SL869x-V2 Family

Product User Guide

1VV0301175 Rev. 9 – 2021-07-05

Telit Technical Documentation

APPLICABILITY TABLE

PRODUCTS
SL869-V2
SL869-V2S
SL869L-V2
SL869L-V2S

CONTENTS

1. INTRODUCTION

1.1. Scope

T The purpose of this document is to provide information regarding the function, features, and usage of the Telit products listed under **Applicability Table**.

Please refer to chapter **2. Product Description** for details of product features and product variants.

1.2. Audience

This document is intended for Telit customers, especially system integrators, about to implement their applications using the Telit SL869x-V2 family.

1.3. Contact Information, Support

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

- *TS-EMEA@telit.com*
- *TS-AMERICAS@telit.com*
- *TS-APAC@telit.com*
- *TS-SRD@telit.com*
- *TS-ONEEDGE@telit.com*

Alternatively, use:

https://www.telit.com/contact-us

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

https://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 the user feedback on our information.

1.4. Symbol Conventions

	Danger: This information MUST be followed or catastrophic equipment failure or personal injury may occur.
	Warning: Alerts the user on important steps about the module integration.
	Note/Tip: Provides advice and suggestions that may be useful when integrating the module.
	Electro-static Discharge: Notifies the user to take proper grounding precautions before handling the product.

Table 1: Symbol Conventions

All dates are in ISO 8601 format, that is YYYY-MM-DD.

1.5. Related Documents

- Datasheets
- Product User Guides
- EVK User Guides
- Software User Guides
- Application Notes
- TelitView installation and documentation
- Authorized Software User Guides
- Product firmware

2. PRODUCT DESCRIPTION

The SL869-V2 family of GNSS receiver modules provides complete position, velocity, and time (PVT) engines featuring high performance, high sensitivity, and low power consumption.

All modules compute a navigation solution using GPS signals. Multi-constellation modules add GLONASS, BeiDou, and Galileo signals to yield better coverage, greater accuracy, and improved availability.

Multi-constellation (MT3333): SL869-V2 and SL869L-V2.

GPS only (MT3337E): SL869-V2S and SL869L-V2S.

2.1. Product Overview

- Complete GNSS receiver modules including memory, TCXO, and RTC
- SL869-V2L and SL869L-V2S also include a built-in LNA and DC blocking cap
- Constellations:
  - SL869x-V2: GPS (L1), QZSS, and either Glonass (L1) or BeiDou (B1) simultaneous ranging with 99 search and 33 tracking channels. Galileo ready.
  - SBAS corrections capable (WAAS, EGNOS, MSAS, GAGAN)
  - SL869x-V2S: Only GPS (L1) and QZSS with 66 search and 22 tracking channels.
- DGPS capable using the RTCM SC-104 protocol.
- AGPS support for extended ephemeris using local or server-based solutions:
  - Local: Embedded Assist System (EASY) Please refer to Note 1.
  - Server: Extended Prediction Orbit (EPO) Please refer to Note 1.
- Jamming Rejection - Active Interference Cancellation (AIC)
- Supports active or passive antenna
- Configurable fix reporting, Default: 1Hz, Max: 10 Hz
- NMEA command input and data output
- 1 or 2 serial ports for input commands and output messages (Please refer to I/O Ports)

  - SL869L-V2: Second serial port is I2C interface, configurable for UART via command
- 1PPS output
- Memory -
  - SL869x-V2: 8 Megabit built-in flash.
  - SL869x-V2S: ROM
- Low power consumption
- Power management modes for extended battery life
- Supported by evaluation kits
- Industrial temperature range: -40°C to +85°C
- Surface mountable by standard SMT equipment
- 24-pad 16.0 x 12.2 x 2.4 mm Industry Standard LLC castellated edge package
- RoHS compliant design

Note 1: Please see **Table 2: SL869x-V2 Family Product Features** for EASY/EPO support.

2.2. Product Naming

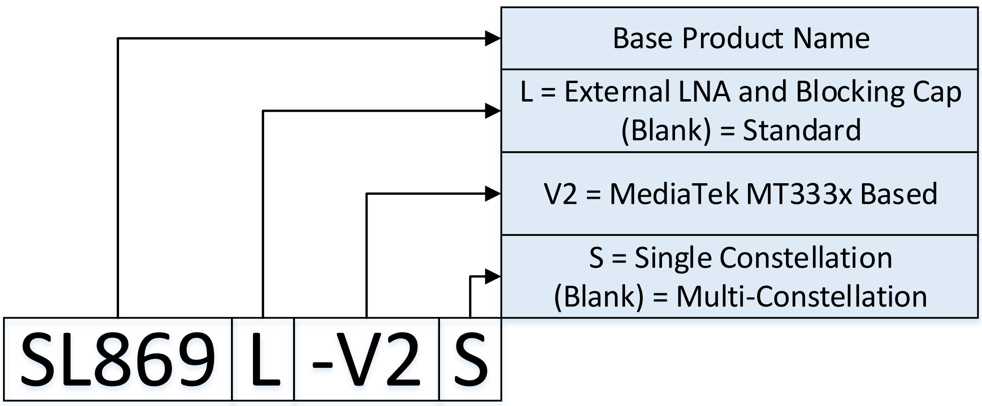


Figure 1: Product Naming

2.3. Product Variants

The SL869-V2 Family includes the following variants:

- SL869-V2: Flash memory based, Multi-constellation
- SL869L-V2: Switching Mode Power Supply, Added LNA and DC blocking capacitor, Antenna On and Antenna Sense pins, 2nd serial port

- SL869-V2S: ROM based, GPS-only
- SL869L-V2S: Switching Mode Power Supply, Added LNA and DC blocking capacitor, Added 2nd UART port for RTCM input.

2.3.1. SL869-V2S and SL869L-V2S Features

- GPS-only
- ROM-based (Firmware cannot be updated)
- The second port is UART only (I2C is not supported)
- Locally generated AGPS (EASY - Embedded Assist System) on SL869-V2S and SL869L-V2S is supported only on MT3337E ROM (version 2.3) after Oct. 2015.
    - Earlier ROM versions did not support EASY.
- Server-generated AGPS (EPO - Extended Prediction Orbit) is supported via a host system (e.g. a microprocessor) for the SL869-V2S and SL869L-V2S.

Please refer to the MT333x Host EPO Application Note.

2.3.1.1. ROM versions

The current SL869-V2S and SL869L-V2S have the MT3337E (enhanced) ROM with the following changes:

Added features:

- Improved TTFF and Position
- EASY
- PPS sync with NMEA

Deleted features:

- SBAS
- Always Locate
- LOCUS

2.3.2. SL869-V2 Family Product Features Table

<table>
<tr><th>Feature</th><th>SL869-V2</th><th>SL869L-V2</th><th>SL869-V2S</th><th>SL869L-V2S</th></tr>
<tr><td>Constellations Supported</td><td colspan="2">GPS
QZSS
Glonass
BeiDou
Galileo ready</td><td colspan="2">GPS
QZSS</td></tr>
<tr><td>Memory</td><td colspan="2">Flash</td><td colspan="2">ROM</td></tr>
<tr><td>Power Supply</td><td>Linear</td><td>Switching</td><td>Linear</td><td>Switching</td></tr>
<tr><td>Internal LNA</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>DC blocking cap</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>2nd Port</td><td>No</td><td>Yes
(default: I2C)</td><td>No</td><td>Yes
(UART only)</td></tr>
<tr><td>Antenna Sense</td><td>No</td><td>Yes</td><td colspan="2">No</td></tr>
<tr><td>Antenna On</td><td>No</td><td>Yes</td><td>No</td><td>Yes</td></tr>
<tr><td>Software Upgradable</td><td colspan="2">Yes</td><td colspan="2">No</td></tr>
<tr><td>EPO</td><td colspan="2">Yes</td><td colspan="2">Yes (host)</td></tr>
<tr><td>ROM version</td><td colspan="2">Not applicable</td><td>3337E
(Note 1)</td><td>3337E</td></tr>
<tr><td colspan="5">Note 1: Early production SL869-V2S used the original 3337 (non-enhanced) ROM</td></tr>
</table>

Table 2: SL869x-V2 Family Product Features

Feature	SL869-V2S (early production)	SL869L-V2S
ROM version	3337	3337E (enhanced)
EASY	No	Yes
SBAS	Yes	No
Always Locate	Yes	No
LOCUS	Yes	No

Table 3 ROM Features (-S modules only)

2.4. Block Diagrams

2.4.1. SL869-V2 Block Diagram

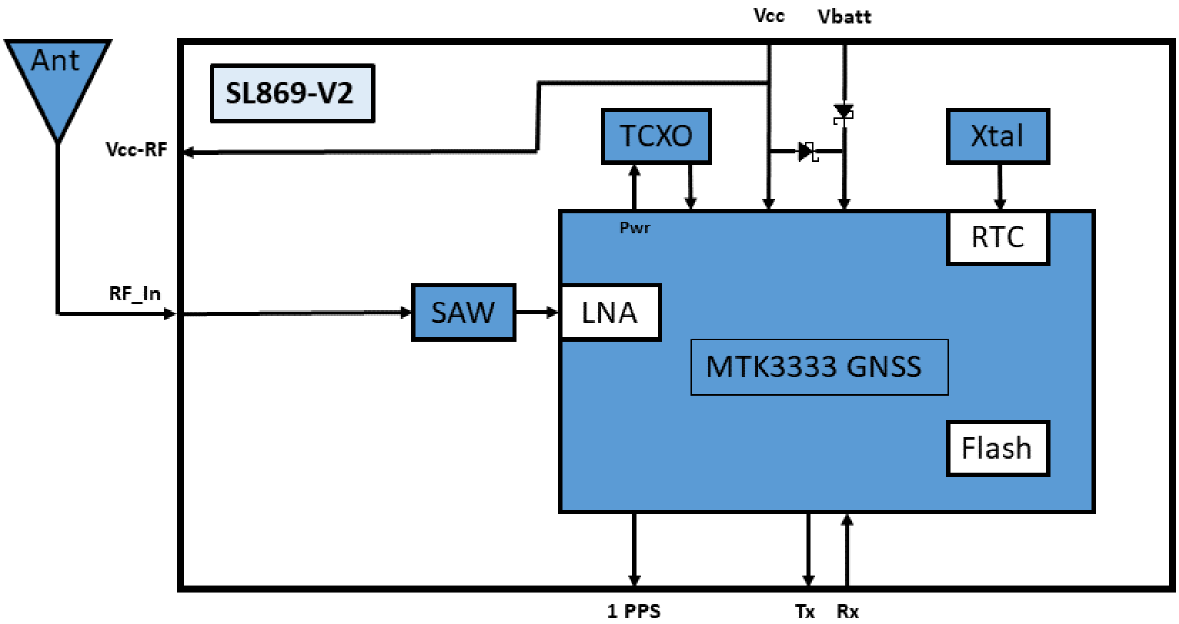


Figure 2: SL869-V2 Block Diagram

2.4.2. SL869L-V2 Block Diagram

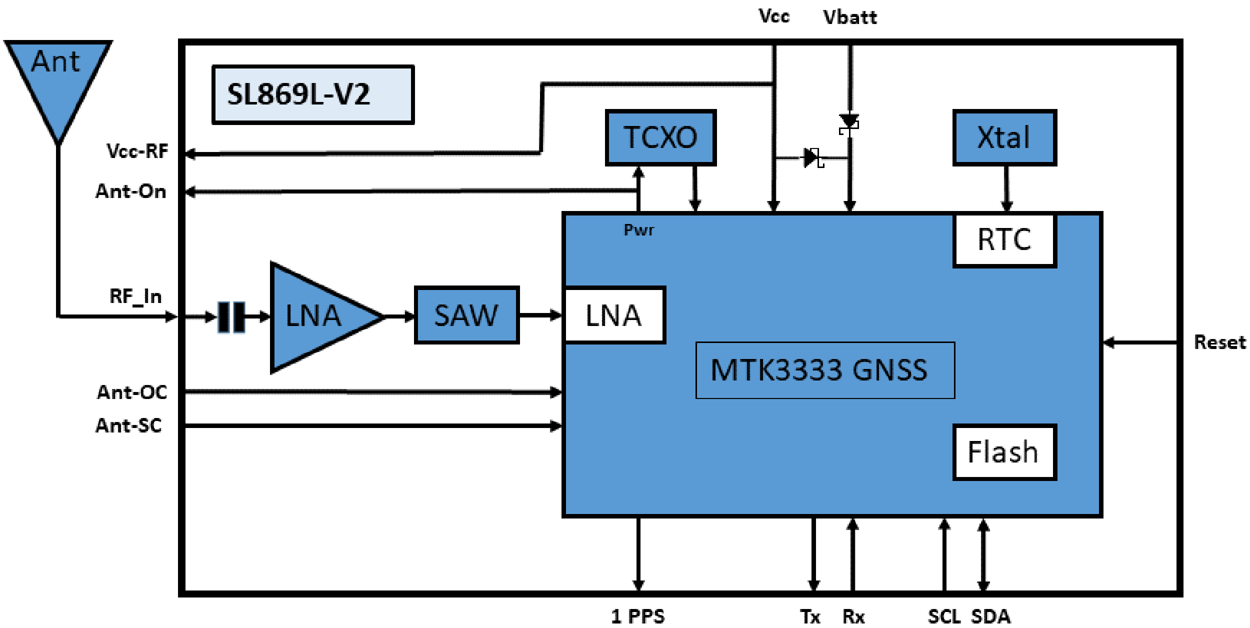


Figure 3: SL869L-V2 Block Diagram

2.4.3. SL869-V2S Block Diagram

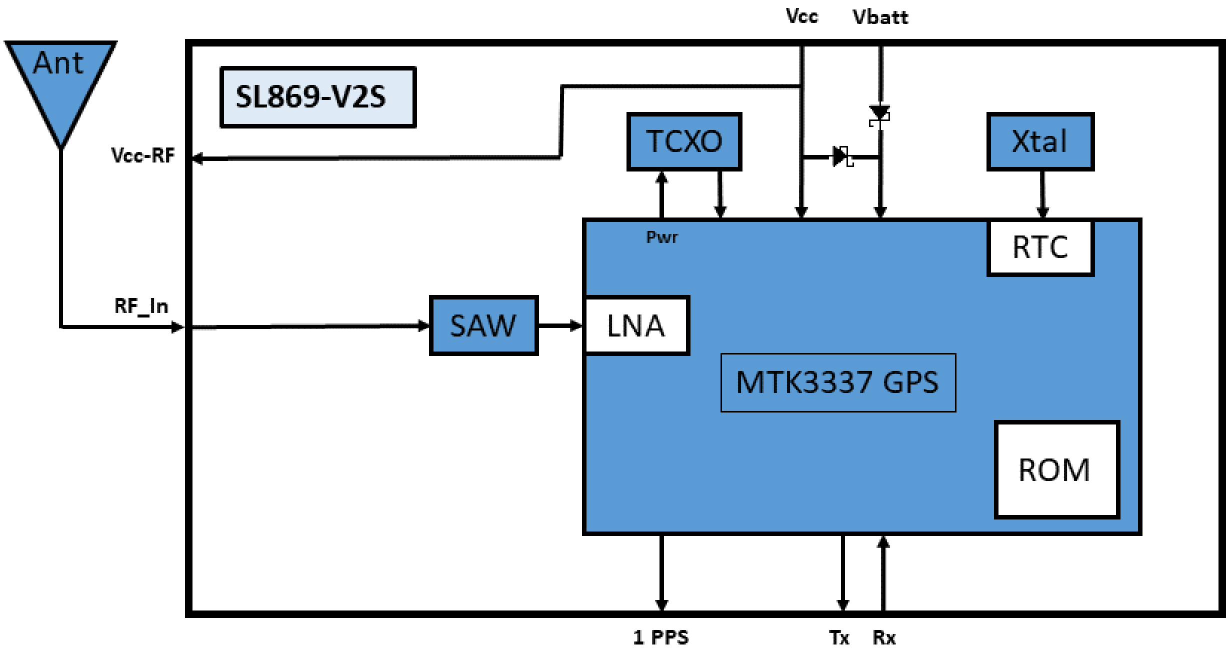


Figure 4: SL869-V2S - Block Diagram

2.4.4. SL869L-V2S Block Diagram

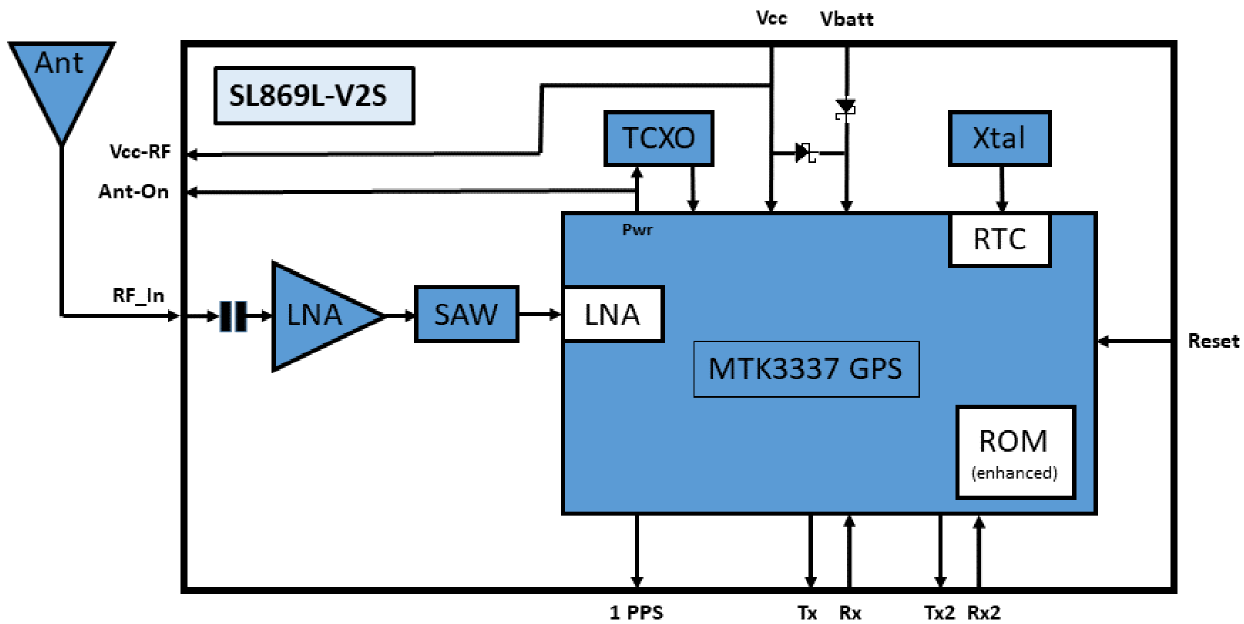


Figure 5: SL869L-V2S - Block Diagram

2.5. Module Photos

Figure 6: SL869-V2 Module Photo

Figure 7: SL869L-V2 Module Photo

Figure 8: SL869-V2S Module Photo

Figure 9: SL869L-V2S Module Photo

3. EVALUATION KIT (EVK)

Figure 10: EVK Contents

3.1. Evaluation Unit

Figure 11: Evaluation Unit

4. PRODUCT FEATURES

4.1. Multi-Constellation Navigation (SL869-V2 and SL869L-V2 only)

GPS and GLONASS constellations are enabled by default. Enabling BeiDou disables GLONASS and Galileo.

The user may enable or disable constellations via the **$PMTK353** command

The SL869-V2S and SL869L-V2S support GPS only.

4.2. Quasi-Zenith Satellite System (QZSS)

The satellites of the Japanese regional SBAS are in a highly inclined, elliptical geosynchronous orbit, allowing continuous high-elevation coverage over Japan using only three satellites plus one geostationary satellite. PRNs 193, 194, and 195 are supported. They provide ranging signals for augmentation of the GPS system.

QZSS constellation usage is controlled by the **$PMTK352** command and is disabled by default.

NMEA reporting for QZSS may be enabled/disabled by the **$PMTK351** command.

4.3. Satellite-Based Augmentation System (SBAS)

SBAS is not supported on the current production SL869L-V2S and SL869-V2S modules (with the enhanced ROM).

The receiver is capable of using SBAS satellites as a source of differential corrections. These systems (WAAS, EGNOS, GAGAN and MSAS) use geostationary satellites to transmit signals similar to those of GPS in the same L1 band.

Enabling 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 selected by the **PMTK301** command.

SBAS is not supported on the SL869L-V2S or the SL869-V2S with enhanced ROM (from Oct 2015).

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.

4.4. Differential GPS (DGPS) (SL869L-V2 and SL869L–V2S only)

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 either by radio to a DGPS receiver or over the internet.

The DGPS receiver can then send them to the module 2nd serial port (RX2) using the RTCM SC-104 protocol message types 1, 2, 3, and 9.

These 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**.

4.5. Assisted GPS (AGPS)

Assisted GPS (or Aided GPS) is a method by which TTFF is improved (reduced) using information from a source other than broadcast GPS signals.

The necessary ephemeris data is calculated either by the receiver itself (locally generated ephemeris), or a server (server-generated ephemeris) and stored in the module.

Please refer to **Section 2.3 Product Variants** for applicability.

4.5.1. Locally generated AGPS - Embedded Assist System (EASY)

This feature is not supported on the SL869-V2S until ROM MT3337E version (enhanced) of Oct 2015. It is supported on the SL869L-V2S.

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 disabled if the fix rate is > 1 Hz

EASY is on by default but can be disabled by command **PMTK869**.

4.5.2. Server-generated AGPS - Extended Prediction Orbit (EPO)

(SL869-V2 and SL869L-V2 only)

Server-based 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.

Note that the EPO data stream does not conform to the NMEA-0183 standard.

Please refer to the Telit EPO Application Note for details.

Example source code is available under NDA.

Contact TELIT for support regarding this service.

Please refer to the next section regarding EPO support (Host EPO) on the SL869-V2S and SL869L-V2S.

4.5.3. Host EPO

The SL869-V2S and SL869L-V2S 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. This data is valid for six hours. Host EPO data is not retained over a power cycle.

Note that the EPO data stream does not conform to the NMEA-0183 standard.

Please refer to the MT333x Host EPO Application Note.

Contact Telit support for further details.

4.6. 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.

The SL869-V2S and SL869L-V2S maximum is 5 Hz.

4.7. Elevation Mask Angle

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

4.8. 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 (10 m) from the frozen position (indicating that the receiver is again in motion). The speed threshold can be set via the **PMTK386** command.

Set this 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 but can be enabled by command $**PMTK386**.

4.9. 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.

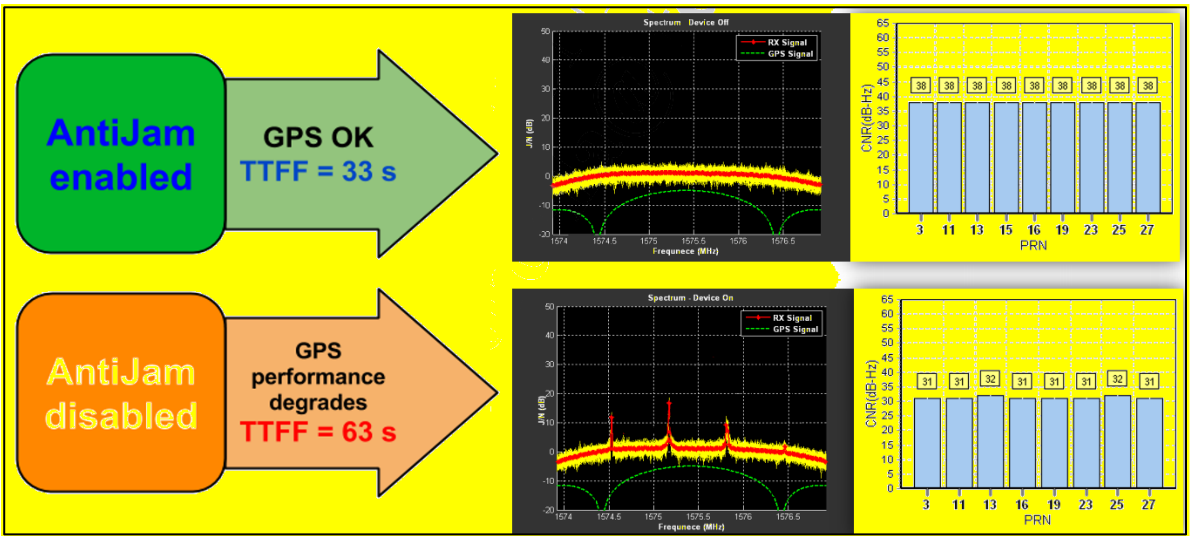


Figure 12: Jamming Rejection

4.10. Internal LNA (SL869L-V2 and SL869L-V2S only)

The SL869L-V2 and SL869L-V2S modules include a built-in LNA to increase sensitivity.

4.11. 1PPS

The module provides a 1PPS output signal.

Please refer to Section **9.3.5.1 1PPS** for detailed information.

4.12. 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).

Power Management - Command Summary		
$PMTK Cmd	**Type**	**State**
Full Power	To exit (wake) from a commanded low-power state	
225	0	Full
Standby	To wake: Character to RX	
161	0	Stop
161	1	Backup
Periodic (MT3333 only)		
223	-	Specify Extended Parameters
225	1	Backup
225	2	Standby
Always Locate (MT3333 and old MT3337 only. Not on new MT3337E)		
223	-	Specify Extended Parameters
225	8	Standby
225	9	Backup
GLP (MT3333 only)		
262	0	Disable
262	3	Enable

Table 4 Power Management - Command Summary

4.12.1. Full Power Continuous Mode

The module 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 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 a **$PMTK225,0*2B**

command 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 present, no data will be lost.

4.12.2. Standby Modes

In these modes the receiver stops navigation, the internal processor enters the standby state, and the current drain at main supply VCC_IN is substantially reduced.

STOP: ARM baseband, RF, and TCXO are powered down

SLEEP: ARM baseband and RF are powered down

To enter a Standby mode, send the following command:

$PMTK161,0*28 (STOP Mode)

$PMTK161,1*29 (SLEEP Mode)

To exit a Standby mode, send any byte to the host port (RX).

4.12.3. GLP Mode (SL869-V2 and SL869L-V2 only)

In the GNSS Low Power (GLP) mode, power consumption is reduced for some time during a one second period. The module will alternate this cycling with periods of full power when necessary, for example weak signals or decoding the navigation message.

A typical current draw is 10 to 14 mA, depending on conditions.

Note that position accuracy will be reduced during GLP operation, therefore the user must determine the tradeoff between power consumption and desired accuracy.

A timeline is shown below:

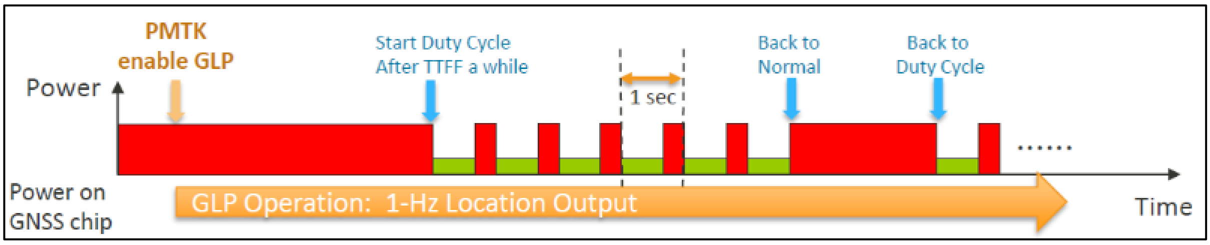


Figure 13: GNSS Low Power (GLP) Mode Diagram

To enter the GLP mode, send the command:

$PMTK262,3

To exit the GLP mode and return to full-power mode, send the command:

$PMTK262,0

4.12.4. Periodic Modes (SL869-V2 and SL869L-V2 only)

Periodic Low Power modes are not available on the SL869-V2S and SL869L-V2S.

These modes allow 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.

STANDBY(SLEEP): ARM baseband and RF are powered down.

BACKUP: ARM baseband, RF, and TCXO are powered down. RTC is powered up.

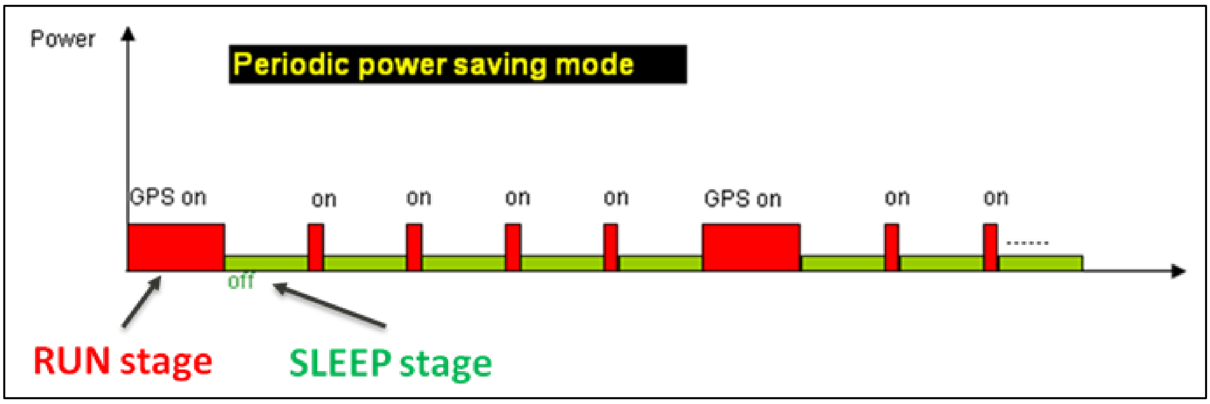


Figure 14: Periodic Modes Diagram

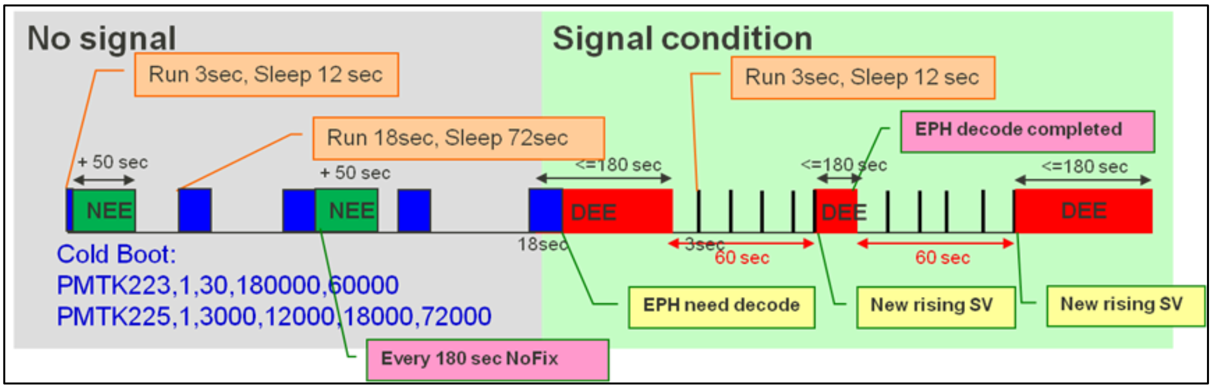


Figure 15: Periodic Mode Example 1

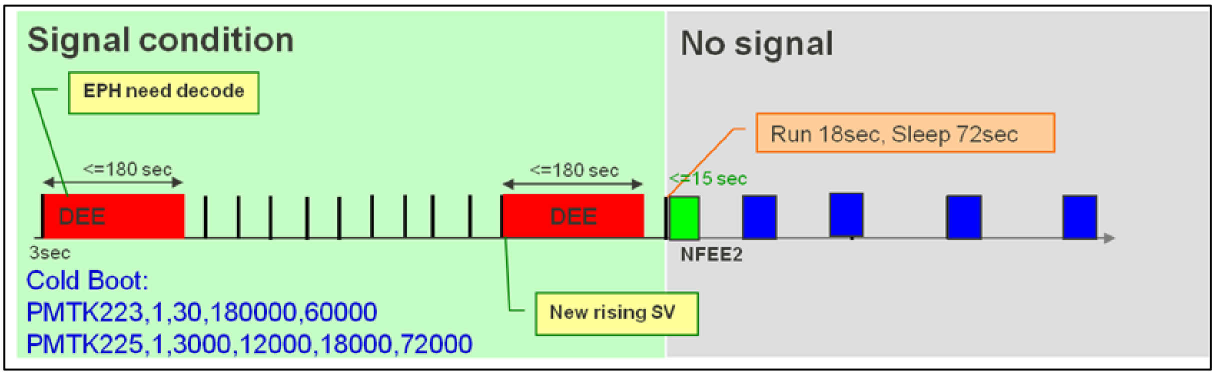


Figure 16: Periodic Mode Example 2

To enter a Periodic mode, send the following NMEA command(s):

$PMTK223,<SV>,<SNR>,<Extension threshold>,<Extension gap>*<checksum> (Optional)

Where:

SV = 1 to 4, default = 1

SNR = 25 to 30, default = 28

Ext. threshold = 40 000 to 180 000 ms, default = 180 000

Ext. gap = 0 to 3 600 000 ms, default = 180 000

This is the limit between successive DEE

$PMTK225,<Type>,<Run_time>,<Sleep_time>,<2nd_run_time>,<2nd_sleep_time>*<checkum>

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

To exit Periodic Sleep mode, send the NMEA command

$PMTK225,0*2B

just after the module wakes up from a previous sleep cycle.

4.12.5. AlwaysLocate™ Modes

Not available on current production SL869-V2S SL869L-V2S (with enhanced ROM)

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.

To enter an AlwaysLocate mode, send 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

To exit AlwaysLocate mode, send the NMEA command:

$PMTK225,0*2B

just after the module wakes up from its previous sleep cycle.

5. DATA RETENTION

(SL869-V2 and SL869L-V2S modules only)

The receiver is capable of retaining data elements under the various initialization types.

If Vbatt is maintained, no data will be lost.

The following table shows which data elements are saved under each type of initialization if both Vcc and Vbatt are removed.

To erase EPO data, use the **$PMTK127** command.

Data Retention (1)							
Initialization	Almanac	Ephemeris	EPO	Host EPO	EASY	Position	Time
Power Cycle			Y (2)				
Reset (signal)			Y				
Full Cold Start			Y				(3)
Cold Start			Y	Y	Y		Y (3)
Warm Start	Y		Y	Y	Y	Y	Y
Hot Start	Y	Y	Y	Y	Y	Y	Y
Reacquisition	Y	Y	Y	Y	Y	Y	Y
Note 1: Commanded parameters (e.g. UART speed, feature enables, etc.) are not preserved over a power cycle.							
Note 2: EPO is not available on the MT3337 (ROM)-based modules. Use Host EPO.							
Note 3: The standard definition of "Cold Start" does not allow time to be preserved. Use "Full Cold Start" to compare with other vendor's products' "Cold Start".							

Table 5 Data Retention

6. PRODUCT PERFORMANCE

6.1. Performance - SL869-V2 and SL869L-V2

Note/Tip: Earlier variants have different performance values.

6.1.1. Horizontal Position Accuracy - SL869-V2 and SL869L-V2

Horizontal Position Accuracy	
Constellation(s)	CEP (m)
GPS	2.5
Glonass	2.6
BeiDou	10.2
GPS + Glonass	2.5
GPS + BeiDou	2.5
Test Conditions: 24-hr Static, Live Signals, Full Power mode	

Table 6 SL869-V2 and SL869L-V2 Horizontal Position Accuracy

6.1.2. Time to First Fix - SL869-V2 and SL869L-V2

Constellation(s)	Start Type	Max TTFF (s)
GPS	Hot	1
	Warm	24
	Cold	31
Glonass	Hot	1.4
	Warm	32
	Cold	33
BeiDou	Hot	1.5
	Warm	35
	Cold	46
GPS + GLO	Hot	1
	Warm	24

Constellation(s)	Start Type	Max TTFF (s)
	Cold	27
GPS + BeiDou	Hot	1
	Warm	32
	Cold	33
Test Conditions: Static scenario, -130 dBm, Full Power mode		

Table 7 SL869-V2 and SL869L-V2 Time to First Fix

6.1.3. Sensitivity - SL869-V2 and SL869L-V2

Constellation(s)	State	Minimum Signal Level (dBm)	
		SL869-V2	SL869L-V2
GPS	Acquisition	-145	-148
	Navigation	-158	-163
	Tracking	-161	-165
GLONASS	Acquisition	-144	-148
	Navigation	-157	-160
	Tracking	-159	-161
BeiDou	Acquisition	-143	-146
	Navigation	-156	-159
	Tracking	-158	-160
Note: The above performance values were measured under lab conditions using a GNSS simulator generating a static scenario.			

Table 8 SL869-V2 and SL869L-V2 Receiver Sensitivity

6.2. Performance - SL869-V2S and SL869L-V2S

6.2.1. Horizontal Position Accuracy - SL869-V2S and SL869L-V2S

Parameter	Constellation	CEP (m)
Horizontal Position Accuracy	GPS	2.5
Test Conditions: 24-hr Static, Live Signals, Full Power mode		

Table 9 SL869-V2S and SL869L-V2S Position Accuracy

6.2.2. Time to First Fix - SL869-V2S and SL869L-V2S

Constellation	Start Type	Max TTFF (s)
GPS	Hot	1.0
	Warm	32
	Cold	33
Test Conditions: Static scenario, -130 dBm, Full Power mode		

Table 10 SL869-V2S and SL869L-V2S Time to First Fix

6.2.3. Sensitivity - SL869-V2S and SL869L-V2S

Constellation	State	Minimum Signal Level (dBm)	
		SL869-V2S	SL869L-V2S
GPS	Acquisition	-144	-148
	Navigation	-159	-161
	Tracking	-160	-162
Note: The above performance values were measured under ideal lab conditions using a GNSS simulator generating a static scenario.			

Table 11 SL869-V2S and SL869L-V2S Sensitivity

6.2.4. Jamming Mitigation Performance

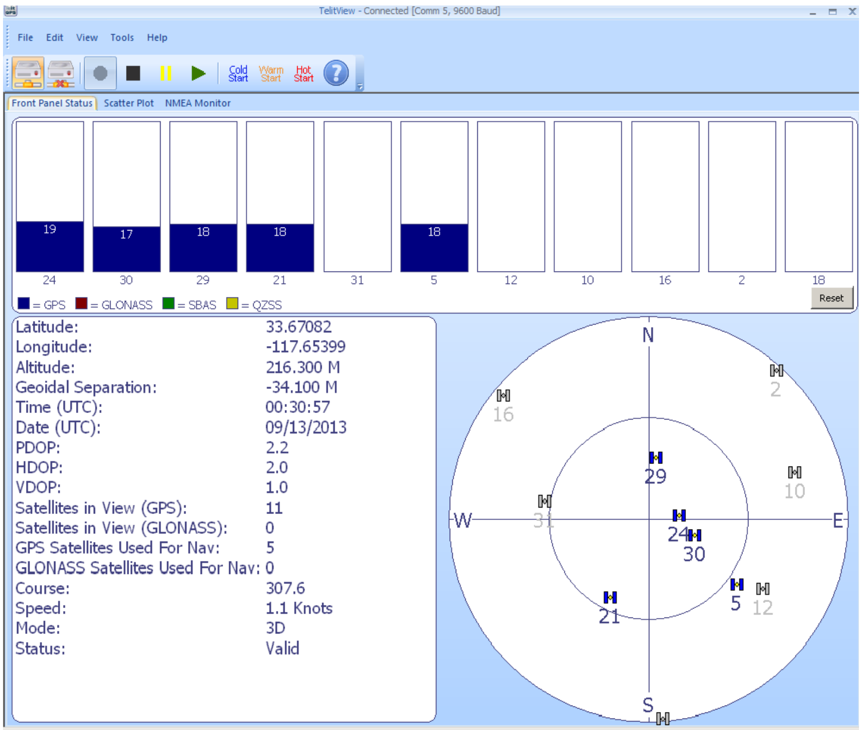


Figure 17:Jamming with AIC Disabled

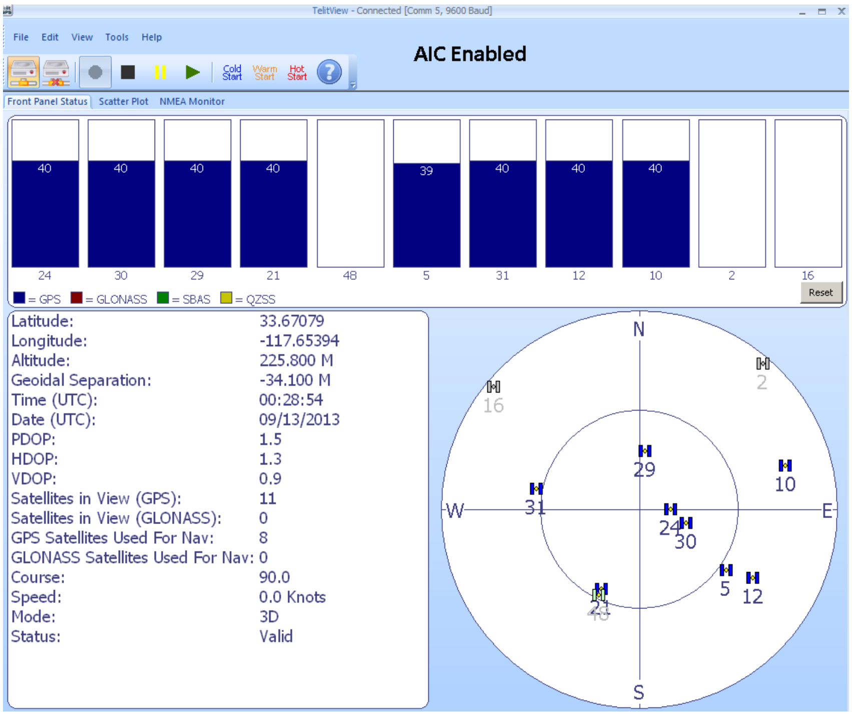


Figure 18: Jamming with AIC Enabled

7. MESSAGE INTERFACE

Serial I/O port 1 (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, 1 stop bit.

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

Note/Tip: Customers that have executed a Non-Disclosure Agreement (NDA) with Telit Wireless may obtain the **SL869-V2 and SL871 Families Authorized Software User Guide**, which contains additional proprietary information.

7.1. NMEA Output Messages

Note/Tip: Some sentences may exceed the NMEA length limitation of 80 characters.

Default: GPS constellation is enabled.

GLONASS is also enabled for SL869-V2 and SL869L-V2.

Default fix rate: 1 Hz. Maximum rate is 10 Hz.

Note: Multiple GSA and GSV messages may be output on each cycle.

7.1.1. Standard Messages

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

Table 12 Default NMEA output messages

The following messages can be enabled by command:

Message ID	Description
GLL	Geographic Position – Latitude & Longitude
VTG	Course Over Ground & Ground Speed
ZDA	Time & Date

Table 13 Available Messages

The following table shows the Talker IDs used:

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

Table 14 NMEA Talker IDs

7.1.2. Proprietary Output Messages

The SL869-V2 receivers support several proprietary NMEA output messages which report additional receiver data and status information.

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

Table 15 Proprietary Output Messages

7.2. 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.

7.2.1. NMEA Commands List

Note/Tip: Please refer to **Table 4 Power Management - Command Summary** for power management commands.

.

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
$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
$PMTK353,0,0,0,0,1	Enable BDS only mode
$PMTK353,1,1,0,0,0	Enable GPS and GLO mode
$PMTK353,1,0,0,0,1	Enable GPS and BDS mode
NOTE: Multi-constellation commands are not supported by the SL869x-V2S modules	

Table 16 NMEA Input commands

8. FLASH UPGRADABILITY

(SL869-V2 and SL869L-V2 only)

Note: The SL869-V2S and SL869L-V2S are ROM-based and therefore are not upgradable.

Please refer to the SL869-V2 EVK User Guide for more detailed information.

The firmware stored in the internal Flash memory of the SL869x-V2 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.

9. ELECTRICAL INTERFACE

9.1. Pin-out Diagrams and Tables

9.1.1. SL869-V2 Pin-out Diagram

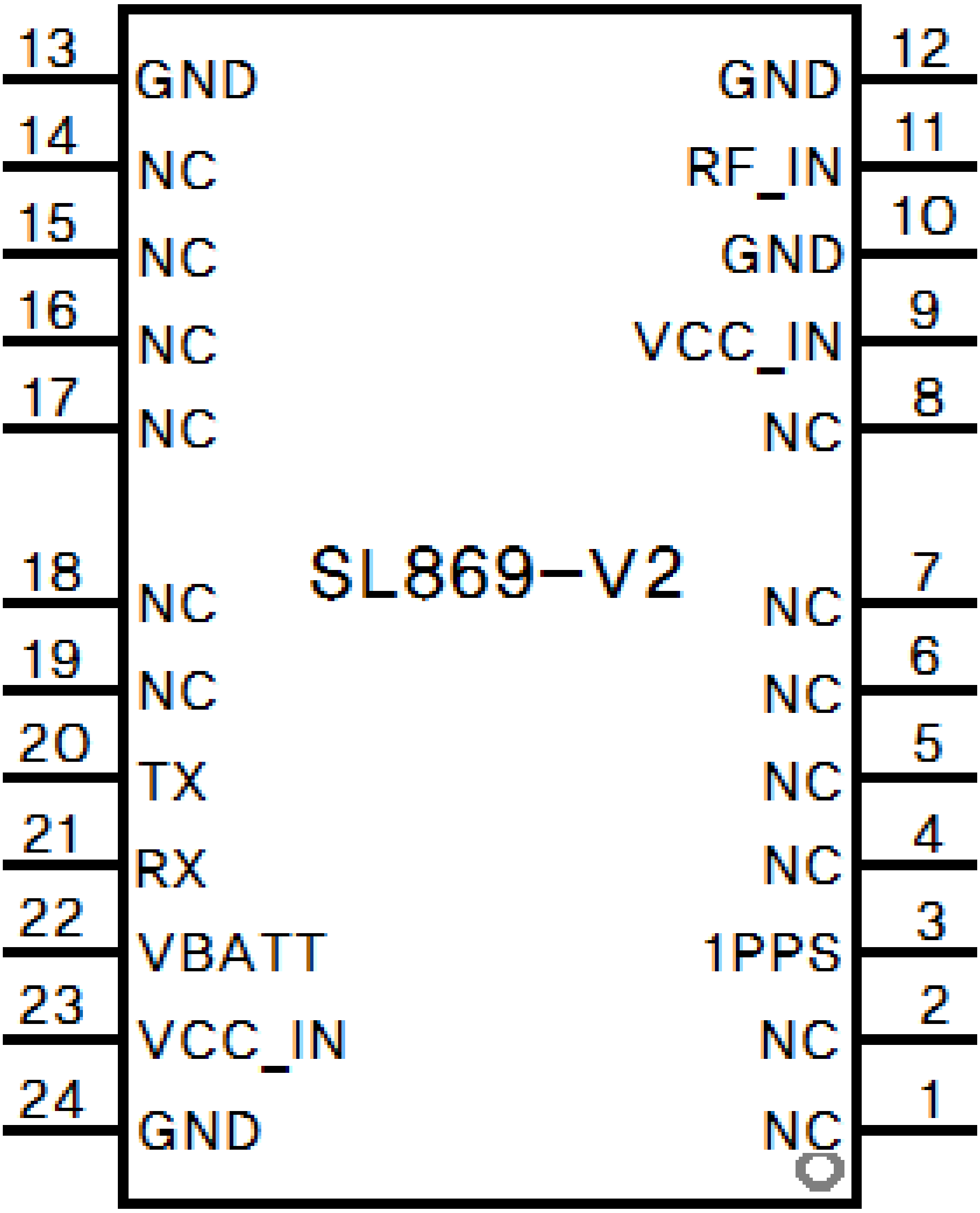


Figure 19: SL869-V2 Pin-out Diagram

9.1.2. SL869-V2 Pin-out Table

Pad	Name	Type	Description
1	NC	NC	No Connection
2	NC	NC	No Connection
3	1PPS	O	Time mark Pulse
4	NC	NC	No Connection
5	NC	NC	No Connection
6	NC	NC	No Connection
7	NC	NC	No Connection
8	NC	NC	No Connection
9	VCC_RF	PWR	Antenna (Bias-T) Supply Voltage (connected by internal trace to pin 23)
10	GND	GND	Ground
11	RF_IN	I	GNSS RF Input, 50 Ohm (pre-select SAW filter)
12	GND	GND	Ground
13	GND	GND	Ground
14	NC	NC	No Connection
15	NC	NC	No Connection
16	NC	NC	No Connection
17	NC	NC	No Connection
18	NC	NC	No Connection
19	NC	NC	No Connection
20	TX	O	TX
21	RX	I	RX
22	VBATT	PWR	Backup Voltage Supply
23	VCC_IN	PWR	Supply Voltage (internally connected to pin 9)
24	GND	GND	Ground
Note: All GROUND pins must be connected to ground			

Table 17 SL869-V2 Pinout Table

9.1.3. SL869L-V2 Pin-out Diagram

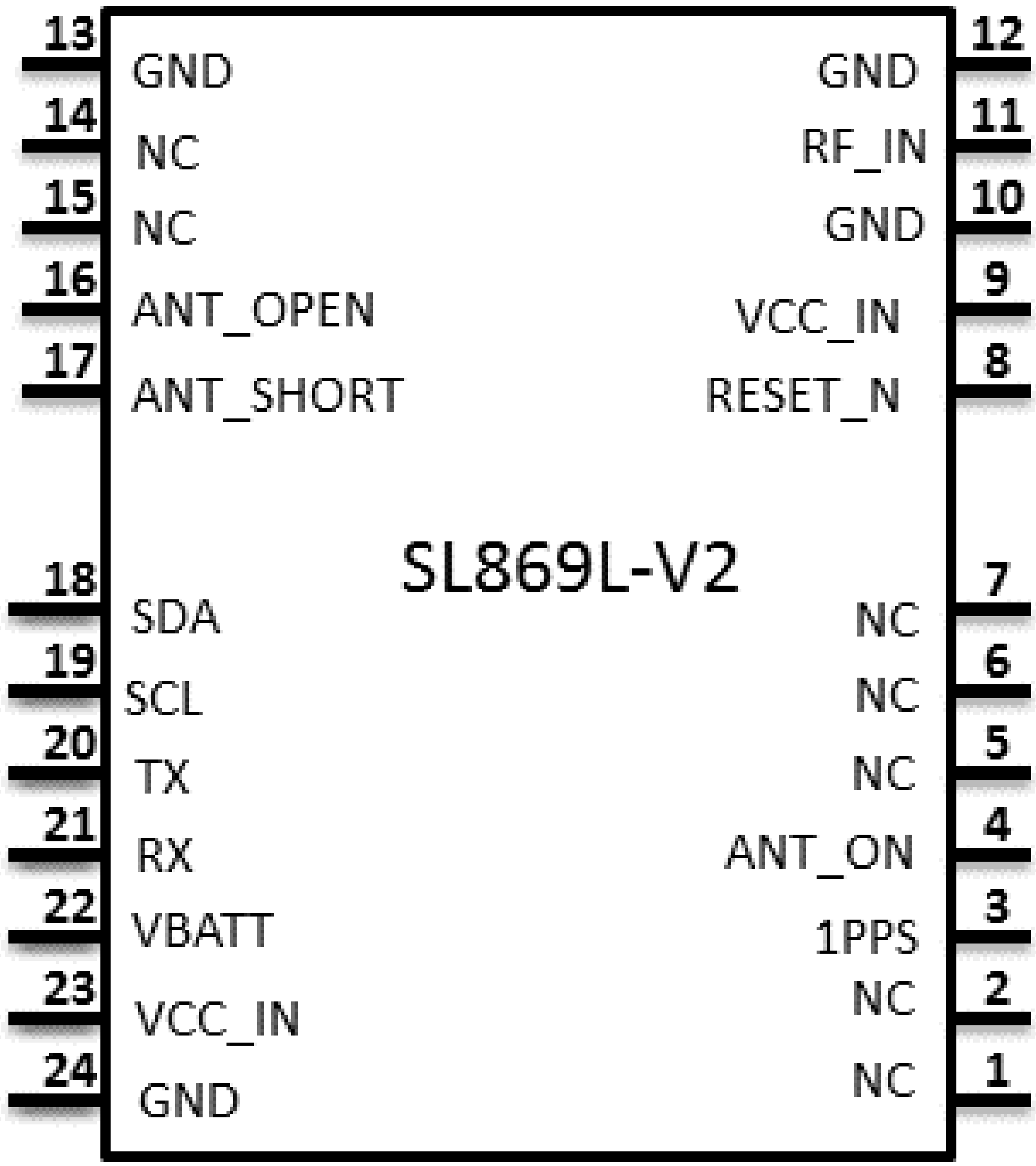


Figure 20: SL869L-V2 Pin-out Diagram

9.1.4. SL869L-V2 Pin-out Table

Pad	Name	Type	Description
1	NC	NC	No Connection
2	NC	NC	No Connection
3	1PPS	O	Time mark Pulse
4	ANT_ON	O	Antenna-On
5	NC	NC	No Connection
6	NC	NC	No Connection
7	NC	NC	No Connection
8	RESET_N	I	RESET-N (Active Low with pullup) May be left unconnected
9	VCC_RF	PWR	Antenna (Bias-T) Supply Voltage (connected by internal trace to pin 23)
10	GND	GND	Ground
11	RF_IN	I	GNSS RF Input, 50 Ohm (LNA input). DC Blocking capacitor has been added to RF_IN in SL869L-V2.
12	GND	GND	Ground
13	GND	GND	Ground
14	NC	NC	No Connection
15	NC	NC	No Connection
16	ANT_OPEN	I	Antenna-Open (High true)
17	ANT_SHORT	I	Antenna-Shorted (Low true)
18	SDA	I/O	I2C Data
19	SCL	O	I2C Clock
20	TX	O	UART Transmit
21	RX	I	UART Receive
22	VBATT	PWR	Backup Voltage Supply
23	VCC_IN	PWR	Supply Voltage (internally connected to pin 9)
24	GND	GND	Ground
The 2nd port (I2C/UART) is on pads 18 & 19. This is different from the SL869L-V2S.			
All GROUND pins must be connected to ground			

Table 18 SL869L-V2 Pinout Table

9.1.5. SL869-V2S Pin-out Diagram

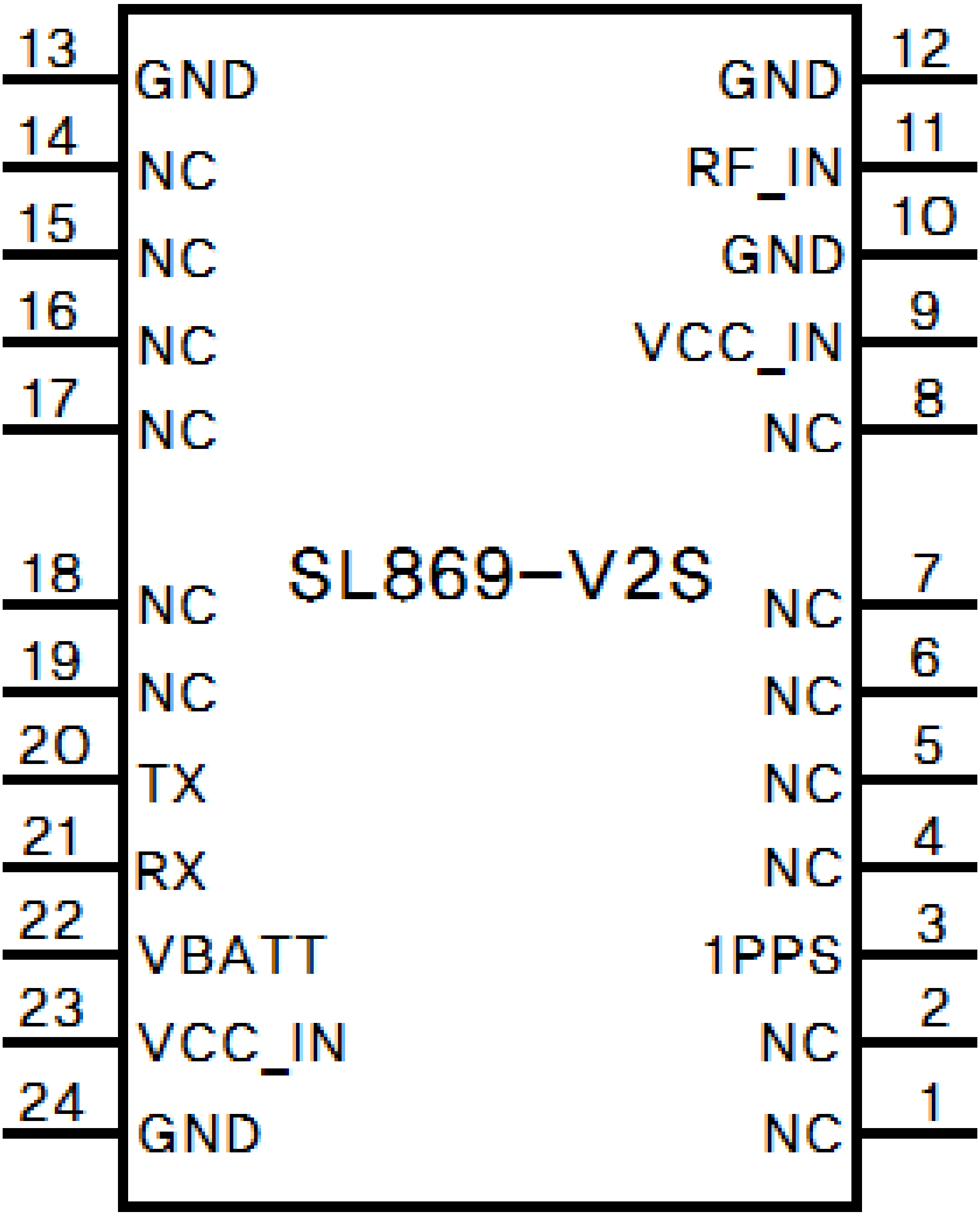


Figure 21: SL869-V2S Pin-out Diagram

9.1.6. SL869-V2S Pin-out Table

Pad	Name	Type	Description
1	NC	NC	No Connection
2	NC	NC	No Connection
3	1PPS	O	Time mark Pulse
4	NC	NC	No Connection
5	NC	NC	No Connection
6	NC	NC	No Connection
7	NC	NC	No Connection
8	NC	NC	No Connection
9	VCC_RF	PWR	Antenna (Bias-T) Supply Voltage (connected by internal trace to pin 23)
10	GND	GND	Ground
11	RF_IN	I	GNSS RF Input, 50 Ohm (pre-select SAW filter)
12	GND	GND	Ground
13	GND	GND	Ground
14	NC	NC	No Connection
15	NC	NC	No Connection
16	NC	NC	No Connection
17	NC	NC	No Connection
18	NC	NC	No Connection
19	NC	NC	No Connection
20	TX	O	TX
21	RX	I	RX
22	VBATT	PWR	Backup Voltage Supply
23	VCC_IN	PWR	Supply Voltage (internally connected to pin 9)
24	GND	GND	Ground
Note: All GROUND pins must be connected to ground			

Table 19 SL869-V2S Pin-out table

9.1.7. SL869L-V2S Pin-out Diagram

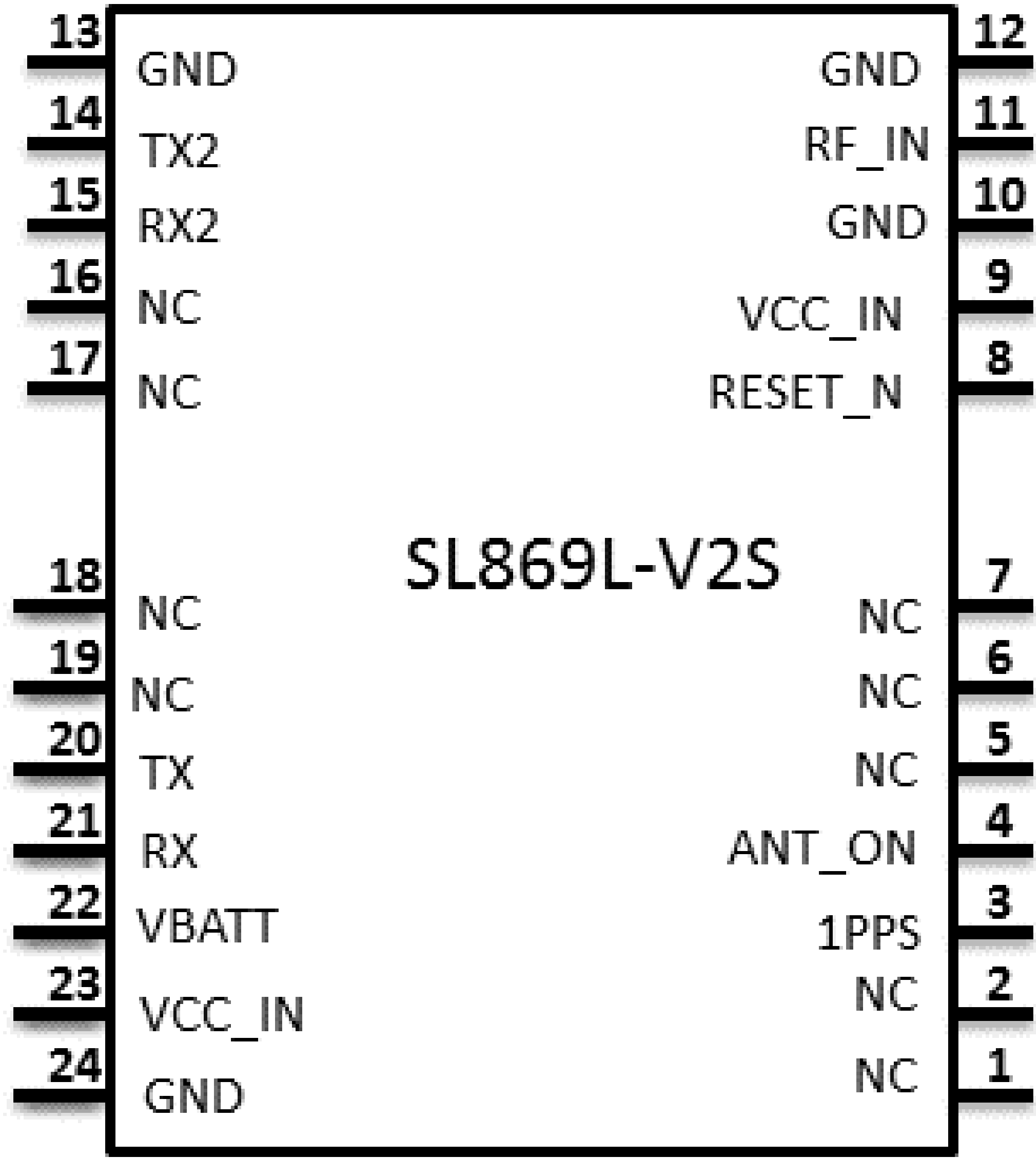


Figure 22: SL869L-V2S Pin-out Diagram

9.1.8. SL869L-V2S Pin-out Table

Pad	Name	Type	Description
1	NC	NC	No Connection
2	NC	NC	No Connection
3	1PPS	O	Time mark Pulse
4	ANT_ON	O	Antenna On
5	NC	NC	No Connection
6	NC	NC	No Connection
7	NC	NC	No Connection
8	RESET_N	I	RESET-N (Active Low with pullup) May be left unconnected
9	VCC_RF	PWR	Antenna (Bias-T) Supply Voltage (connected by internal trace to pin 23)
10	GND	GND	Ground
11	RF_IN	I	GNSS RF Input, 50 Ohm (LNA input). DC Blocking capacitor has been added to RF_IN in SL869L-V2.
12	GND	GND	Ground
13	GND	GND	Ground
14	TX2	O	UART 2 Transmit
15	RX2	I	UART 2 Receive
16	NC	NC	No Connection
17	NC	NC	No Connection
18	NC	NC	No Connection
19	NC	NC	No Connection
20	TX	O	UART Transmit
21	RX	I	UART Receive
22	VBATT	PWR	Backup Voltage Supply
23	VCC_IN	PWR	Supply Voltage (internally connected to pin 9)
24	GND	GND	Ground
Note: All GROUND pins must be connected to ground			
The 2nd port (UART) is on pads 14 & 15. This is different from the SL869L-V2.			

Table 20 SL869L-V2S Pin-out Table

9.2. DC Power Supply

The modules have two power supply pins Vcc and Vbatt.

Note/Tip: Note that I/O voltage ranges are different from supply voltages VCC and VBATT.

9.2.1. VCC

This is the main power input. The supply voltage must be in the range specified in **Table 21 DC Supply Voltage** below.

Note/Tip: Vcc supplies power through a diode to Vbatt. Therefore, Vbatt may be left unconnected.

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.

9.2.2. VBATT

The battery backup power input range is specified in the table below.

Vbatt supplies power to the following elements (the RTC domain):

- Real-time clock (RTC)
- Battery backed RAM (BBRAM)
- EASY data
- Persistent data elements (not commanded option values).

This allows the module to retain time and ephemeris information, thus enabling hot and warm starts, which will improve TTFF.

Note that Vbatt is internally connected to Vcc through a diode, so it may be left unconnected if not required by the application design. Vbatt should be lower than Vcc to avoid current swings during operation as the battery-backed RAM is accessed.

9.2.3. VCC_RF

VCC_RF is directly connected to Vcc by an internal trace and may be used to power an external LNA or bias-T. Maximum current available is 50 mA. It may be left unconnected.

9.2.4. DC Power Requirements

Main Supply Voltage & Backup Voltage					
Supply	Name	Min	Typ	Max	Units
Vcc and Vbatt	Vcc & Vbatt	3.0	3.3	4.3	V
⚠ The drop from 3.0 V to 0 V must be > 1 ms. Also, keep the supply ripple as low as possible (< 50 mV)					

Table 21 DC Supply Voltage

9.2.5. DC Power Consumption: SL869-V2

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	84	123	mW
GPS and Glonass	103	146	mW
GPS and BeiDou	94	143	mW
Navigation/Tracking			
GPS Only	74	120	mW
GPS and Glonass	81	139	mW
GPS and BeiDou	92	152	mW
Low Power – Periodic (500 ms On)			
GPS Only	19		mW
GPS and (Glonass or BeiDou)	25		mW
Vbatt	50	99	µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal SBAS: enabled 1PPS sync: enabled			

Table 22 SL869-V2 Power Consumption

9.2.6. DC Power Consumption: SL869L-V2

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	79	102	mW
GPS + Glonass	86	122	mW
GPS + BeiDou	86	122	mW
Navigation/Tracking			
GPS Only	74	102	mW
GPS + Glonass	80	116	mW
GPS + BeiDou	86	116	mW
Low Power - Periodic			
GPS Only	24		mW
GPS + Glonass	30		mW
GPS + BeiDou	30		mW
Low Power – AlwaysLocate Standby			
GPS Only	16		mW
GPS + Glonass	23		mW
GPS + BeiDou	23		mW
Vbatt	50	99	µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: Periodic 500 ms duty cycle SBAS: disabled 1PPS sync: disabled			

Table 23 SL869L-V2 Power Consumption

9.2.7. DC Power Consumption: SL869-V2S

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	74	110	mW
Navigation/Tracking			
GPS Only	64	108	mW
Vbatt	25	66	µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal SBAS: enabled 1PPS sync: enabled			

Table 24 SL869-V2S Power Consumption

9.2.8. DC Power Consumption: SL869L-V2S

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	56	91	mW
Navigation/Tracking			
GPS Only	53	84	mW
Vbatt	25	66	µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal SBAS: disabled 1PPS sync: disabled			

Table 25 SL869L-V2S Power Consumption

9.3. Digital Interface Signals

Note/Tip: Note that I/O voltage ranges are different from supply voltages VCC and VBATT.

Note/Tip: Several different logic levels are utilized by the digital signal interfaces of the module as shown in the tables below.

9.3.1. Logic Levels - Inputs

RX, RX1, Reset-N, ANT-SC-N, and ANT_OC					
Signal	Symbol	Min	Typ	Max	Units
Input Voltage (L)	Vil	0		0.5	V
Input Voltage (H)	Vih	1.9		3.4	V
Note: These inputs have an internal pullup of 40 kΩ to 190 kΩ.					

Table 26 Input Logic Levels

9.3.2. Logic Levels - Outputs

TX, TX1, and 1PPS					
Signal	Symbol	Min	Typ	Max	Units
Output Voltage (L)	Vol			0.4	V
Output Voltage (H)	Voh	2.14		2.89	V
Normal Current (L)	Iol		-2		mA
Output Current (H)	Ioh		-2		mA

Table 27 Logic Levels: TX and 1PPS

ANT-ON					
Signal	Symbol	Min	Typ	Max	Units
Output Voltage (L)	Vol			0.4	V
Output Voltage (H)	Voh	2.71		2.89	V
Normal Current (L)	Iol		-2		mA
Output Current (H)	Ioh		-2		mA

Table 28 Logic Levels: ANT_ON

9.3.3. Antenna Related Signals

9.3.3.1. VCC-RF (Active Antenna Supply Voltage)

If an active antenna or external LNA is used, an external bias-T is required to provide voltage to it.

(SL869-V2 and SL869-V2S only)

Note/Tip: A DC blocking capacitor is also required to prevent out-of-range DC voltage from being applied to RF-IN except for SL869L-V2 and SL869L-V2S modules (which include a DC blocking capacitor).

9.3.3.2. ANT-ON (SL869L-V2 and SL869L-V2S only)

Antenna on (ANT-ON) is an output logic level to control the power supplied to an external LNA or active antenna (e.g., using an external FET switch connected from VCC-RF to a bias-T).

When logic high, the external antenna or LNA should be active; when logic low the external antenna should be powered down. Since this pin is internally connected to the TCXO supply, it should be free of noise and loading should be minimal.

This signal is not available on the SL869-V2 or SL869-V2S.

The logic levels are shown in **Table 28 Logic Levels: ANT_ON.**

9.3.3.3. ANT-OC (SL869L-V2 only)

This signal is a high true input. When the input is at logic 1, the receiver will output a special NMEA message indicating the antenna line is open. The circuitry to drive this input is external to the SL869-V2 module. This signal is only available on the SL869L-V2.

The logic levels are shown in **Table 26 Input Logic Levels.**

9.3.3.4. ANT-SC-N (SL869L-V2 only)

This signal is a low true input. When the input is at logic 0, the receiver will output a special NMEA message indicating the antenna line is shorted. The circuitry to drive this input is external to the SL869-V2 module.

This signal is only available on the SL869L-V2.

The logic levels are shown in **Table 26 Input Logic Levels.**

9.3.4. Control (Input) Signals

9.3.4.1. RESET-N (SL869L-V2 and SL869L-V2S only)

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, it is recommended to bring it out to a test point.

If used, the signal can only be driven low, never high since it has an internal pullup.

The logic levels are shown in **Table 26 Input Logic Levels.**

9.3.5. Output Signals

9.3.5.1. 1PPS

1PPS is a one pulse per output second signal. Its default characteristics are:

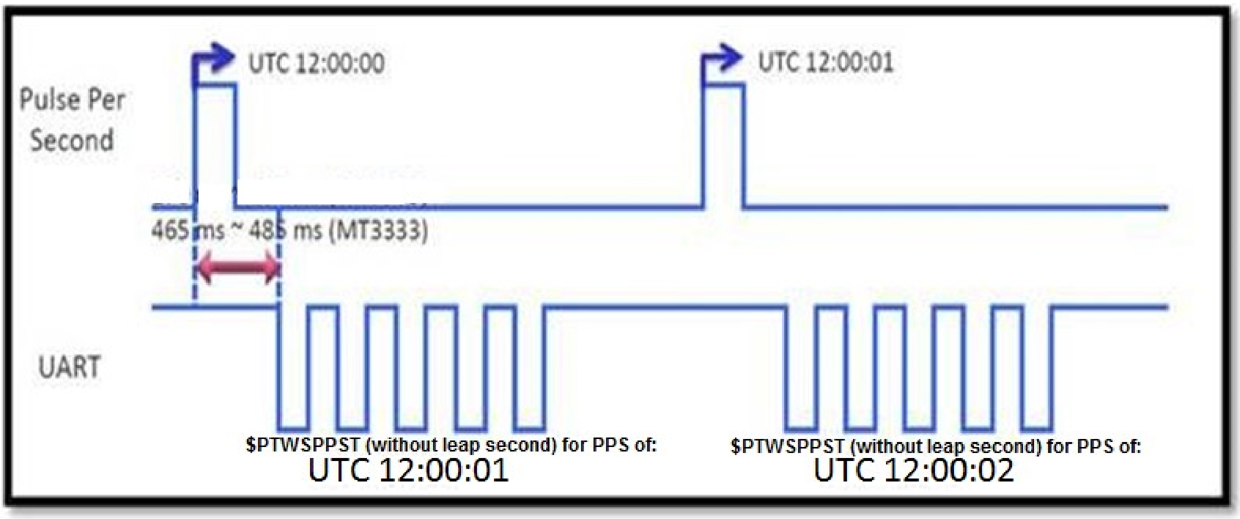
- Pulse duration: 100 ms
- Active: during 3D navigation.

The pulse availability and duration can be configured via the **$PMTK285** command.

Options for availability are:

- Disable
- After 1st fix
- 3D Fix only
- 2D/3D Fix only
- Always.

NMEA output (timestamp) can be configured to have a fixed latency behind the 1PPS pulse of 460 to 485 ms via the **$PMTK255** command. Default is variable latency.



These configurations will not be preserved across a power cycle or reset.

1PPS is disabled if the fix rate > 1 Hz.

Variation is ≈ 30 ns (1 σ).

The logic levels are shown in **Table 27 Logic Levels: TX and 1PPS.**

9.4. Serial I/O Ports

All modules include a primary UART serial port.

SL869L-V2: The secondary port is I^2C. It can be changed to UART via **$PMTK258** command

Note that the module will reset when the interface is changed.

SL869L-V2S: The secondary port is UART.

9.4.1. Serial Port Usage

9.4.1.1. Primary Port Usage

TX: NMEA message output.

RX: NMEA proprietary commands, RTCM SC-104 (DGPS) input, EPO data.

TX/RX: Re-flash the module (SL869-V2 and SL869L-V2 only).

9.4.1.2. Secondary Port Usage

TX1/SDA: NMEA message output.

RX1/SCL: This port accepts DGPS input using the RTCM SC-104 protocol or NMEA commands. Input is selected via the **$PMTK250** command.

9.4.2. UART Port Operation

UART ports are full-duplex and support configurable baud rates.

Frame is 8 bits, no parity bit, and 1 stop bit.

The default rate of 9600 bps can be changed via the following commands:

- Primary port: **$PMTK251**
- Secondary port: **$PMTK250**

The idle state of the interface lines is logic high.

The input and output levels are LVTTL compatible. Please refer to **Table 27 Logic Levels: TX and 1PPS** and **Table 26 Input Logic Levels.**

Note/Tip: Note that the RX pins have a maximum input voltage of 3.4 V (which is lower than the maximum for Vcc or Vbatt).

Note/Tip: Care must be used to prevent backdriving the RX line(s) when the module is powered down or in a low-power state.

9.4.3. I2C Port Operation (SL869L-V2 only)

The SL869-V2, SL869-V2S and SL869L-V2S do not support I^{2}C interface.

The I2C_Clock and I2C_Data lines require external pullups (example value: 10 KΩ).

Features:

- Slave mode only (hard-coded address = 0x10)
- Fast mode (up to 400 Kbps)
- 7-bit address
- 255-byte buffer
- The module operates in the polled mode (with the host as the master.)

Transmit

The host must be able to read several packets each report cycle. A minimum pause of 2 ms is required between reads to allow the module to fill the buffer. A longer delay is permissible. 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 maximum length for commands sent to the module.is 255 bytes.

A minimum of 10 ms is required between packets.

Note/Tip: The following features are fully supported via I2C:

- GLP mode (Enable/Disable)
- Low Power modes supported by the module (Set and Wakeup)
- 1-PPS Sync to NMEA.

Note/Tip: On the other hand, the following features are not supported via I2C:

- FW Flashing
- EPO
- Always locate

Further details and sample code are available under NDA from **Telit MT3333 I2C Application Note**.

9.5. Antenna RF Interface

9.5.1. RF-IN

The RF input (RF-IN) pin accepts GNSS signals in the range of 1561 MHz to 1606 MHz (1573.42 to 1577.42 MHz for the SL869-V2S) at a level between -125 dBm and -165 dBm into 50 Ohm impedance.

Note/Tip: The RF input pin is ESD sensitive.

(SL869-V2 and SL869-V2S)

Note/Tip: Max ± 3V DC can be applied to the RF input.

(SL869L-V2 and SL869L-V2S)

The SL869L-V2 and SL869L-V2S modules include a DC blocking capacitor.

Note/Tip: Note that the RX pins have a maximum input voltage of 3.4 V (which is lower than the maximum for Vcc or Vbatt).

(SL869-V2 and SL869-V2S)

These modules include a preselect SAW filter. This allows them to work well with a passive GNSS antenna. For improved performance, or if the antenna cannot be located near the receiver, an active antenna (that is, an antenna with a built-in low noise amplifier) can be used.

(SL869L-V2 and SL869L-V2S)

These modules include a DC blocking capacitor, additional LNA and a SAW filter. This provides improved performance in poor signal conditions or with passive antennas. The LNA precedes the SAW filter in the RF path.

9.5.2. Frequency Plan

Signal	Frequency (MHz)
TCXO Frequency	26.000
LO Frequency	1588.6

Table 29 Frequency Plan

9.5.3. Burnout Protection

The receiver accepts without risk of damage a signal of +10 dBm from 0 to 2 GHz carrier frequency, except in band 1560 to 1610 MHz where the maximum level is –10 dBm.

9.5.4. Jamming Rejection – Active Interference Cancellation

Jamming Rejection can be used for solving narrow band (CW) EMI problems in the customer's system. It is effective against narrow band clock harmonics. Jamming Rejection is not effective against wide band noise, e.g. from a host CPU memory bus or switching power supply because these sources typically cannot be distinguished from thermal noise. A wide-band jamming signal effectively increases the noise floor and reduces GNSS signal levels.

Please refer to Section **4.9 Jamming Rejection – Active Interference Cancellation (AIC).**

10. RF FRONT END DESIGN

The SL869-V2 and SL869-V2S modules contain a preselect SAW filter in front of the RF input. The SL869L-V2 and SL869L-V2S modules add an LNA in front of the (post-select) SAW filter which allows the modules to work well with passive GNSS antennas. For improved performance, or if the antenna cannot be located near the receiver, an active antenna (that is, an antenna with a built-in low noise amplifier) can be used.

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 ephemeris data and compute the location within a 5-minute period. In the GNSS signal acquisition process, demodulating 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 or ephemeris aiding is available, acquisition can be accomplished at lower signal levels.

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, and the signal level typically increases if a satellite has higher elevation angles.

The GLONASS signal is defined by GLONASS ICD 2008 Version 5.1. This document states that the power level of the received RF signal from 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 of 5 degrees or more above the horizon.

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:

- GNSS satellite transmit power
- GNSS satellite elevation angle
- Free space path loss
- Extraneous path loss (such as 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 GNSS signal is relatively immune to attenuation from rainfall. However, it is heavily influenced by attenuation due to foliage (such as tree canopies, etc.) as well as outright blockage caused by buildings, terrain or other objects near the line of sight to each 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 result is a lower accuracy of position. 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, plus 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 is a phenomenon where the signal from a particular satellite is reflected and is received by the GNSS antenna 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 and 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 (as well as the partial sky obscuration) that makes GNSS navigation in urban canyons (narrow roads surround 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 Polarization

The GPS, Glonass and BeiDou satellites all a broadcast signal that is Right Hand Circularly Polarized (RHCP).

An RHCP antenna will have 3 dB gain compared to a linearly-polarized antenna (assuming the same antenna gain specified in dBic and dBi respectively).

An RHCP antenna is better at rejecting multipath interference than a linearly polarized antenna because the reflected signal changes polarization to LHCP. This signal would be rejected by the RHCP antenna, typically by 20 dB or greater.

If the multipath signal is attenuating the line of sight signal, then the RHCP antenna would show a higher signal level than a linearly polarized antenna because the interfering signal is rejected.

However, in the case where the multipath signal is replacing the line of sight signal, such as in an urban canyon environment, then the number of satellites in view could drop below the minimum needed to determine a 3D position. This is a case where a bad signal may be better than no signal. The system designer needs to understand trade-offs in their application to determine the better choice.

10.3. Active versus Passive Antenna

If the GNSS antenna is placed near the receiver and the RF trace losses are not excessive (nominally 1 dB), then a passive antenna may be used. This would often be the lowest cost option and most of the time the simplest to use. However, if the antenna needs to be located away from the receiver, then an active antenna may be required to obtain the best system performance. An active antenna includes a built-in low noise amplifier (LNA) to overcome RF trace and cable losses. Also, many active antennas have a pre-select filter, a post-select filter, or both.

Important specifications for an active antenna LNA are gain and noise figure.

10.4. GNSS Antenna Gain

Antenna gain is defined as the amplified signal power from the antenna compared to a theoretical isotropic antenna (equally sensitive in all directions).

For example, a 25 mm by 25 mm square patch antenna on a reference ground plane (usually 70 mm by 70 mm) may give an antenna gain at zenith of 5 dBic. A smaller 18 mm by 18 mm square patch on a reference ground plane (usually 50 mm by 50 mm) may give an antenna gain at zenith of 2 dBic.

An antenna vendor should specify a nominal antenna gain (usually at zenith (directly overhead) and antenna pattern curves specifying gain as a function of elevation, and gain at a fixed elevation as a function of azimuth. Pay careful attention to requirements to meet the required design, such as ground plane size and any external matching components. Failure to follow these requirements could result in very poor antenna performance.

It is important to note that GNSS antenna gain is not the same as external LNA gain. Most antenna vendors will specify these numbers separately, but some combine them into a single number. Both numbers are significant when designing the front end of a GNSS receiver.

For example, antenna X has an antenna gain of 5 dBic at azimuth and an LNA gain of 20 dB for a combined total of 25 dB. Antenna Y has an antenna gain of -5 dBic at azimuth and an LNA gain of 30 dB for a combined total of 25 dB. However, in the system, antenna X will outperform antenna Y by about 10 dB.

An antenna with higher gain will generally outperform an antenna with lower gain. However, once the signals are above about -130 dBm for a particular satellite, no improvement in performance would be realized. But for those satellites with a signal level below about -135 dBm, a higher gain antenna would amplify the signal and improve the performance of the GNSS receiver. In the case of really weak signals, a good antenna could mean the difference between being able to use a particular satellite signal or not.

10.5. 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 Noise Floor

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.

10.6. RF Trace Losses

RF Trace losses on a PCB are difficult to estimate without having appropriate tables or RF simulation software. A good rule of thumb would be to keep the RF traces as short as possible, make sure they are 50 Ω impedance and don't contain any sharp bends.

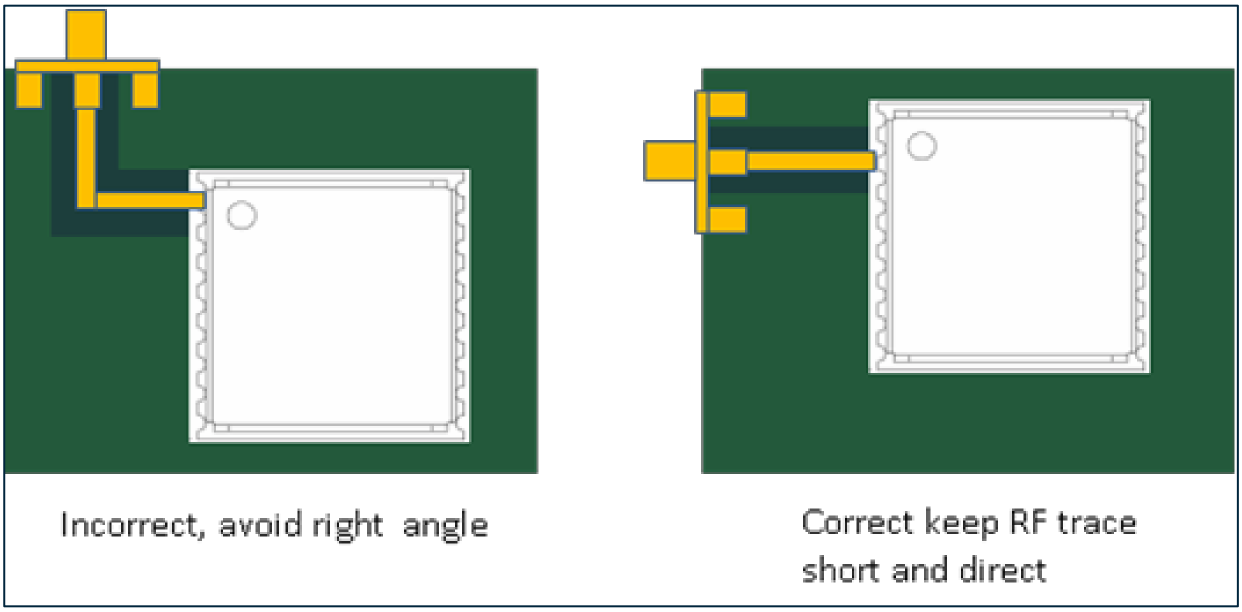


Figure 23: RF Trace Examples

10.7. PCB Stack and Trace Impedance

It is important to maintain a 50 Ω impedance on the RF path trace. Design software for calculating trace impedance can be found from multiple sources on the internet. The best method is to contact your PCB supplier and request a stackup for a 50 Ω controlled impedance board. They will give you a suggested trace width along with PCB stackup needed to create the specified impedance.

It is also important to consider the effects of component pads that are in the path of the 50 Ω trace. If the traces are shorter than a 1/16th wavelength, transmission line effects will be minimized, but stray capacitance from large component pads can induce additional RF losses. It may be necessary to ask the PCB vendor to generate a new PCB stackup and suggested trace width that is closer to the component pads, or modify the component pads themselves.

10.8. Input to the Pre-select SAW Filter (SL869-V2 and SL869-V2S only)

The SL869-V2 and SL869-V2S modules include a pre-select SAW filter at the RF input in front of the internal LNA. Thus, the RF input of the module is connected directly to the SAW filter. Any circuit connected to the RF input pin would see a complex impedance presented by the SAW filter (especially out of band), rather than the relatively broad and flat return loss presented by an LNA. Filter devices pass the desired in-band signal, resulting in low reflected energy (good return loss), and reject the out-of-band signals by reflecting it back to the input, resulting in poor return loss.

If an external amplifier is to be used with the receiver, the overall design should be checked for RF stability to prevent the external amplifier from oscillating. Amplifiers that are unconditionally stable at the output will function correctly.

If an external filter is to be connected directly to the module, care needs to be used in making sure the external filter or the internal SAW filter performance is not compromised. These components are typically specified to operate into 50 ohms impedance, which is generally true in-band, but would not be true out of band. If there is extra gain associated with the external filter, then a 6 dB Pi or T resistive attenuator is suggested to improve the impedance match between the two components.

10.9. Input to the LNA (SL869L-V2 AND SL869L-V2S only)

The SL869L-V2 and SL869L-V2S modules add an LNA followed by the post select SAW filter in the RF path. Thus, the RF input of the module presents a relatively broad and flat return loss from the LNA. However, out-of-band signals at high level could drive this LNA into saturation, reducing the performance of the LNA for the desired in-band GNSS signals.

If an external filter is to be connected directly to the module, care needs to be used in making sure the external filter or the internal SAW filter performance is not compromised. These components are typically specified to operate into 50 ohms impedance, which is generally true in-band. However, unlike the Gen 2 implementation, a resistive pad would not be required between the external SAW filter and the module.

10.10. Powering an External LNA (or active antenna)

An external LNA requires a source of power. Many active antennas accept 3 V or 5 V DC that is impressed upon the RF signal line.

Two approaches can be used:

1. Use an inductor to tie directly to the RF trace. This inductor should be at self-resonant at L1 (1.57542 GHz) and should have good Q for low loss. The higher the inductor Q, the lower the loss will be. The side of the inductor connecting to the antenna supply voltage should be bypassed to ground with a good quality RF capacitor, also with self-resonance at the L1 frequency.
2. Use a quarter wave stub in place of the inductor. The length of the stub is designed to be exactly a quarter wavelength at L1 (1.57542 GHz), which has the effect of

making an RF short at one end of the stub to appear as an RF open at the other end. The RF short is created by the good quality RF capacitor operating at self-resonance.

The choice between the two would be determined by:

- RF path loss introduced by either the inductor or quarter wave stub.
- Cost of the inductor.
- Space availability for the quarter wave stub.

Simulations done by Telit show the following results:

Inductor	Additional signal loss (dB)
Murata LQG15HS27NJ02 Inductor	0.65
Quarter wave stub on FR4	0.59
Coilcraft B09TJLC Inductor (used in ref. design)	0.37

Table 30 Inductor Loss

Since this additional loss occurs after the LNA, it is generally not significant unless the circuit is being designed to work with both active and passive antennas.

10.11. 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 up to 12 in-band CW jamming signals, 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 strength.

10.12. Shielding

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

11. REFERENCE DESIGNS

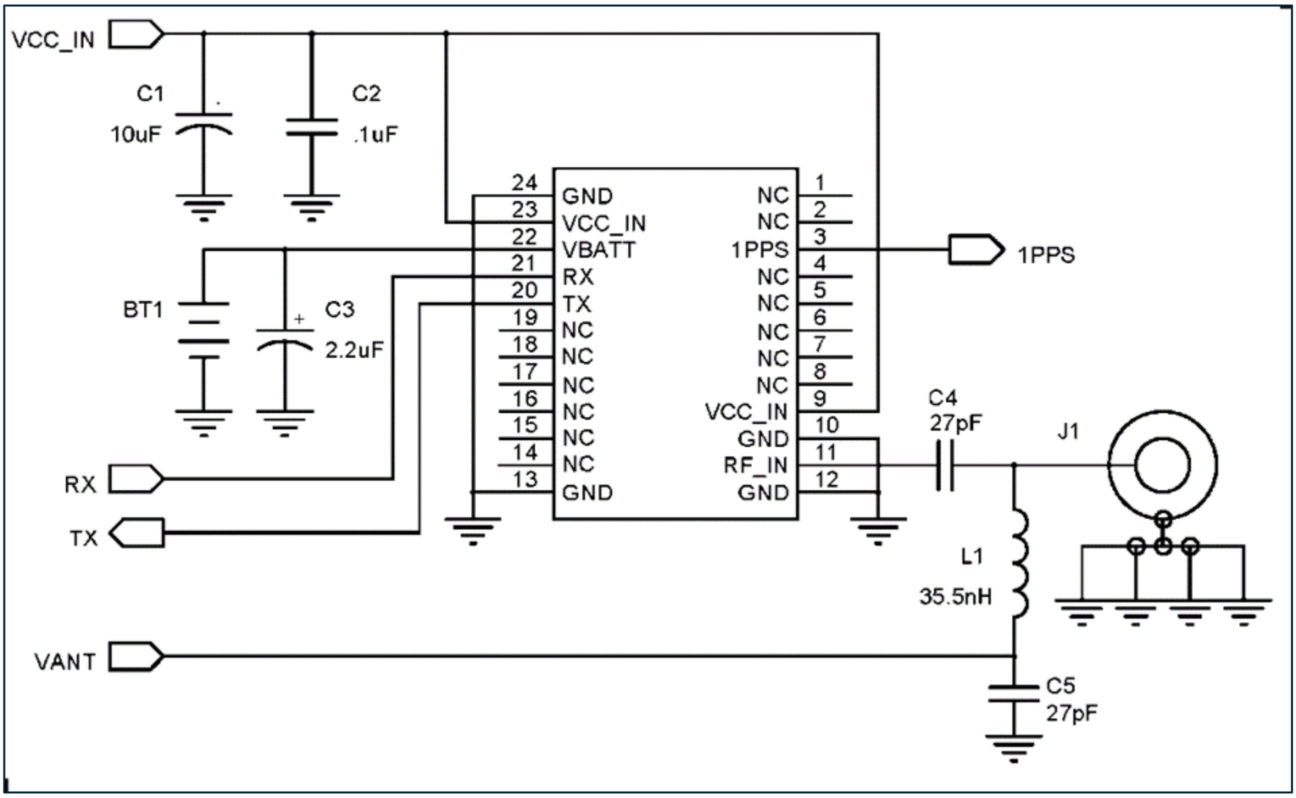


Figure 24: SL869-V2 Family Reference Design

Along with power and grounds, the minimum signals required to operate the receiver properly are the RF input signal and two digital signals (TX and RX). The RF input can be connected directly to a passive GNSS antenna. The reference design shows a DC power feed for an active antenna.

Note/Tip: C4 is used to block the DC voltage from entering the module but is not required on SL869L-V2 modules since they include an internal DC blocking capacitor.

Inductor L1 is chosen to be self-resonant at the GNSS frequency (approximately 1.57542 GHz) to minimize loading on the RF trace. Capacitor C5 is chosen to be self-resonant so that it is close to an RF short at the GNSS frequency.

The circuit above does not provide input to ANT-OC and ANT-SC-N (SL869-V2 only).

Please refer to the schematic below.

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.

Refer to the tables in chapter **9 Electrical Interface** for details.

Note/Tip: Note that some pins are different for the SL869-V2S and SL869L-V2S.

Please refer to section 9.1 **Pin-out Diagrams and Tables**.

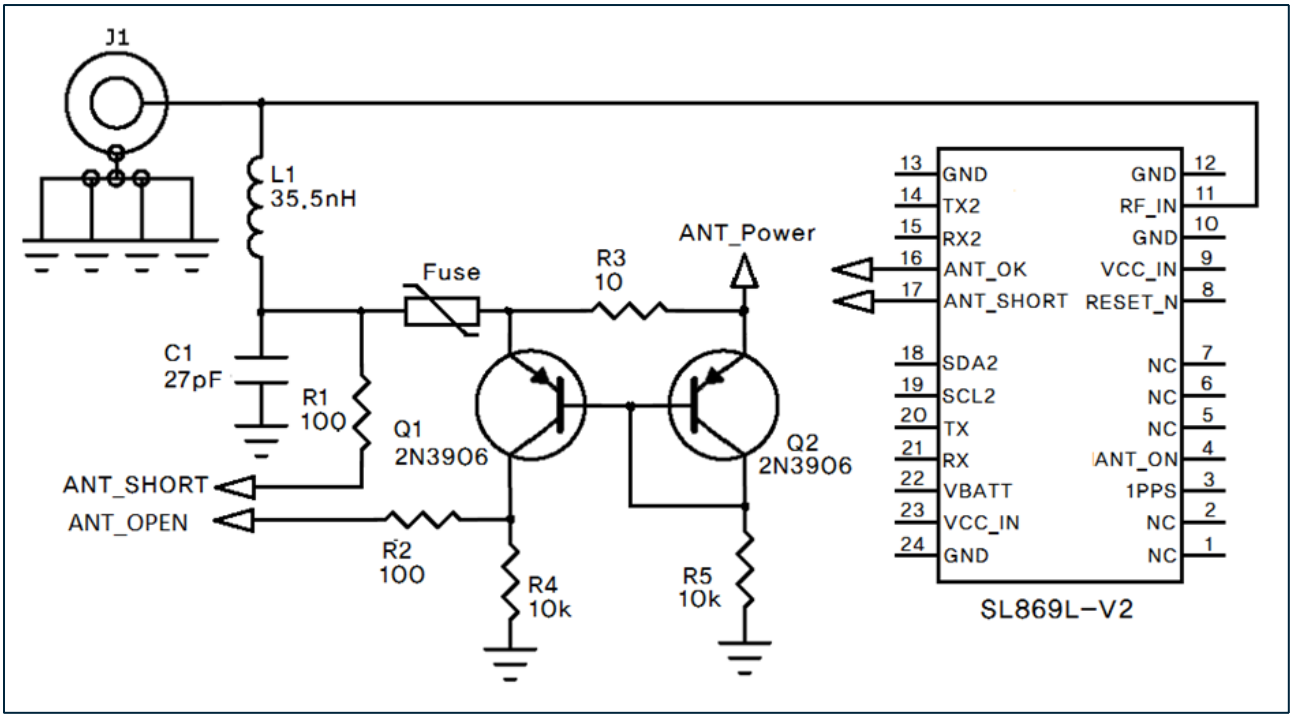


Figure 25: SL869L-V2 Antenna Detection Reference Design

12. MECHANICAL DRAWING

The SL869x-V2 modules have advanced miniature packaging with a base metal of copper and an Electroless Nickel Immersion Gold (ENIG) finish.

There are 24 interface pads with castellated edge contacts. The shield is tin-plated.

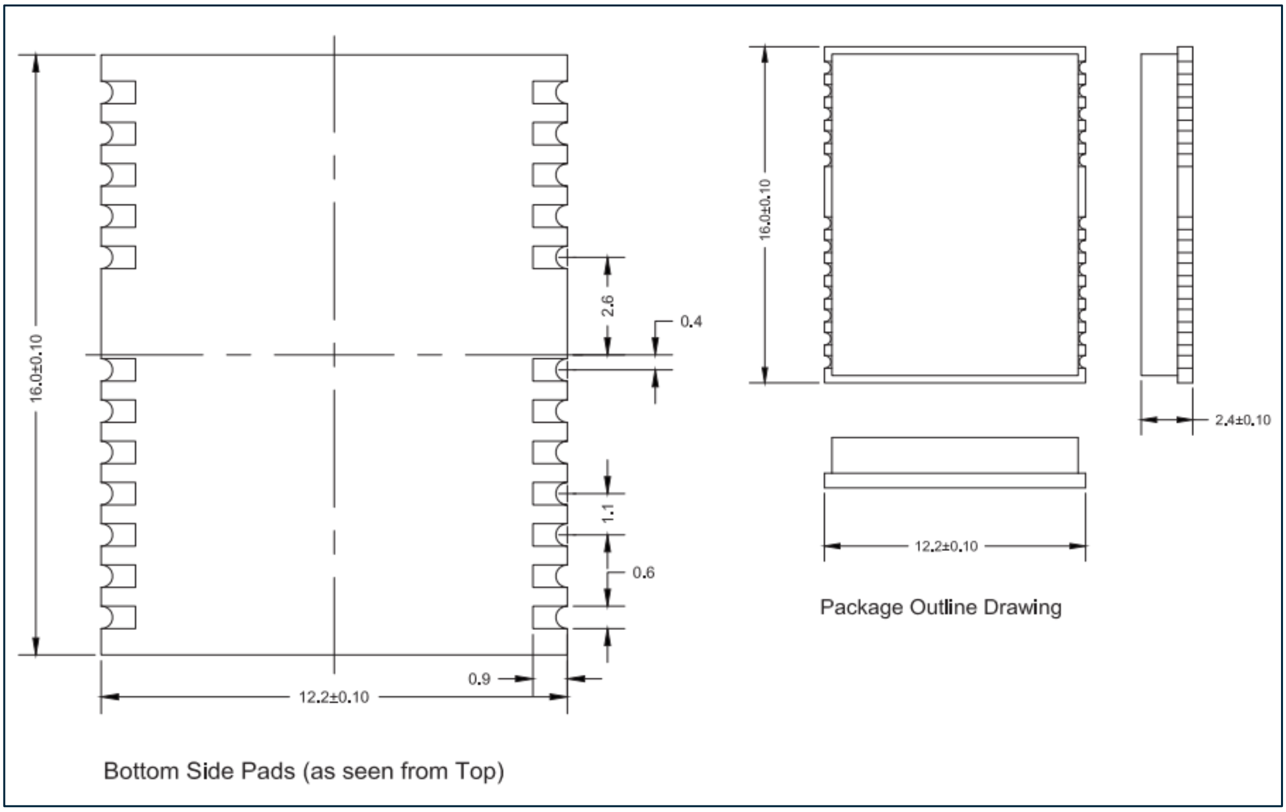


Figure 26: SL869-V2 Family Mechanical Drawing

13. PCB FOOTPRINT

The PCB footprint on the PC board should match the module pad design shown below. The solder mask opening is generally determined by the component geometry of other parts on the board and can be followed here.

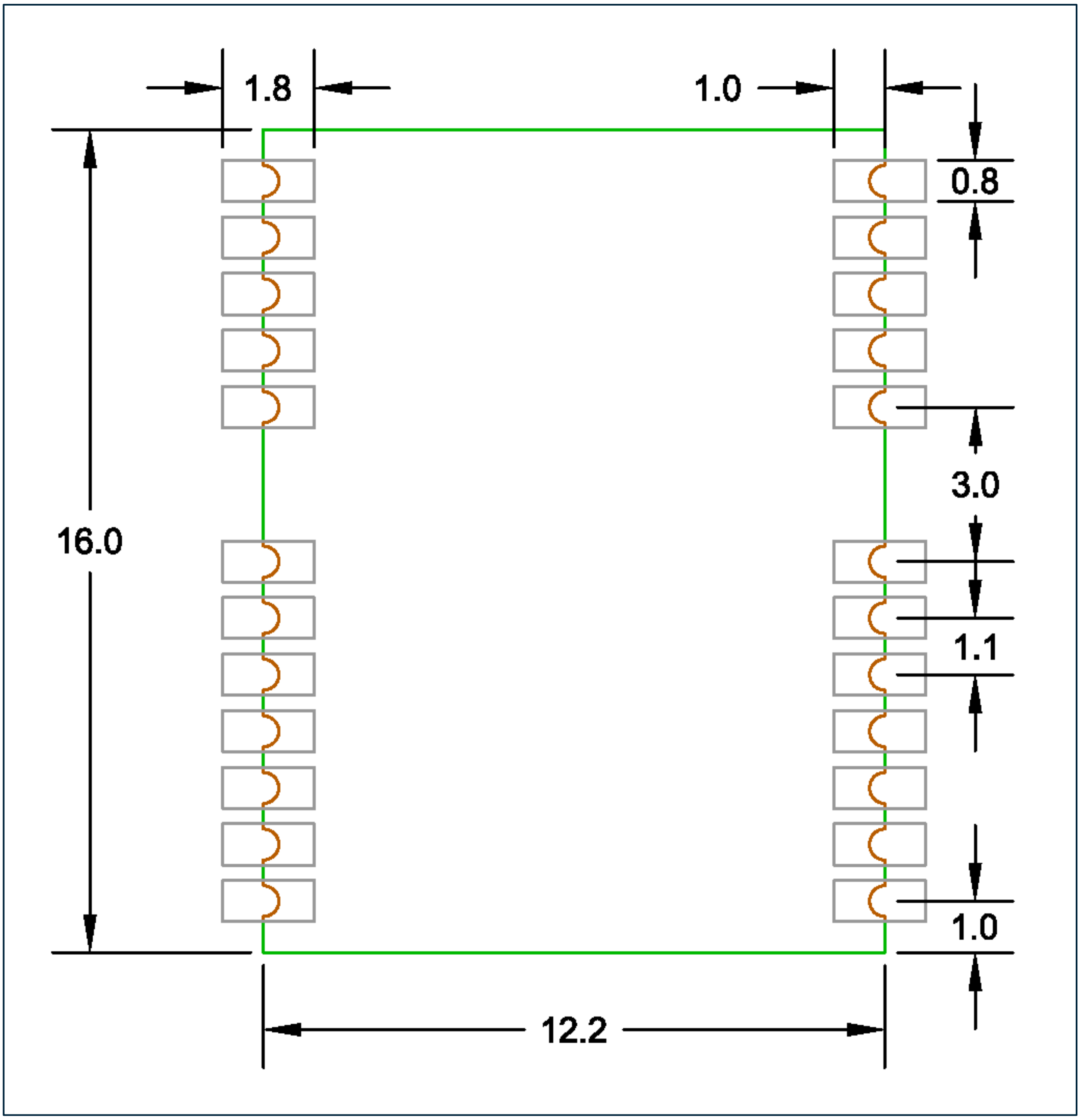


Figure 27: SL869-V2 Family PCB Footprint

14. PRODUCT PACKAGING AND HANDLING

14.1. Product Marking and Serialization

The SL869-V2 modules have a 2D barcode label identifying the product (**SL869-V2**, **SL869L-V2**, **SL869-V2S** or **SL869L-V2S**) and its serial number.

Contact a Telit representative for information on specific module serial numbers.

The label format is as follows:

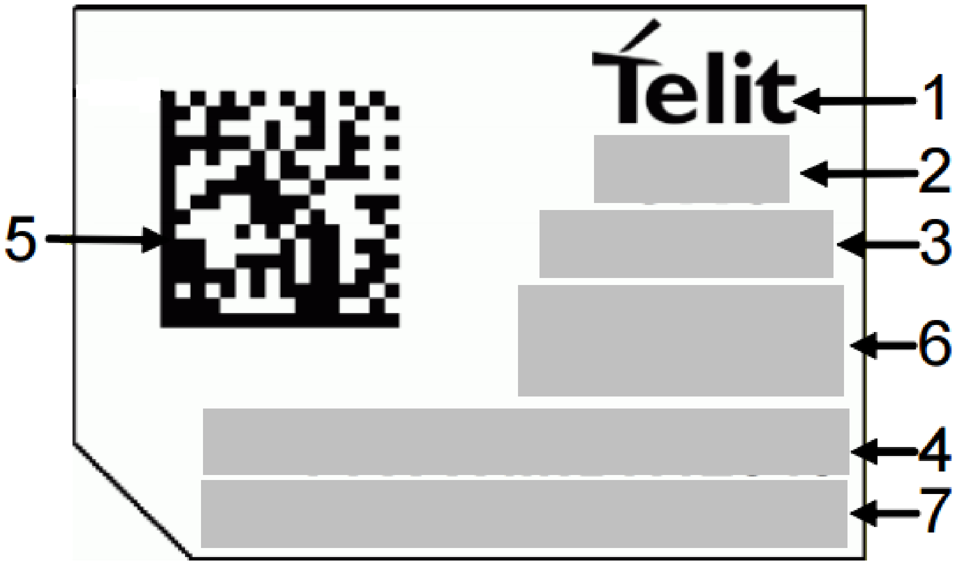


Figure 28: Product Label

Key	Description
1	Telit logo
2	Product Name
4	Telit Serial Number
5	Telit Serial Number barcode (type 2D datamatrix) 11 digit (base 36 – 0 to 9 followed by A to Z)
6	CE mark
Note: Other fields are unused	

Table 31 Product Marking Description

14.2. Product Packaging

SL869-V2 modules are shipped in Tape and Reel form on 24 mm reels with 1000 units per reel or Trays with 72 units. Each reel or tray is 'dry' packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and a humidity indicator card which is then placed in a carton.

All packaging is ESD protective lined.

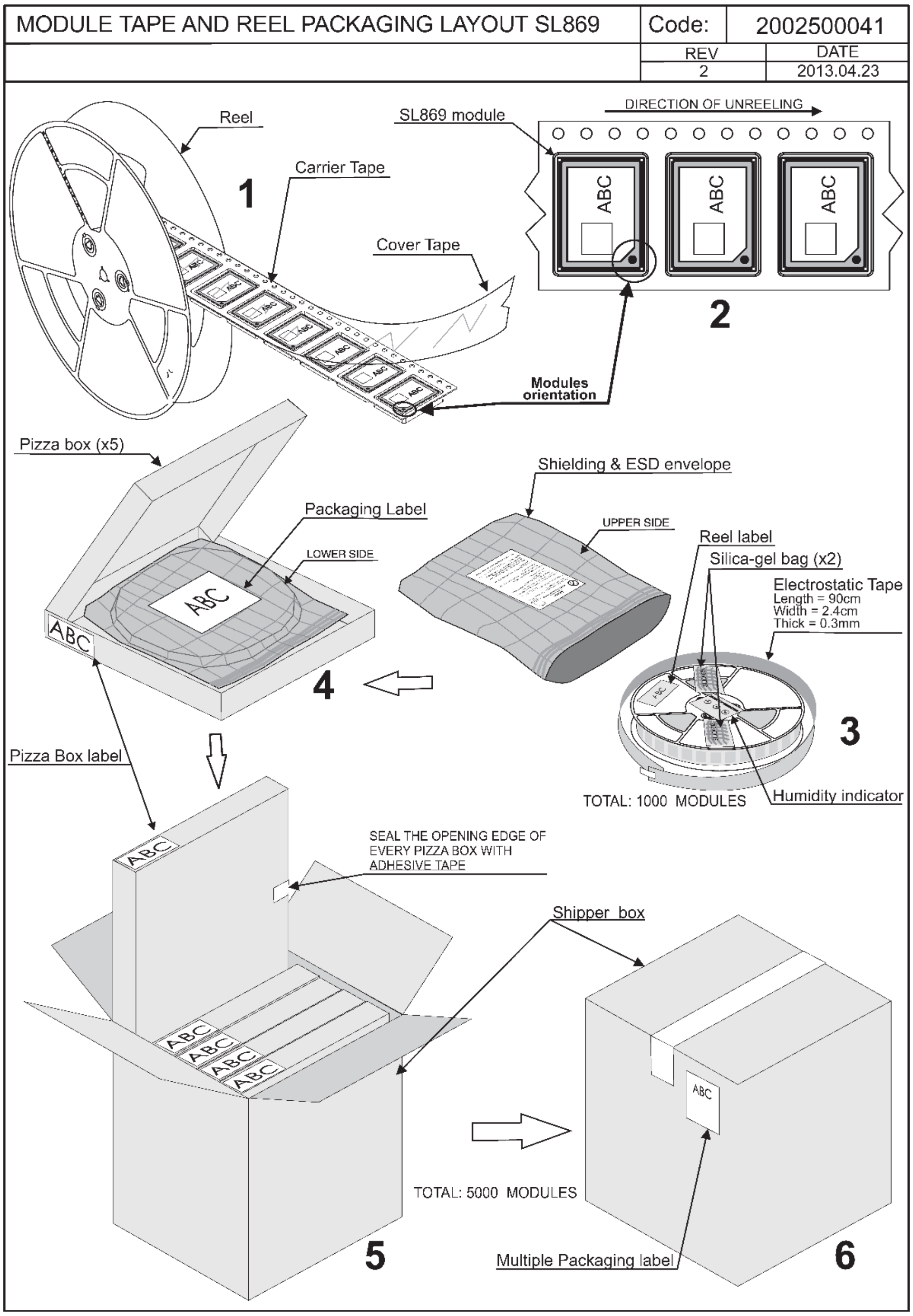


Figure 29: Tape and Reel Packaging

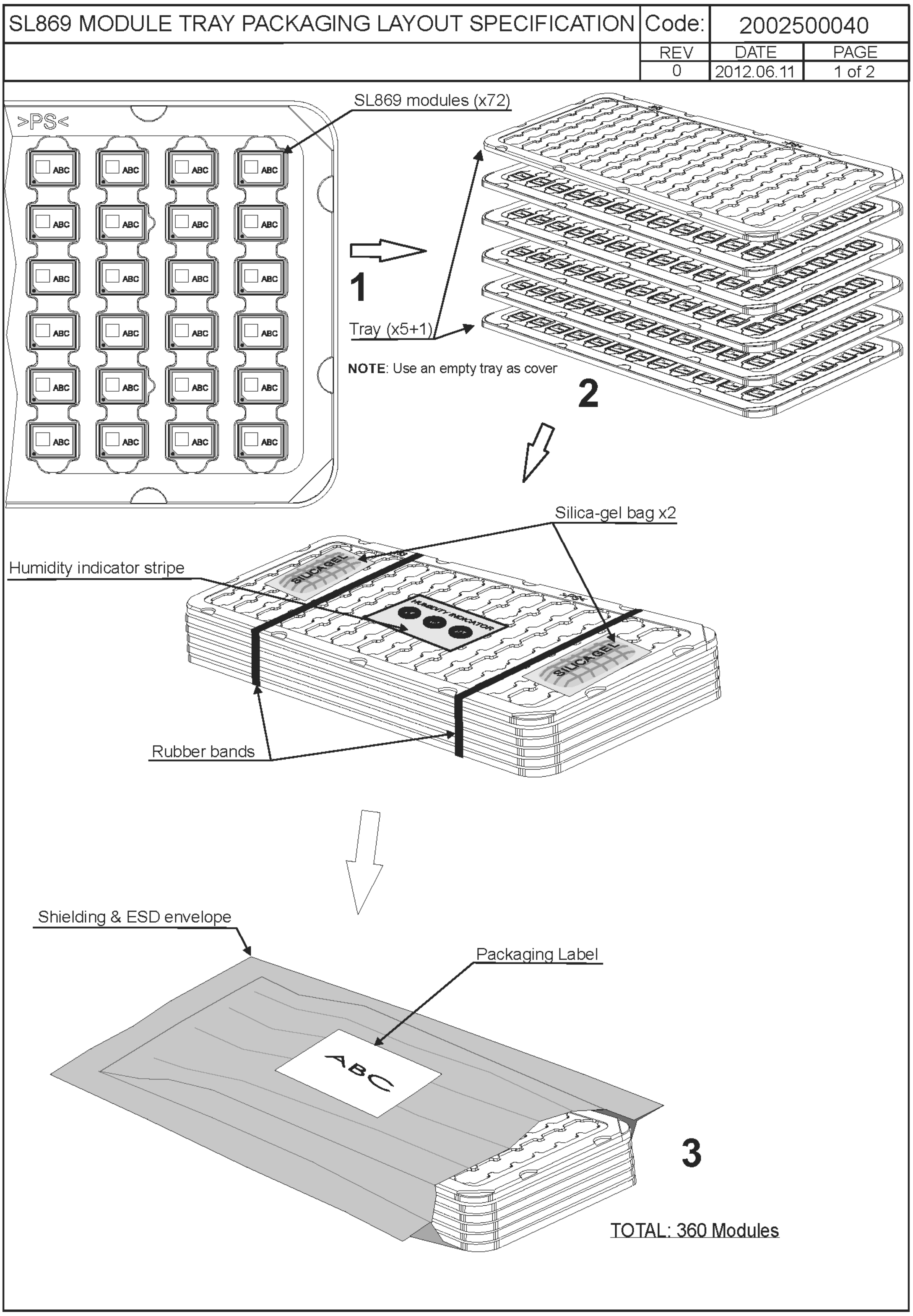


Figure 30: Tray Packaging

14.3. Moisture Sensitivity

Precautionary measures are required in handling, storing and using these 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.

Note/Tip: The module is a Moisture Sensitive Device (MSD) Level 3 as defined by **IPC/JEDEC J-STD-020**. This rating is assigned due to some of the components used within the module.

Please follow the MSD and ESD handling instructions on the labels of the MBB and exterior carton.

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

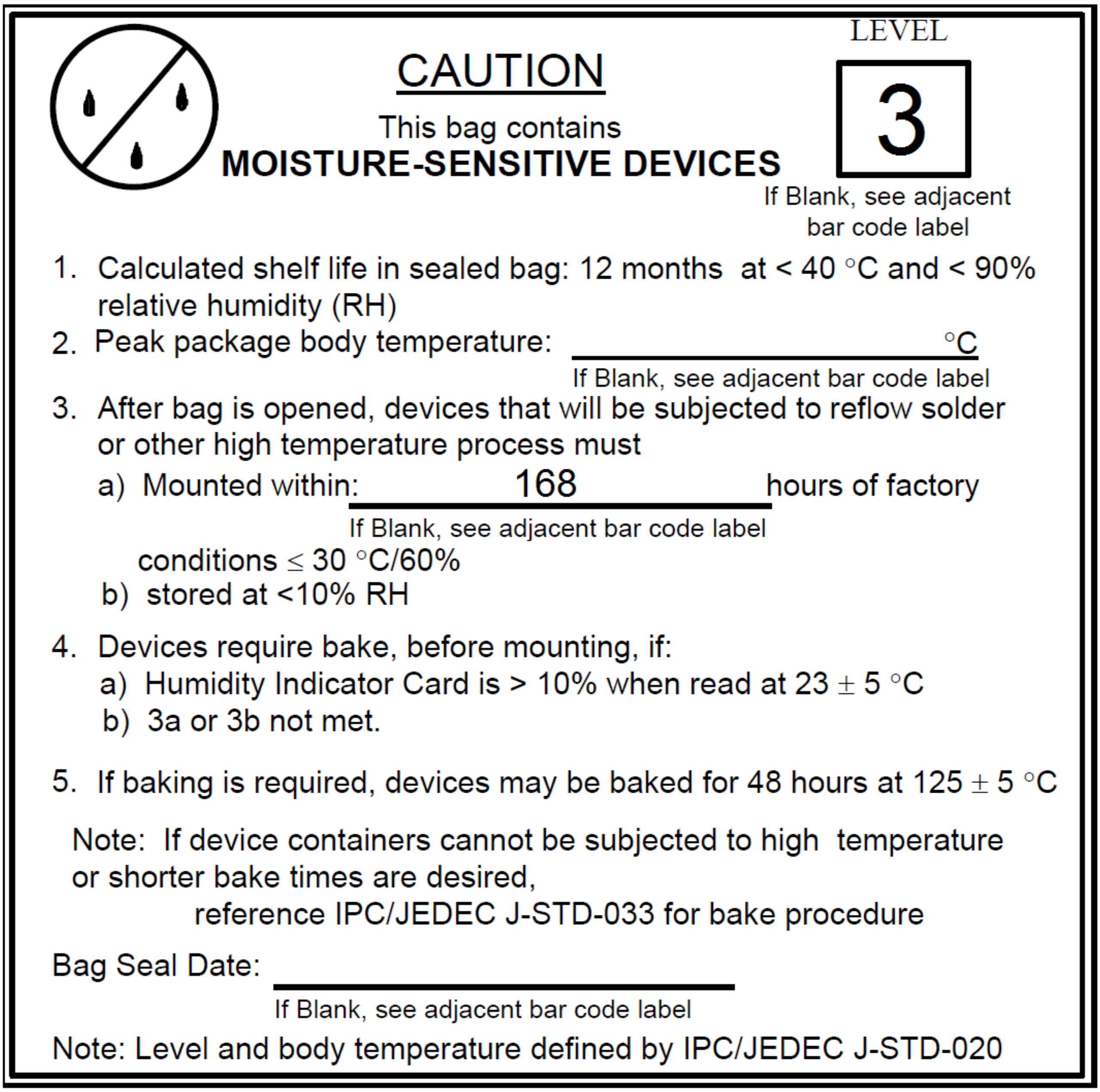
If the package has been opened or the humidity indicator card indicates above 10%, then the parts will need to be baked prior to reflow. The parts may be baked at +90°C ± 5°C for 96 hours.

Note/Tip: However, the packaging materials (e.g. tape & reel) can NOT withstand that temperature. Lower temperature baking is feasible if the humidity level is low and time is available.

Please refer to **IPC/JEDEC J-STD-033 "Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices**" for additional information.

Please refer to the MSL tag affixed to the outside of the hermetically sealed bag.

Note: JEDEC standards are available at no charge from the JEDEC website http://www.jedec.org.



LEVEL

3

If Blank, see adjacent bar code label

CAUTION

This bag contains

MOISTURE-SENSITIVE DEVICES

1. Calculated shelf life in sealed bag: 12 months at < 40 °C and < 90% relative humidity (RH)
2. Peak package body temperature: ______ °C
   If Blank, see adjacent bar code label
3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must
   a) Mounted within: 168 hours of factory
      If Blank, see adjacent bar code label
      conditions ≤ 30 °C/60%
   b) stored at <10% RH
4. Devices require bake, before mounting, if:
   a) Humidity Indicator Card is > 10% when read at 23 ± 5 °C
   b) 3a or 3b not met.
5. If baking is required, devices may be baked for 48 hours at 125 ± 5 °C

Note: If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IPC/JEDEC J-STD-033 for bake procedure

Bag Seal Date: ______

If Blank, see adjacent bar code label

Note: Level and body temperature defined by IPC/JEDEC J-STD-020

Figure 31: Moisture Sensitive Devices Label

14.4. ESD Sensitivity

Note/Tip: These modules contain class 1 devices and are Electro-Static Discharge Sensitive (ESDS). Telit recommends two basic techniques for 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**", which can be downloaded free of charge from: www.jedec.org.

Note/Tip: The RF-IN pin is considered to be ESD sensitive.

14.5. 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.

14.6. Washing Considerations

After assembly, the module can be washed with de-ionized water using standard PCB cleaning procedures. The shield does not provide a water seal to 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 residual moisture out. 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.

14.7. Reflow

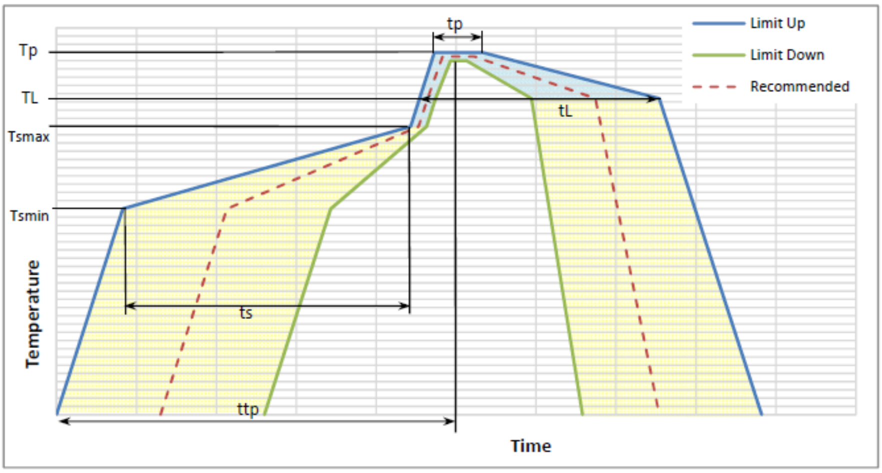
The modules are compatible with lead free soldering processes as defined **in IPC/JEDEC J-STD-020**. The reflow profile must not exceed the profile given **IPC/JEDEC J-STD-020 Table 5-2, "Classification Reflow Profiles"**.

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

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 32: Recommended Reflow Profile

Note/Tip: Please note that the JEDEC document includes important information in addition to the above figure. Please refer to: http://www.jedec.org/sites/default/files/docs/jstd020d-01.pdf

14.8. Disposal

We recommend 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.

14.9. Safety

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

Please refer to section **17.3. Safety Recommendations** for further details.

15. ENVIRONMENTAL REQUIREMENTS

15.1. Operating Environmental Limits

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

Table 32 Operating Environmental Limits

15.2. Storage Environmental Limits

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

Table 33 Storage Environmental Limits

16. COMPLIANCES

The modules comply with the following:

- Directive 2011/65/EU art. 16 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
- Manufactured in an ISO 9001: 2008 accredited facility
- Manufactured to TS 16949:2009 requirements
- Directive 2014/53/EU Radio Equipment Directive (RED).

16.1. EU (RED) Declarations of Conformity

Telit

EU DECLARATION OF CONFORMITY [20433DOC00090A]

1 **SL869-V2** (product name)

2 Telit Wireless Solutions -3131 RDU Center Dr. Suite 135 Morrisville, NC 27560 USA R&D Center -27422 Portola Parkway Suite 320 Foothill Ranch, CA 92610 (manufacturer)

3 This declaration of conformity is issued under the sole responsibility of the manufacturer

4 GNSS L1 receiver Wireless Module
SW Version(s) v13-2.2.0-STD-3.8.13-N96

Operating frequency bands and related max radio-frequency power transmitted:
1559-1607 MHz Receiver only

5 The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 2014/53/EU (RED)

6 The conformity with the essential requirements set out in Art.3 of the 2014/53/EU has been demonstrated against the following harmonized standards:

Harmonized Standard reference	Article of Directive 2014/53/EU
EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013	3.1 (a): Health and Safety of the User
Draft ETSI 301 489-1 v2.2.0 & 301 489-19 v2.1.0	3.1 (b): Electromagnetic Compatibility
ETSI 303 413 v1.1.1	3.2: Effective use of spectrum allocated

7 The conformity assessment procedure referred to in Article 17 and detailed in Annex III of Directive 2014/53/EU has been followed with the involvement of the following Notified Body:

Compatible electronics, Inc., 114 Olinda Drive - Brea, California 92823 - United States, Notified Body No: 1925

Thus, CE is placed on the product

8 The product can be considered compliant to the essential requirements set out in Art.3 of 2014/53/EU only in combination with the above-mentioned SW version(s).

9 The Technical Documentation (TD) 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

Trieste, **2017-10-16**

Group CFO, Corporate
Eran Edri

VP R&D GNSS
Georgia Frousiakis

EU-Type Examination Certificate No. 20170905125122

Technical Documentation: 30433TCF00077A

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Società soggetta all'attività
di direzione e coordinamento
da parte di Telit Communications PLC
con sede in Londra (art.2497 bis C.C.)

Società con socio unico
(Telit Communications PLC)

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Figure 33: SL869-V2 EU (RED) Declaration of Conformity

EU DECLARATION OF CONFORMITY [20433DOC00092A]

1 **SL869L-V2** (product name)

2 Telit Wireless Solutions -3131 RDU Center Dr. Suite 135 Morrisville, NC 27560 USA R&D Center -27422 Portola Parkway Suite 320 Foothill Ranch, CA 92610 (manufacturer)

3 This declaration of conformity is issued under the sole responsibility of the manufacturer

4 GNSS L1 receiver Wireless Module
SW Version(s) v13-2.2.0-STD-3.8.13-N96

Operating frequency bands and related max radio-frequency power transmitted:
1559-1607 MHz Receiver only

5 The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 2014/53/EU (RED)

6 The conformity with the essential requirements set out in Art.3 of the 2014/53/EU has been demonstrated against the following harmonized standards:

Harmonized Standard reference	Article of Directive 2014/53/EU
EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013	3.1 (a): Health and Safety of the User
Draft ETSI 301 489-1 v2.2.0 & 301 489-19 v2.1.0	3.1 (b): Electromagnetic Compatibility
ETSI 303 413 v1.1.1	3.2: Effective use of spectrum allocated

7 The conformity assessment procedure referred to in Article 17 and detailed in Annex III of Directive 2014/53/EU has been followed with the involvement of the following Notified Body:

Compatible electronics, Inc., 114 Olinda Drive - Brea, California 92823 - United States, Notified Body No: 1925

Thus, CE is placed on the product

8 The product can be considered compliant to the essential requirements set out in Art.3 of 2014/53/EU only in combination with the above-mentioned SW version(s).

9 The Technical Documentation (TD) 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

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VP R&D GNSS
Georgia Frousiakis

EU-Type Examination Certificate No. 20170913153436

Technical Documentation: 30433TCF00060A

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Società soggetta all'attività
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Figure 34: SL869L-V2 EU (RED) Declaration of Conformity

EU DECLARATION OF CONFORMITY [20433DOC00091A]

1 **SL869-V2S** (product name)

2 Telit Wireless Solutions -3131 RDU Center Dr. Suite 135 Morrisville, NC 27560 USA R&D Center -27422 Portola Parkway Suite 320 Foothill Ranch, CA 92610 (manufacturer)

3 This declaration of conformity is issued under the sole responsibility of the manufacturer

4 GPS L1 receiver Wireless Module
SW Version(s) AXN_2.32_3337_15010801

Operating frequency bands and related max radio-frequency power transmitted:
1574-1576 MHz Receiver only

5 The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 2014/53/EU (RED)

6 The conformity with the essential requirements set out in Art.3 of the 2014/53/EU has been demonstrated against the following harmonized standards:

Harmonized Standard reference	Article of Directive 2014/53/EU
EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013	3.1 (a): Health and Safety of the User
Draft ETSI 301 489-1 v2.2.0 & 301 489-19 v2.1.0	3.1 (b): Electromagnetic Compatibility
ETSI 303 413 v1.1.1	3.2: Effective use of spectrum allocated

7 The conformity assessment procedure referred to in Article 17 and detailed in Annex III of Directive 2014/53/EU has been followed with the involvement of the following Notified Body:

Compatible electronics, Inc., 114 Olinda Drive - Brea, California 92823 - United States, Notified Body No: 1925

Thus, CE is placed on the product

8 The product can be considered compliant to the essential requirements set out in Art.3 of 2014/53/EU only in combination with the above-mentioned SW version(s).

9 The Technical Documentation (TD) 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

Trieste, **2017-10-16**

Group CFO Corporate
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VP R&D GNSS
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Technical Documentation: 30433TCF00078A

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Figure 35: SL869-V2S EU (RED) Declaration of Conformity

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EU DECLARATION OF CONFORMITY [30433TCF00061A]

1 **SL869L-V2S** (product name)

2 Telit Wireless Solutions -3131 RDU Center Dr. Suite 135 Morrisville, NC 27560 USA R&D Center -27422 Portola Parkway Suite 320 Foothill Ranch, CA 92610 (manufacturer)

3 This declaration of conformity is issued under the sole responsibility of the manufacturer

4 GPS L1 receiver Wireless Module
SW Version(s) AXN_2.32_3337_15010801

Operating frequency bands and related max radio-frequency power transmitted:
1574-1576 MHz Receiver only

5 The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 2014/53/EU (RED)

6 The conformity with the essential requirements set out in Art.3 of the 2014/53/EU has been demonstrated against the following harmonized standards:

Harmonized Standard reference	Article of Directive 2014/53/EU
EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013	3.1 (a): Health and Safety of the User
Draft ETSI 301 489-1 v2.2.0 & 301 489-19 v2.1.0	3.1 (b): Electromagnetic Compatibility
ETSI 303 413 v1.1.1	3.2: Effective use of spectrum allocated

7 The conformity assessment procedure referred to in Article 17 and detailed in Annex III of Directive 2014/53/EU has been followed with the involvement of the following Notified Body:

Compatible electronics, Inc., 114 Olinda Drive - Brea, California 92823 - United States, Notified Body No: 1925

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EU-Type Examination Certificate No. 20170913153705

Technical Documentation: 20433DOC00093A

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Figure 36: SL869L-V2S EU (RED) Declaration of Conformity

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17.3. Safety Recommendations

Make sure the use of this product is allowed in your country and in the environment required. The use of this product may be dangerous and has to be avoided in areas where:

- it can interfere with other electronic devices, particularly in environments such as hospitals, airports, aircrafts, etc.
- there is a risk of explosion such as gasoline stations, oil refineries, etc. It is the responsibility of the user to enforce the country regulation and the specific environment regulation.

Do not disassemble the product; any mark of tampering will compromise the warranty validity. We recommend following the instructions of the hardware user guides for correct wiring of the product. The product has to be supplied with a stabilized voltage source and the wiring has to be conformed to the security and fire prevention regulations. The product has to be handled with care, avoiding any contact with the pins because electrostatic discharges may damage the product itself. Same cautions have to be taken for the SIM, checking carefully the instruction for its use. Do not insert or remove the SIM when the product is in power saving mode.

The system integrator is responsible for the functioning of the final product. Therefore, the external components of the module, as well as any project or installation issue, have to be handled with care. Any interference may cause the risk of disturbing the GSM network or external devices or having an impact on the security system. Should there be any doubt, please refer to the technical documentation and the regulations in force. Every module has to be equipped with a proper antenna with specific characteristics. The antenna has to be installed carefully in order to avoid any interference with other electronic devices and has to guarantee a minimum distance from the body (20 cm). In case this requirement cannot be satisfied, the system integrator has to assess the final product against the SAR regulation.

The equipment is intended to be installed in a restricted area location.

The equipment must be supplied by an external specific limited power source in compliance with the standard EN 62368-1:2014.

The European Community provides some Directives for the electronic equipment introduced on the market. All of the relevant information is available on the European Community website:

https://ec.europa.eu/growth/sectors/electrical-engineering_en

18. GLOSSARY

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. Please refer to 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. Please refer to **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 or restarted after a period on inactivity. Almanac information may be used to identify previously visible satellites and their approximate positions. Please refer to **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. Please refer to 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. Please refer to **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. Please refer to **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 regional system.
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 receiving a restart command, generally used for testing rather than normal operation. A restart can also result from a power-up. Please refer to 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. Please refer to **AGPS**.
TCXO	Temperature-Compensated Crystal Oscillator
Tracking Sensitivity	The lowest signal level at which a GNSS receiver can 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. Please refer to **Restart**.

19. DOCUMENT HISTORY

Revision	Date	Changes
9	2021-07-05	Modified section 9.4.3 to document features supported via I2C port. Updated document to new Telit standard template.
8	2019-08-23	Corrected RF_IN pin descriptions (SAW vs. LNA inputs)
7	2018-12-21	Removed incorrect description of Ant_OC and ANT_SC_N for the SL869-V2. Changed minimum Vcc and Vbatt from 2.8 to 3.0 V. Added Schottky diodes to the block diagrams
6	2018-08-10	Removed prohibition against driving RESET_N high. Updated performance numbers. Minor formatting changes.
5	2018-07-13	Updated photos and packaging information Added "Always Locate" is not included on the MT3337E ROM. SBAS ranging is not supported I/O 2nd port description updated Removed restriction prohibiting fast-discharge LDO Minor text revisions
4	2018-03-12	Changed Vcc limits to 2.8 - 4.3 (testing completed) Changed QZSS default to "disabled" Added RTCM Version & Message types Removed restriction of RTCM data over I2C Updated Vcc voltage range Added diagrams: EASY, Jamming, GLP, Periodic, Always Loc Added power management command summary table Added configuration command references Added 1PPS information Rearranged Serial Port information Changed MT3333-based 2nd port default configuration to I2C Rearranged Product Features table(s) Deleted incorrect references to Force-On and Perpetual Backup Corrected commands for Backup and Standby modes Corrected commands for Periodic Low Power modes Added information on the new GLP low-power mode Corrected checksum on the $PMTK161,1 command

		Rearranged Electrical Interface information Updated to EU RED Declarations of Conformity Minor text revisions
3	2016-11-02	Changed incorrect Vcc & Vbatt from 2.8 - 4.3 to 3.0 – 3.6 Added CE certificates Minor text revisions.
2	2016-10-06	Deleted incorrect reference to Force-On. Minor text revisions & reorganization
1	2016-07-11	Add "L" module information Update performance and power consumption numbers Minor text corrections & changes
0	2014-10-17	Draft edition

From Mod.0809 rev.3

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