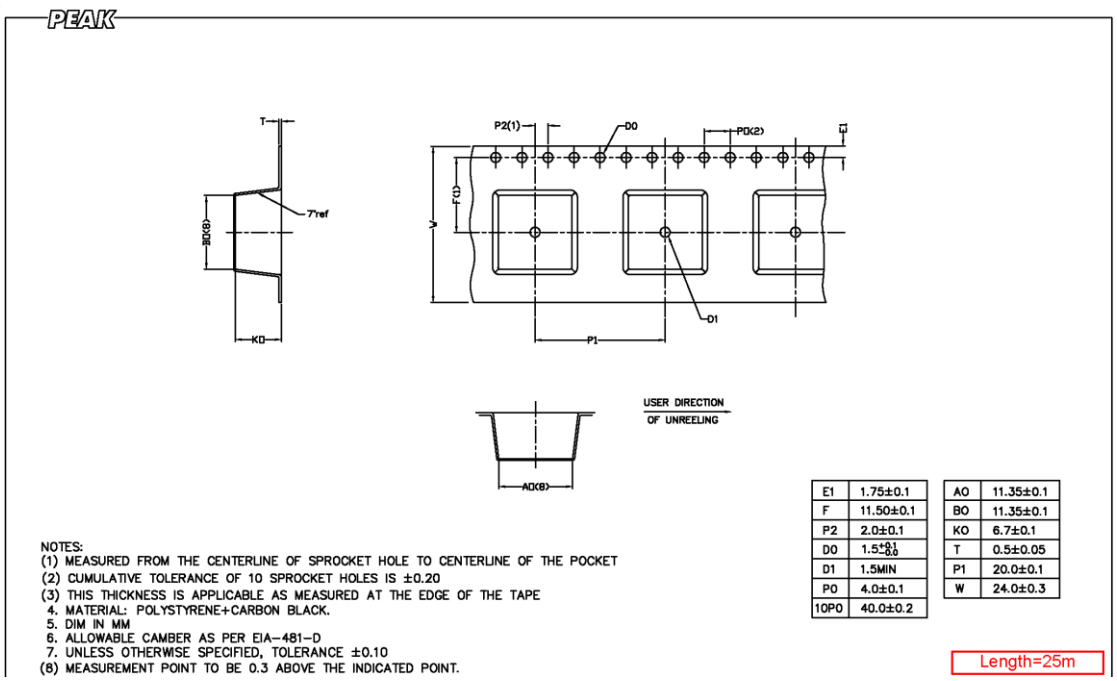


Figure 13-4 SE868xx-Ax Tape

13.3 Moisture Sensitivity

Precautionary measures are required in handling, storing and using these electronic devices to avoid damage from moisture absorption. If localized heating is required to rework or repair the device, precautionary methods are required to avoid exposure to solder reflow temperatures that can result in performance degradation or damage.

The module has a moisture sensitivity level rating of 3 as defined by IPC/JEDEC J-STD-020. This rating is assigned due to some of the components used within the module.

The modules are supplied in a hermetically sealed bag with desiccant and humidity indicator cards. The parts must be placed and reflowed within 168 hours of first opening the hermetic seal provided the factory conditions are less than 30°C and less than 60% and the humidity indicator card indicates less than 10% relative humidity.

If the package has been opened or the humidity indicator card indicates above 10%, then the parts will need to be baked prior to reflow. The parts may be baked at +125°C ± 5°C for 48 hours.

However, the packaging materials (tape and reel or trays) can NOT withstand that temperature. Lower temperature baking is feasible if the humidity level is low and time is available.

Additional information can be found on the MSL tag affixed to the outside of the hermetically sealed bag and IPC/JEDEC J-STD-033.

NOTE: JEDEC standards are available free of charge from the JEDEC website http://www.jedec.org.

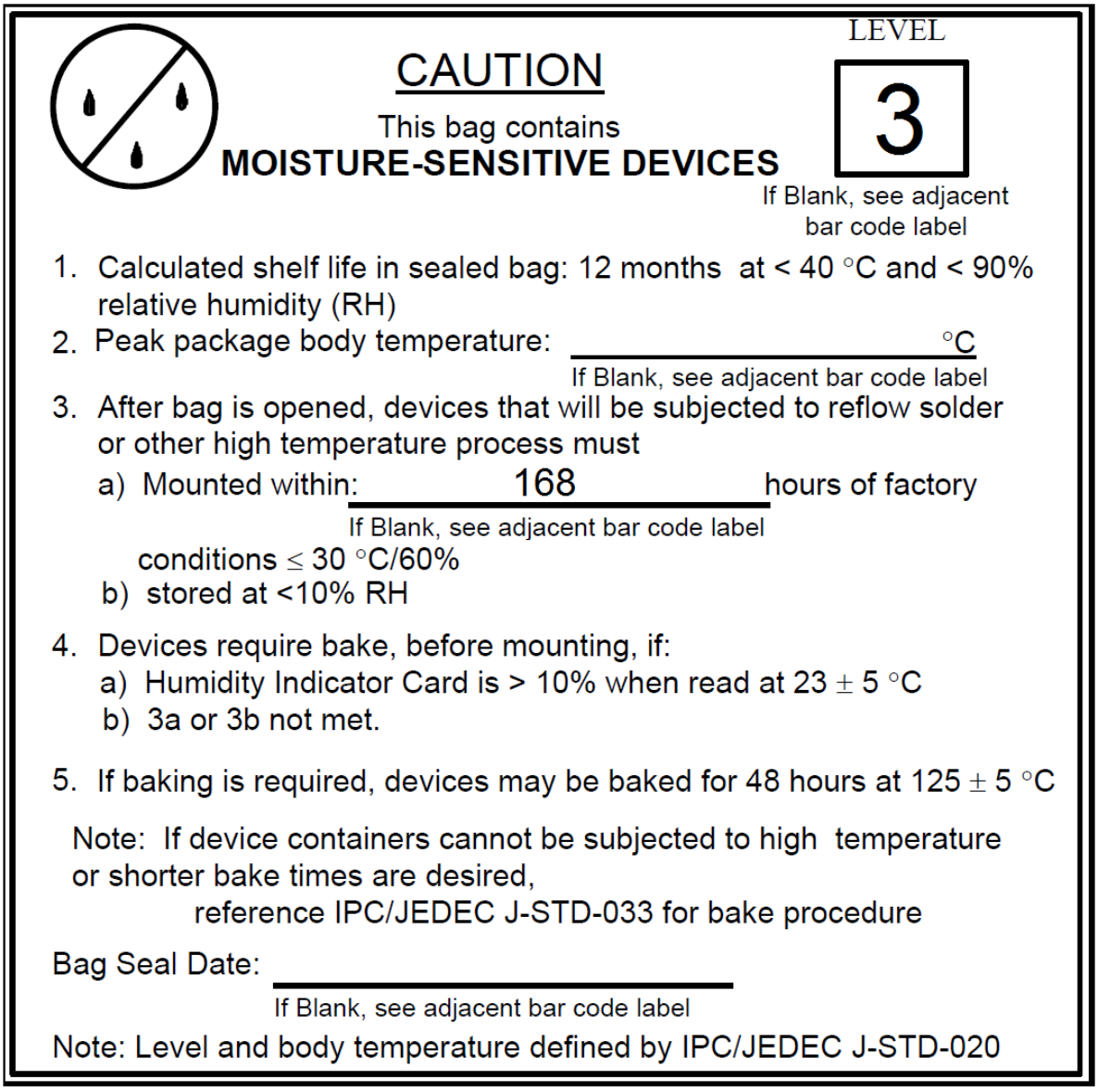


Figure 13-5 Moisture Sensitive Device Label

13.4 ESD Sensitivity

The module contains class 1 devices and is Electro-Static Discharge Sensitive (ESDS).

Telit recommends the two basic principles of protecting ESD devices from damage:

- Handle sensitive components only in an ESD Protected Area (EPA) under protected and controlled conditions;
- Protect sensitive devices outside the EPA using ESD protective packaging.

All personnel handling ESDS devices have the responsibility to be aware of the ESD threat to the reliability of electronic products.

Further information can be obtained from the JEDEC standard **JESD625-A Requirements for Handling Electrostatic Discharge Sensitive (ESDS) Devices**.

13.5 Assembly Considerations

Since the module contains piezo-electric components, it should be placed near the end of the assembly process to minimize mechanical shock to it.

During board assembly and singulation process steps, pay careful attention to unwanted vibrations, resonances and mechanical shocks, e.g. those introduced by manufacturing equipment.

13.6 Washing Considerations

The module can be washed using standard PCB cleaning procedures after assembly. The shield does not provide a water-tight seal for the internal components of the module, so it is important that the module be thoroughly dried prior to use by blowing excess water and then baking the module to drive out residual moisture. Depending upon the board cleaning equipment, the drying cycle may not be sufficient to thoroughly dry the module, so additional steps may need to be taken. Exact process details will need to be determined by the type of washing equipment as well as other components on the board to which the module is attached. The module itself can withstand standard JEDEC baking procedures.

13.7 Reflow

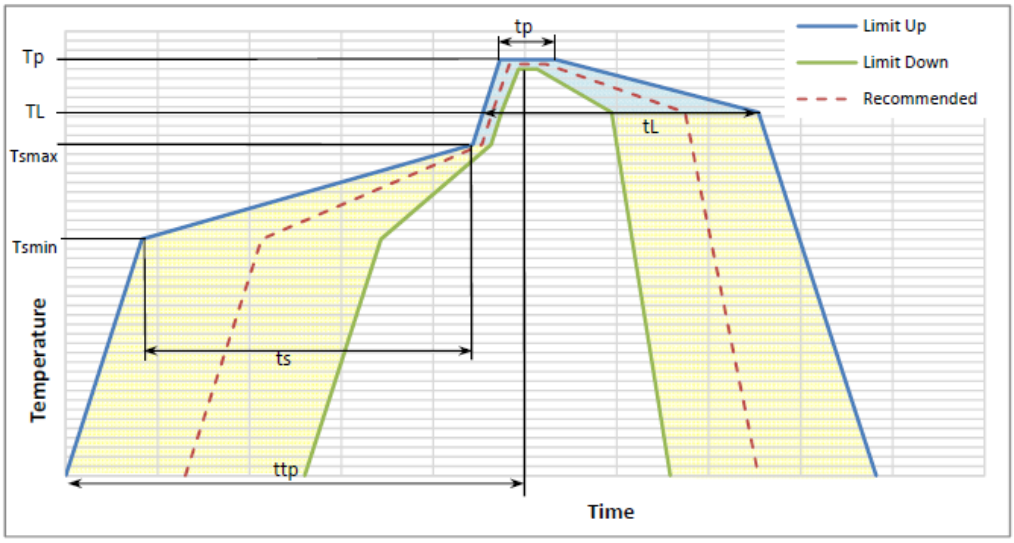
The modules are compatible with lead free soldering processes as defined in **IPC/JEDEC J-STD-020**. The reflow profile must not exceed the profile given **IPC/JEDEC J-STD-020 Table 5-2, "Classification Reflow Profiles".**

Although **IPC/JEDEC J-STD-020** allows for three reflows, the assembly process for the module uses two of those profiles, therefore the module is limited to one reflow.

When re-flowing a dual-sided SMT board, it is important to reflow the side containing the module last. This prevents heavier components within the module from becoming dislodged if the solder reaches liquidus temperature while the module is inverted.

Note: JEDEC standards are available free from the JEDEC website http://www.jedec.org.

The recommended reflow profile is shown in the following figure:



Profile Feature	Pb-Free Assembly
Average ramp-up rate (TL to Tp)	3°C/seccond max
Preheat	
- Temperature Min (Tsmin)	150°C
- Temperature Max (Tsmax)	200°C
- Time (Tsmin to Tsmax) ts	60-180 seconds
Tsmax to TL	
- Ramp-up rate	3°C/seccond max
Time maintained above:	
- Temperature (TL)	217°C
- Time (tL)	60-150 seconds
Peak Temperature (Tp)	245°C +0/-5 °C
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds
Ramp-down Rate	6°C/second max
Time 25°C to Peak Temperature Tp (ttp)	8 minutes max

Figure 13-6 SE868-A Modules Recommended Reflow Profile

13.8 Safety

Improper handling and use of this module can cause permanent damage to the receiver. There is also the possible risk of personal injury from mechanical trauma or choking hazard.

Please refer to **Section 16 Safety Recommendations** for further safety recommendations.

13.9 Disposal

Telit recommends that this product should not be treated as household waste. For more detailed information about recycling this product please contact your local waste management authority or the reseller from whom you purchased the product.

14 ENVIRONMENTAL REQUIREMENTS

14.1 Operating Environmental Limits

Temperature	-40°C to +85°C
Temperature Rate of Change	±1°C / minute maximum
Humidity	Up to 95% non-condensing or a wet bulb temperature of +35°C, whichever is less
Maximum Vehicle Dynamics	600 m/sec (acquisition and navigation) 2G acceleration

Table 14-1 SE868xx-Ax Operating Environmental Limits

14.2 Storage Environmental Limits

Temperature	-40°C to +85°C
Humidity	Up to 95% non-condensing or a wet bulb temperature of +35°C, whichever is less
Shock	18 G peak, 5 millisecond duration
Shock (in shipping container)	10 drops from 75 cm onto concrete floor

Table 14-2 SE868xx-Ax Storage Environmental Limits

15 COMPLIANCES

The SE868xx-Ax modules comply with the following:

- Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
- Manufactured in an ISO 9000: 2008 accredited facility
- Manufactured to TS 16949 requirement (upon request)

The module conforms to the following European Union Directives:

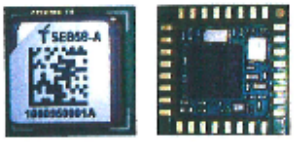
- Low Voltage Directive 2006/95/EEC and product safety test
- Directive EMC 2004/108/EC for conformity for EMC

15.1 CE Declarations of Conformity

Telit wireless solutions

EC DECLARATION OF CONFORMITY

1. SE868-A (product name)
2. Telit Communications S.p.A - loc. Sa Illetta, S.S. 195, Km 2.300, 09122 Cagliari - ITALY (manufacturer)
3. This declaration of conformity is issued under the sole responsibility of the manufacturer
4. GPS Receiving Module



5. The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 1999/05/EC (R&TTE)
6. The conformity with the essential requirements of the 1999/05/EC has been demonstrated against the following harmonized standards:

EN 60950-1:2006 + CORR:2006 + A11:2009 + A1:2010 + A12:2011	For article 3.1 (a): Health and Safety of the User
EN 301 489-1 V1.9.2 EN 301 489-3 V1.6.1	For article 3.1 (b): Electromagnetic Compatibility
EN 300 440-2 V1.4.1	For article 3.2: Effective use of spectrum allocated

7. The conformity assessment procedure referred to in Article 10 and detailed in Annex IV of Directive 1999/05/EC has been followed with the involvement of the following Notified Body:
   CETECOM ICT Services GmbH Untertürkheimer Straße 6-10, D-66117 Saarbrücken, Germany.
   Notified Body Number: 0682
   Due to the equipment dimensions, the CE marking cannot be visibly and legibly affixed on the product itself.
   Thus, CE 0682 is affixed to the packaging, if it exists, and to the accompanying documents.
8. The Technical Construction File (TCF) relevant to the product described above, and which supports this Declaration of Conformity, is held at: Telit Communications S.p.A, Via Stazione di Prosecco, 5/b - 34010 Sgonico (TRIESTE) - ITALY

Signed for and on behalf of Telit Communications S.p.A

Trieste, *2014-12-11*

EMEA Quality Director
Guido Walcher

Quality Manager
Cesare Robelli

Notified Body Opinion No : R0034488 01-EO
Technical Construction File : 30452TC[illegible]8A

Mod 0211 2012-11 Rev.2 This declaration of conformity is issued in compliance with 768/2008/E

Figure 15-1 SE868-A CE Declaration of Conformity

CETECOM ICT Services GmbH
Notified Body

CETECOM ICT Services GmbH • Postfach 10 04 45 • D-66004 Saarbrücken

Telit Communications S.p.A.
Via Stazione di Prosecco, 5/B
34010 Sgonico, Trieste
Italy

Your reference, your message from	Our reference, our message from	Phone / Fax	Saarbrücken
4500014048	SCHM	+49 (0)2054 / 9519-0	2014-12-11
Order dated 2014-11-26	R000448B-01-EO	+49 (0)2054 / 9519-997	

- **Conformity Assessment acc. to Annex IV of Directive 1999/5/EC (R&TTE Directive)**

Registration Number: **R000448B-01-EO**

Applicant: **Telit Communications S.p.A., Italy**

Product Designation: **SE868-A**
GNSS Module

Dear Sir/Madam,
following your order we have performed the conformity assessment for your product given above. Please find enclosed the relating issue of the

Expert Opinion with the registration number : **R000448B-01-EO**

Notes: The EC conformity marking (CE mark) of products as designated in the above given Expert Opinion shall be accompanied by our notified body identification number 0682 and the equipment class identifier if applicable (class 2 devices only) before the placing on the market. Please pay attention to further formal provisions of Directive 1999/5/EC regarding product labelling, obligatory information to the user or to authorities that may apply. Guidance is available from the EC commission's R&TTE web pages. For other products than those designated in the related Expert Opinion our notified body identification number may not be used without our written permission.

The order is concluded herewith. We will charge for our services by a separate invoice.

Yours faithfully
CETECOM ICT Services GmbH

i.A. Marc Schmidt

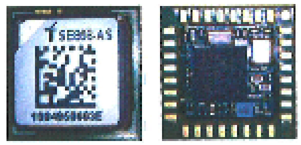
Enclosure
- Expert Opinion

Figure 15-2 SE868-A Conformity Assessment

Telit wireless solutions

EC DECLARATION OF CONFORMITY

1. SE868-AS (product name)
2. Telit Communications S.p.A - loc. Sa Illetta, S.S. 195, Km 2.300, 09122 Cagliari - ITALY (manufacturer)
3. This declaration of conformity is issued under the sole responsibility of the manufacturer
4. GPS Receiving Module



5. The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 1999/05/EC (R&TTE)
6. The conformity with the essential requirements of the 1999/05/EC has been demonstrated against the following harmonized standards.

EN 60950-1:2006 + CORR:2006 + A11:2009 + A1:2010 + A12:2011	For article 3.1 (a): Health and Safety of the User
EN 301 489-1 V1.9.2 EN 301 489-3 V1.6.1	For article 3.1 (b): Electromagnetic Compatibility
EN 300 440-2 V1.4.1	For article 3.2: Effective use of spectrum allocated

7. The conformity assessment procedure referred to in Article 10 and detailed in Annex IV of Directive 1999/05/EC has been followed with the involvement of the following Notified Body
   CETECOM ICT Services GmbH Untertürkheimer Straße 6-10, D-66117 Saarbrücken, Germany.
   Notified Body Number: 0682
   Due to the equipment dimensions, the CE marking cannot be visibly and legibly affixed on the product itself
   Thus, CE 0682 is affixed to the packaging, if it exists, and to the accompanying documents.
8. The Technical Construction File (TCF) relevant to the product described above, and which supports this Declaration of Conformity, is held at: Telit Communications S.p.A Via Stazione di Prosecco, 5/b 34010 Sgonico (TRIESTE) - ITALY

Signed for and on behalf of Telit Communications S.p.A

Trieste, 2014-12-11

EMEA Quality Director
Guido Walcher

Quality Manager
Cesare Robelli

Notified Body Opinion No :	[illegible]
Technical Construction File :	[illegible]

Mod 0211 2012-11 Rev.2 This declaration of conformity is issued in compliance with 768/2008/E

Figure 15-3 SE868-AS CE Declaration of Conformity

CETECOM ICT Services GmbH
Notified Body

CETECOM ICT Services GmbH • Postfach 10 04 45 • D-66004 Saarbrücken

Telit Communications S.p.A.
Via Stazione di Prosecco, 5/B
34010 Sgonico, Trieste
Italy

Your reference, your message from	Our reference, our message from	Phone / Fax	Saarbrücken
4500014048	SCHM	+49 (0)2054 / 9519-0	2014-12-11
Order dated 2014-11-26	R000449B-01-EO	+49 (0)2054 / 9519-997	

- **Conformity Assessment acc. to Annex IV of Directive 1999/5/EC (R&TTE Directive)**

Registration Number: **R000449B-01-EO**

Applicant: **Telit Communications S.p.A., Italy**

Product Designation: **SE868-AS**
GPS Module

Dear Sir/Madam,
following your order we have performed the conformity assessment for your product given above. Please find enclosed the relating issue of the

Expert Opinion with the registration number : **R000449B-01-EO**

Notes: The EC conformity marking (CE mark) of products as designated in the above given Expert Opinion shall be accompanied by our notified body identification number 0682 and the equipment class identifier if applicable (class 2 devices only) before the placing on the market. Please pay attention to further formal provisions of Directive 1999/5/EC regarding product labelling, obligatory information to the user or to authorities that may apply. Guidance is available from the EC commission's R&TTE web pages. For other products than those designated in the related Expert Opinion our notified body identification number may not be used without our written permission.

The order is concluded herewith. We will charge for our services by a separate invoice.

Yours faithfully
CETECOM ICT Services GmbH

i.A. Marc Schmidt

Enclosure
- Expert Opinion

Figure 15-4 SE868-AS Conformity Assessment

16 SAFETY RECOMMENDATIONS

PLEASE READ CAREFULLY

Be sure that the use of this product is allowed in the country and in the environment required. The use of this product may be dangerous and must be avoided in the following areas:

- Where it can interfere with other electronic devices in environments such as hospitals, airports, aircraft, etc.
- Where there is risk of explosion such as gasoline stations, oil refineries, etc.

It is the responsibility of the user to enforce the country regulations and specific environmental regulations.

Do not disassemble the product. Evidence of tampering will invalidate the warranty.

- Telit recommends following the instructions in product user guides for correct installation of the product.
- The product must be supplied with a stabilized voltage source and all wiring must conform to security and fire prevention regulations.
- The product must be handled with care, avoiding any contact with the pins because electrostatic discharges may damage the product itself.

The system integrator is responsible for the functioning of the final product; therefore, care must be taken with components external to the module, as well as for any project or installation issue. Should there be any doubt, please refer to the technical documentation and the regulations in force.

Non-antenna modules must be equipped with a proper antenna with specific characteristics.

The European Community provides some Directives for electronic equipment introduced on the market. All the relevant information is available on the European Community website:
http://ec.europa.eu/enterprise/sectors/rtte/documents/
The text of the Directive 99/05 regarding telecommunication equipment is available, while the applicable Directives (Low Voltage and EMC) are available at:
http://ec.europa.eu/enterprise/sectors/electrical/

The power supply used shall comply the clause 2.5 (Limited power sources) of the standard EN 60950-1 and the module shall be mounted on a PCB which complies with V-0 flammability class.

Since the module must be built-in to a system, it is intended only for installation in a RESTRICTED ACCESS LOCATION. Therefore, the system integrator must provide an enclosure which protects against fire, electrical shock, and mechanical shock in accordance with relevant standards.

17 GLOSSARY AND ACRONYMS

AGPS: Assisted (or Aided) GPS
AGPS provides ephemeris data to the receiver to allow faster **cold start** times than would be possible using only broadcast data.
This extended ephemeris data could be either server-generated or locally-generated.
See Local Ephemeris prediction data and Server-based Ephemeris prediction data

Almanac:
A reduced-precision set of orbital parameters for the entire GPS constellation that allows calculation of approximate satellite positions and velocities. The almanac may be used by a receiver to determine satellite visibility as an aid during acquisition of satellite signals. The almanac is updated weekly by the Master Control Station. See **Ephemeris**.

BeiDou (BDS) - formerly COMPASS:
The Chinese **GNSS**, currently being expanded towards full operational capability.

Cold Start:
A cold start occurs when a receiver begins operation with unknown position, time, and ephemeris data, typically when it is powered up after a period on inactivity. This typically occurs at powerup or being sent a restart command. Almanac information may be used to identify previously visible satellites and their approximate positions. See **Restart**.

Cold Start Acquisition Sensitivity:
The lowest signal level at which a GNSS receiver is able to reliably acquire satellite signals and calculate a navigation solution from a Cold Start. Cold start acquisition sensitivity is limited by the data decoding threshold of the satellite messages.

EGNOS: European Geostationary Navigation Overlay Service
The European **SBAS** system.

Ephemeris (plural ephemerides):
A set of precise orbital parameters that is used by a GNSS receiver to calculate satellite position and velocity. The satellite position is then used to calculate the navigation solution. Ephemeris data is updated frequently (normally every 2 hours for GPS) to maintain the accuracy of the position calculation. See **Almanac**.

ESD: Electro-Static Discharge
Large, momentary, unwanted electrical currents that can cause damage to electronic equipment.

GAGAN:
The Indian **SBAS** system.

Galileo:
The European **GNSS** currently being built by the European Union (EU) and European Space Agency (ESA).

GDOP: Geometric Dilution of Precision
A factor used to describe the effect of satellite geometry on the accuracy of the time and position solution of a **GNSS** receiver. A lower value of GDOP indicates a smaller error in the solution. Related factors include PDOP (position), HDOP (horizontal), VDOP (vertical) and TDOP (time).

GLONASS: ГЛОбальная НАвигационная Спутниковая Система
GLObal'naya NAvigatsionnaya Sputnikovaya Sistema
(Global Navigation Satellite System)
The Russian **GNSS,** which is operated by the Russian Aerospace Defense Forces

GNSS: Global Navigation Satellite System
Generic term for a satellite-based navigation system with global coverage. The current or planned systems are: **GPS, GLONASS, BDS,** and **Galileo.**

GPS: Global Positioning System
The U.S. **GNSS,** a satellite-based positioning system that provides accurate position, velocity, and time data. GPS is operated by the US Department of Defense.

Hot Start:
A hot start occurs when a receiver begins operation with known time, position, and ephemeris data, typically after being sent a restart command. See **Restart**.

LCC: Leadless Chip Carrier
A module design without pins. In place of the pins are pads of bare gold-plated copper that are soldered to the printed circuit board.

LNA: Low Noise Amplifier
An electronic amplifier used for very weak signals which is especially designed to add very little noise to the amplified signal.

Local Ephemeris prediction data:
Extended Ephemeris (i.e. predicted) data, calculated by the receiver from broadcast data received from satellites, which is stored in memory. It is usually useful for up to three days. See **AGPS.**

MSAS: MTSAT Satellite Augmentation System
The Japanese **SBAS** system.

MSD: Moisture sensitive device.

MTSAT: Multifunctional Transport Satellites
The Japanese system of geosynchronous satellites used for weather and aviation control.

Navigation Sensitivity: The lowest signal level at which a GNSS receiver is able to reliably maintain navigation after the satellite signals have been acquired.

NMEA: National Marine Electronics Association

QZSS: Quasi-Zenith Satellite System
The Japanese **SBAS** system (part of MSAS).

Reacquisition: A receiver, while in normal operation, loses RF signal (perhaps due to the antenna cable being disconnected or a vehicle entering a tunnel), and re-establishes a valid fix after the signal is restored. Contrast with **Reset** and **Restart.**

Restart: A receiver beginning operation after being sent a restart command, generally used for testing rather than normal operation. A restart can also result from a power-up. See **Cold Start, Warm Start,** and **Hot Start.** Contrast with **Reset** and **Reacquisition.**

Reset: A receiver beginning operation after a (hardware) reset signal on a pin, generally used for testing rather than normal operation**.** Contrast with **Restart** and **Reacquisition.**

RoHS: The Restriction of Hazardous Substances
Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment, which was adopted in February 2003 by the European Union.

RTC: Real Time Clock
An electronic device (chip) that maintains time continuously while powered up.

SAW: Surface Acoustic Wave filter
Electromechanical device used in radio frequency applications. SAW filters are useful at frequencies up to 3 GHz.

SBAS: Satellite Based Augmentation System
A system that uses a network of ground stations and geostationary satellites to provide differential corrections to GNSS receivers. These corrections are transmitted on the same frequency as navigation signals, so the receiver can use the same front-end design to process them. Current examples are **WAAS, EGNOS, MSAS,** and **GAGAN**.

Server-based Ephemeris prediction data:
Extended Ephemeris (i.e. predicted) data, calculated by a server and provided to the receiver over a network. It is usually useful for up to 14 days. See **AGPS.**

TCXO: Temperature-Compensated Crystal Oscillator

Tracking Sensitivity:
The lowest signal level at which a **GNSS** receiver is able to maintain tracking of a satellite signal after acquisition is complete.

TTFF: Time to First Fix
The elapsed time required by a receiver to achieve a valid position solution from a specified starting condition. This value will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design.
A standard reference level of -130 dBm is used for testing.

UART: Universal Asynchronous Receiver/Transmitter
An integrated circuit (or part thereof) which provides a serial communication port for a computer or peripheral device.

WAAS: Wide Area Augmentation System
The North American **SBAS** system developed by the US FAA (Federal Aviation Administration).

Warm Start:
A warm start occurs when a receiver begins operation with known (at least approximately) time and position, but unknown ephemeris data, typically after being sent a restart command..
See **Restart**.

18 DOCUMENT HISTORY

Revision	Date	Changes
0	2015-02-11	First edition
1	2015-10-19	Removed BeiDou reference from § 2.1, 2.2, 5.1, 5.2
2	2017-03-09	Added SE868Kx-Ax modules and comparison/migration information Revised mechanical drawings Deleted reference to SMPS Added reference diagram Corrected pinout diagram: Pins RX1 and TX1 were swapped. Sensitivity values are preliminary.

SUPPORT INQUIRIES

Link to **www.telit.com** and contact our technical support team for any questions related to technical issues.

www.telit.com

Telit Communications S.p.A.
Via Stazione di Prosecco, 5/B
I-34010 Sgonico (Trieste), Italy

Telit IoT Platforms LLC
5300 Broken Sound Blvd, Suite 150
Boca Raton, FL 33487, USA

Telit Wireless Solutions Inc.
3131 RDU Center Drive, Suite 135
Morrisville, NC 27560, USA

Telit Wireless Solutions Co., Ltd.
8th Fl., Shinyoung Securities Bld.
6, Gukjegeumyung-ro8-gil, Yeongdeungpo-gu
Seoul, 150-884, Korea

Telit Wireless Solutions Ltd.
10 Habarzel St.
Tel Aviv 69710, Israel

Telit Wireless Solutions
Technologia e Servicos Ltda
Avenida Paulista, 1776, Room 10.C
01310-921 São Paulo, Brazil

Mod. 0815 2016-08 Rev.1