SL871 Family

Product User Guide

1VV0301170 Rev. 11 – 2021-12-14

Telit Technical Documentation

APPLICABILITY TABLE

PRODUCTS
SL871
SL871L
SL871-S
SL871L-S

CONTENTS

1. INTRODUCTION

1.1. Scope

The purpose of this document is to provide information regarding the function, features, and usage of the Telit products listed in 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 SL871 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

1.6. Related Documents Requiring a Non-Disclosure Agreement

- Authorized Software User Guides
- Product firmware

2. PRODUCT DESCRIPTION

The SL871 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-based): SL871 and SL871L

GPS only (MT3337E-based): SL871-S and SL871L-S.

2.1. Product Overview

- Complete GNSS receiver modules including memory, TCXO, and RTC
- SL871L and SL871L-S modules also include a built-in LNA and DC blocking cap
- Constellations:
  - SL871x: GPS (L1), QZSS, and either Glonass (L1) or BeiDou (B1) simultaneous ranging with 99 search and 33 tracking channels. Galileo ready.
  - SL871x-S: GPS (L1) and QZSS ranging with 66 search and 22 tracking channels.
- SBAS corrections capable (WAAS, EGNOS, MSAS, GAGAN) (SL871x only)
- DGPS capable using the RTCM SC-104 protocol
- AGPS support for extended ephemeris using local or server-based solutions:
  - Local: Embedded Assist System (EASY) 1
  - Server: Extended Prediction Orbit (EPO) 1
- Jamming Rejection: Active Interference Cancellation (AIC)
- Supports active or passive antenna
- NMEA command input and data output
- Configurable fix reporting - Default: 1Hz, Max: 10 Hz
- Two serial ports for input commands and output messages
  - SL871L: Second serial port is I2C interface, configurable for UART via command
- 1PPS output
- Memory:

  - SL871: 8 Megabit built-in flash.
  - SL871-S: ROM
- 76 mW typical power consumption (Full Power, GPS + GLONASS)
- Power management modes for extended battery life
- Supported by evaluation kits
- -40°C to +85°C industrial temperature range
- 18-pad 10.1 x 9.7 x 2.4 mm Industry Standard LLC castellated edge package
- Surface mountable by standard SMT equipment
- RoHS compliant design

Note 1: See Table 2: SL871 Family Product Features for EASY and EPO support.

2.2. Product Naming

SL871: Product family name

S: GPS-only ROM-based receiver

L: Added LNA and DC blocking capacitor

2.3. Product Variants

The SL871 family includes the following variants:

- SL871 – Flash memory based, Multi-constellation
- SL871 (Gen 1): EOL in July 2015
- SL871 (Gen 2): Switching Mode Power Supply; Added Antenna On, Antenna Sense, and Force On pins
- SL871L: Added an LNA and DC blocking capacitor
- SL871-S – ROM based, GPS-only
- SL871-S: Switching Mode Power Supply and Antenna On pin
- SL871 L-S: Added an LNA and DC blocking capacitor

2.3.1. SL871-S and SL871L-S Features

- GPS-only
- ROM-based (Firmware cannot be updated)

- The 2nd port is UART only (I2C is not supported)
- Locally generated AGPS (EASY - Embedded Assist System) on SL871-S and SL871L-S 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 for the SL871-S and SL871L-S.

Please refer to the MT333x Host EPO Application Note.

2.3.1.1. ROM versions

The current SL871-S and SL871L-S 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. SL871 Product Features Table

Feature	SL871	SL871L	SL871-S (Early Production)	SL871-S	SL871L-S
Constellations Supported	GPS QZSS Glonass BeiDou Galileo		GPS QZSS		
Memory	Flash		ROM		
Power Supply	Switching		Switching		
Internal LNA	No	Yes	No	No	Yes
DC blocking cap	No	Yes	No	No	Yes
2nd Port	Yes (I2C / UART)		Yes (UART only)		
Antenna Sense	Yes		No		
Antenna On	Yes		Yes		

Feature	SL871	SL871L	SL871-S (Early Production)	SL871-S	SL871L-S
Force On	Yes		No		
Software Upgradable	Yes		No		
EPO	Yes		Yes (host)		

Table 2: SL871 Family Product Features

Feature	SL871-S (Early production)	SL871L-S
ROM version	3337	3337E (enhanced)
EASY	No	Yes
SBAS	Yes	No
AlwaysLocate	Yes	No
LOCUS	Yes	No

Table 3: ROM Features (-S modules only)

2.4. Block Diagrams

2.4.1. SL871 (Gen 2) Block Diagram

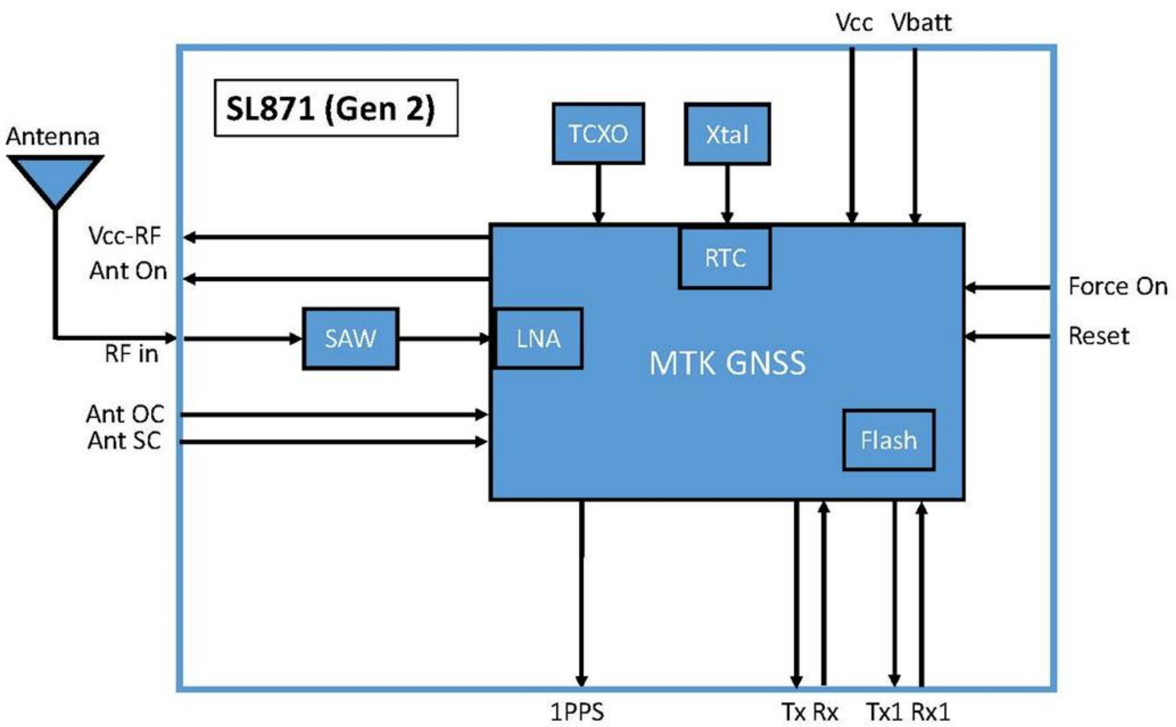


Figure 1: SL871 (Gen 2) Block Diagram

2.4.2. SL871L Block Diagram

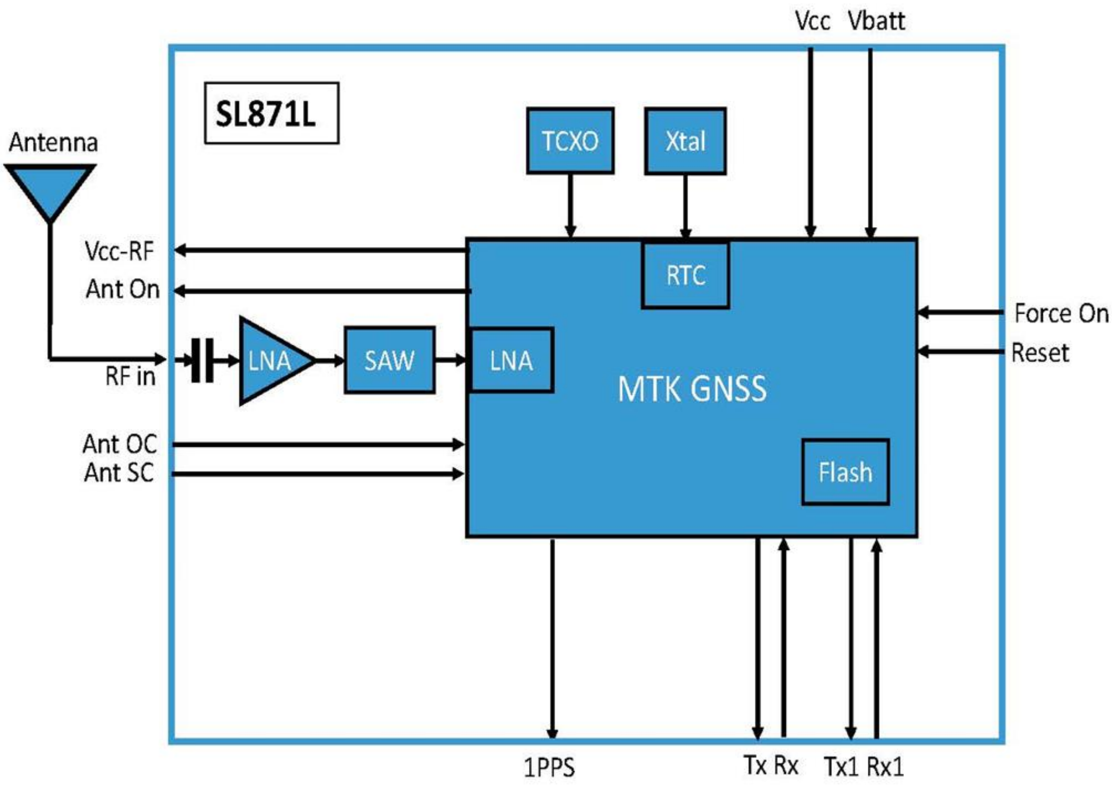


Figure 2: SL871L Block Diagram

2.4.3. SL871-S Block Diagram

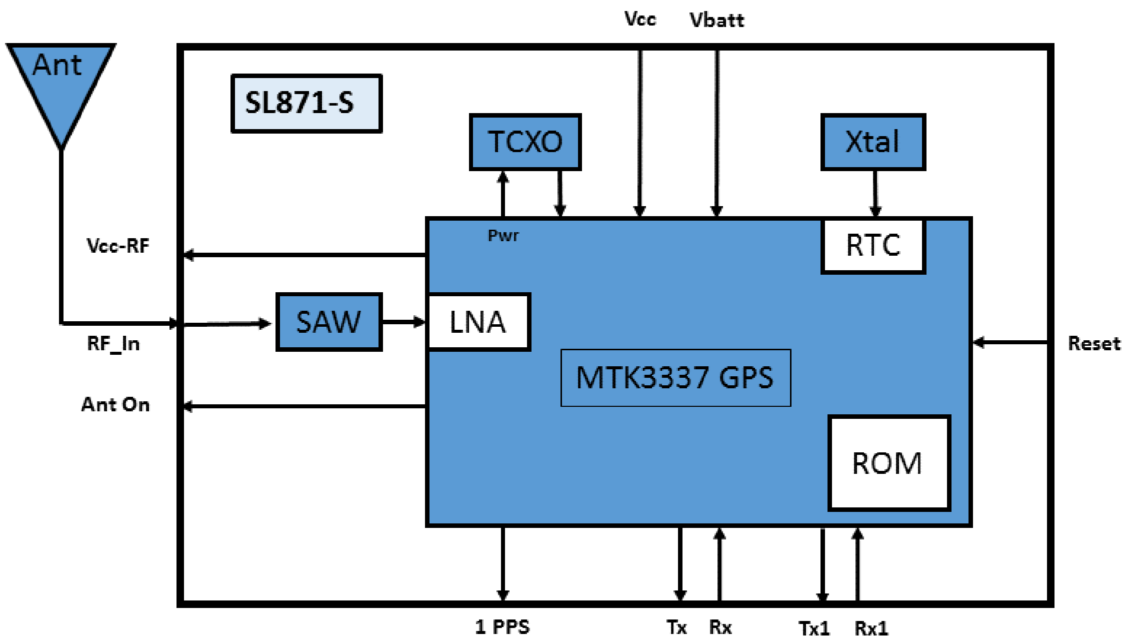


Figure 3: SL871-S - Block Diagram

2.4.4. SL871L-S Block Diagram

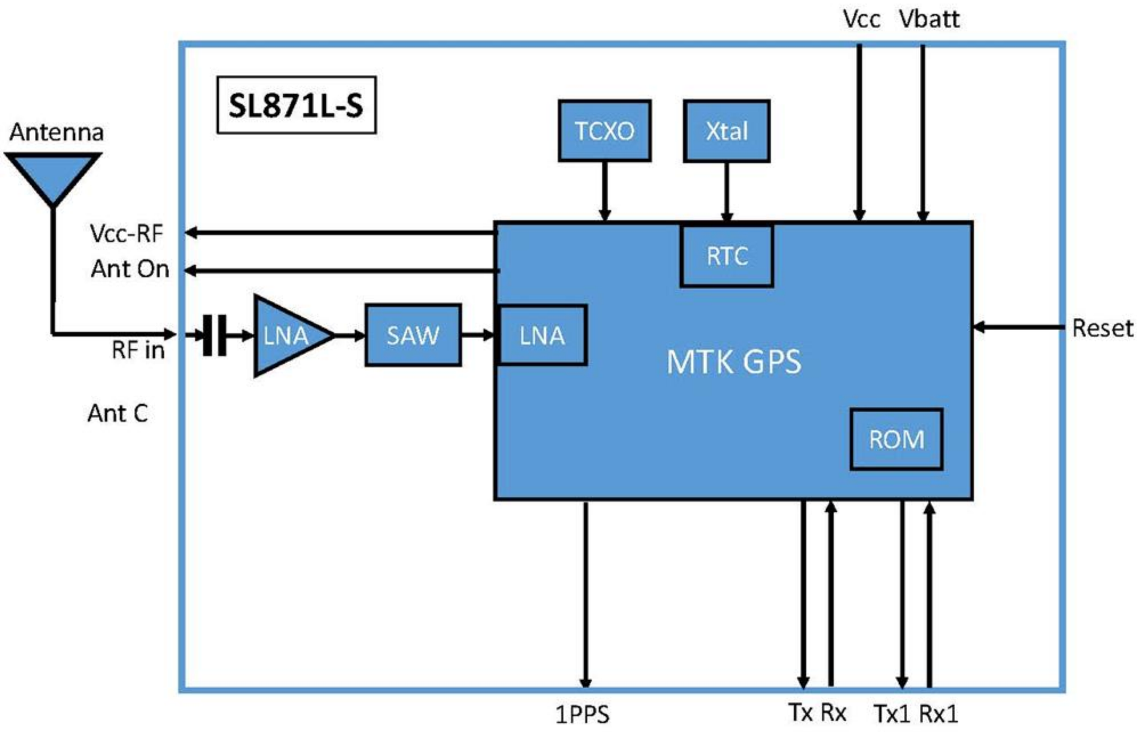


Figure 4: SL871L-S - Block Diagram

2.5. Module Photo

Figure 5: SL871 Family Module – Photo

Note: All variants have similar appearance (except for the product name).

3. EVALUATION KIT

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

Figure 6: Evaluation Kit Contents

Note: The SL871 kit includes a GPS / GLONASS / BeiDou antenna.

3.1. Evaluation Unit

Figure 7: SL871 Evaluation Unit

4. PRODUCT FEATURES

4.1. Multi-Constellation Navigation (SL871 and SL871L only)

GPS and GLONASS constellations are enabled by default. If BeiDou is enabled, GLONASS and Galileo are disabled.

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

The SL871-S and SL871L–S 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 SL871L-S 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 set by the $PMTK301 command.

4.3.1. SBAS Corrections

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

4.4. Differential GPS (DGPS) (SL871 and SL871L 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 to a DGPS receiver either by radio or over the internet.

The DGPS receiver can then send them to serial port 2 (RX1) 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 information from a source other than broadcast GPS signals is used to improve (i.e. reduce) TTFF.

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

See section 2.3 Product Variants for applicability.

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

This feature is not supported on the SL871-S until ROM MT3337E (enhanced) version of Oct 2015. It is supported on the SL871L-S.

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 AGPSS - Extended Prediction Orbit (EPO)

(SL871 and SL871L only)

Server-generated ephemeris predictions are maintained on Telit AGPS servers. The predicted ephemeris file is obtained from the AGPS server and is transmitted to the module over a serial port. 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.

See the next section regarding EPO support (Host EPO) on the SL871-S and SL871L-S.

4.5.3. Host EPO

The SL871-S and SL871L-S 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 a 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.

Please 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 SL871-S and SL871L-S 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 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.

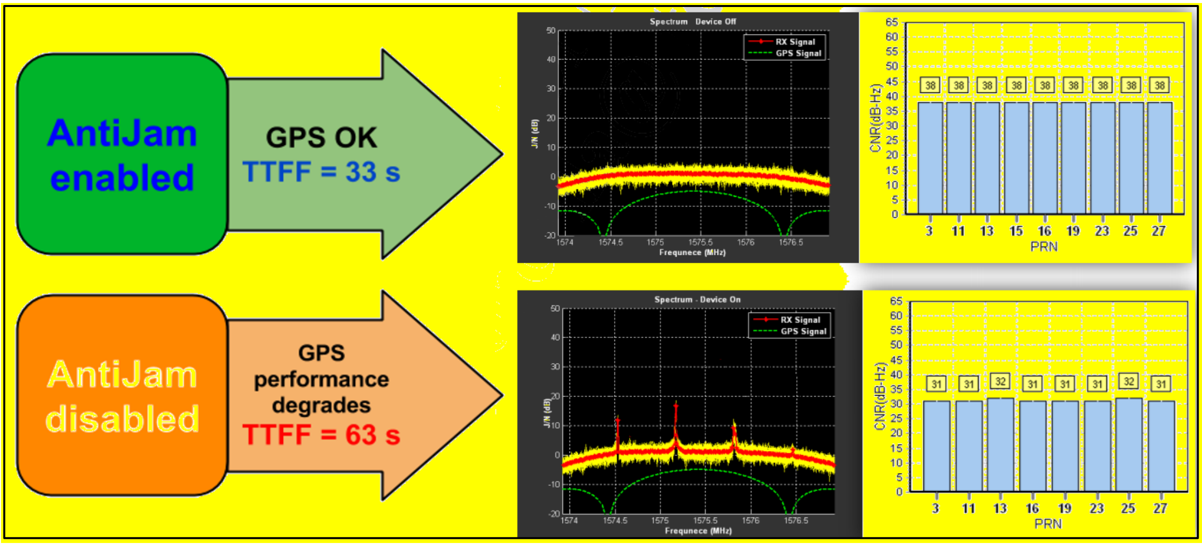


Figure 8: Jamming Rejection

4.10. Internal LNA (SL871L and SL871L-S only)

The SL871L and SL871L-S modules include a built-in LNA to increase sensitivity.

4.11. 1PPS

The module provides a 1PPS output signal. See section 9.3.4.1 1PPS for details.

4.12. Serial I/O Ports

Port 0:

All modules include a primary UART serial port.

Port 1:

The secondary port on MT3333-based modules is I2C by default, but can be changed to UART via command.

The secondary port on MT3337-based modules is UART and cannot be changed.

Please refer to section 9.4 Serial I/O Ports for details.

4.13. Power Management Modes

The receiver supports operating modes that reduce overall current consumption with less frequent position fixes. Availability of GNSS signals in the operating environment will be a factor in choosing power management modes. The designer can choose a mode that provides the best trade-off of navigation performance versus power consumption.

The various power management modes can be enabled by sending the desired command using the host serial port (RX).

Power Management - Command Summary		
$PMTK Cmd	Type	State
Full Power	To Exit (wake) from a commanded low-power state	
225	0	Full
Perpetual Backup	To wake:Force_ON Signal (MT3333 only)	
225	4	Backup
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

4.13.1. 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 then switches to the tracking engine to lower the power consumption when:

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

To return to Full Power mode from a low power mode, send a $PMTK225,0*2B

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

If power is removed from Vbatt, then Time, Ephemeris, Almanac, EASY, EPO data, and PMTK configuration data will be lost. If Vbatt is present, no data will be lost.

4.13.2. Backup Mode (Perpetual) (SL871 and SL871L only)

In the backup mode, the internal Power Management Unit is turned off, leaving only BBRAM and the RTC powered up. This reduces power consumption to the minimum required that still provides data retention to enable hot and warm starts.

To enter the Perpetual Backup mode, use the NMEA command: $PMTK225,4.

Warning: Only the SL871 and SL871L have a Force_On pin.

This command will be rejected on the other modules (SL871-S and SL871L-S).

To exit the Perpetual Backup mode, bring the Force_On signal high, then return to low.

See section 9.3.3.2 FORCE-ON for details.

4.13.3. 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).

4.13.4. GLP Mode (SL871 and SL871L modules 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:

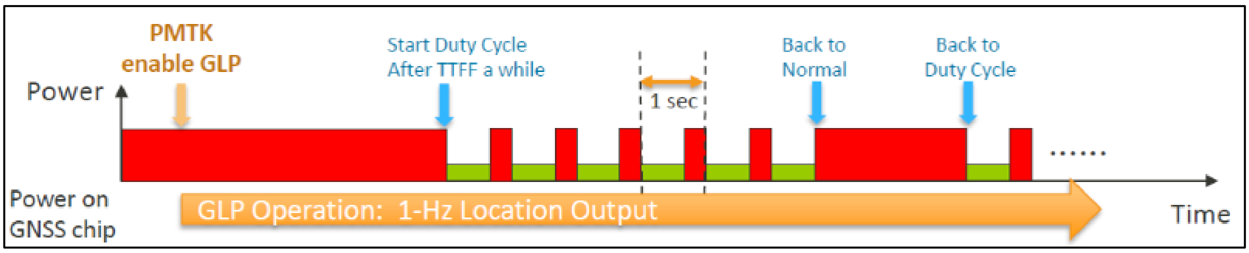


Figure 9: GNSS Low Power (GLP) Mode Diagram

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

4.13.5. Periodic Modes (SL871 and LS871L only)

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.

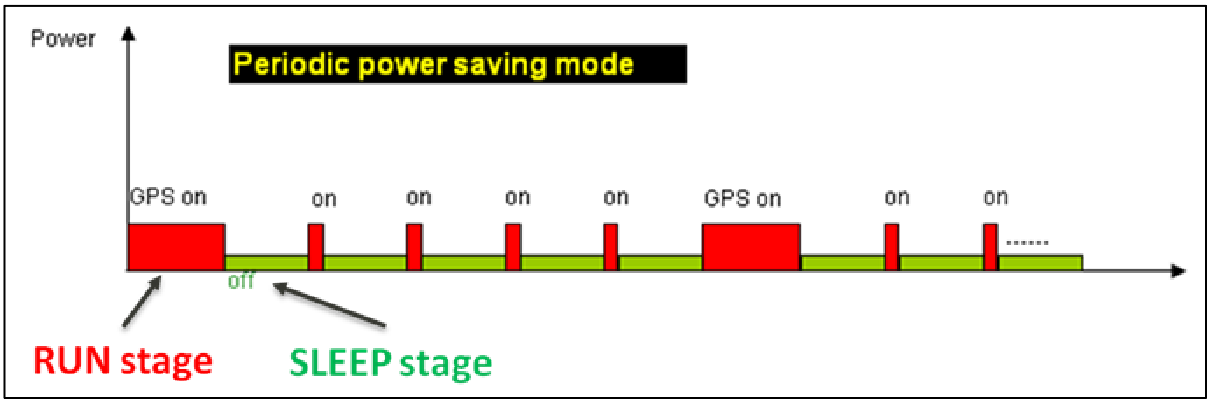


Figure 10: Periodic Modes Diagram

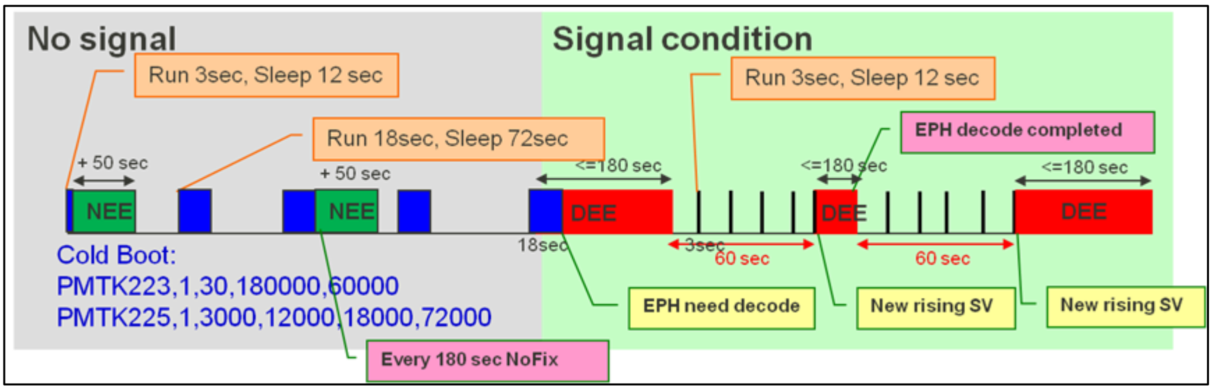


Figure 11: Periodic Mode Example 1

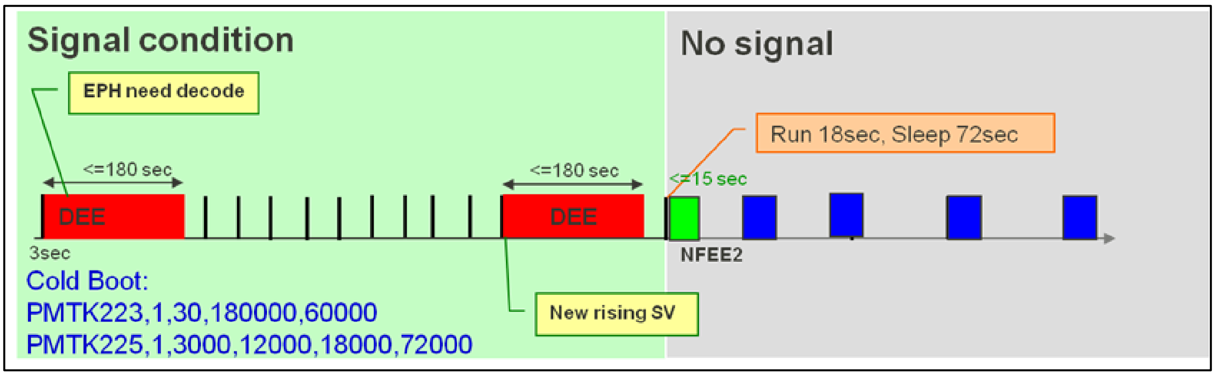


Figure 12: Periodic Mode Example 2

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.

4.13.6. AlwaysLocate™ Modes

(Not available on the SL871L-S and current production SL871-S 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

(SL871 and SL871L 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 (For example, 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 - SL871 and SL871L

Note: Earlier variants have different performance values.

6.1.1. Horizontal Position Accuracy - SL871 and SL871L

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, -130 dBm, Full Power mode.	

Table 6: SL871 and SL871L Horizontal Position Accuracy

6.1.2. Time to First Fix - SL871 and SL871L

Constellation(s)	Start Type	Max TTFF (s)
GPS	Hot	1
	Warm Assisted	2.4
	Warm	32
	Cold	33
Glonass	Hot	1.4
	Warm Assisted 2.5	2.4
	Warm	32
	Cold	33
BeiDou	Hot	1.5
	Warm	35
	Cold	46
GPS + GLO	Hot	1
	Warm Assisted 2.5	2.4
	Warm	28
	Cold	31
GPS + BeiDou	Hot	1
	Warm	32

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

Table 7: SL871 and SL871L Time to First Fix

6.1.3. Sensitivity - SL871 (Gen 2) and SL871L

Constellation(s)	State	Minimum Signal Level (dBm)	
		SL871 (Gen 2)	SL871L
GPS	Acquisition	-146	-148
	Navigation	-160	-163
	Tracking	-162	-165
GLONASS	Acquisition	-144	-146
	Navigation	-156	-159
	Tracking	-158	-161
BeiDou	Acquisition	-143	-146
	Navigation	-156	-159
	Tracking	-158	-162
Note: The above performance values were measured under ideal lab conditions using a GNSS simulator generating a static scenario.			

Table 8: SL871 (Gen 2) and SL871L Receiver Sensitivity

6.2. Performance - SL871-S and SL871L-S

6.2.1. Position Accuracy - SL871-S and SL871L-S

Parameter	Constellation	CEP (m)
Horizontal Position Accuracy	GPS	2.5
Test Conditions: 24-hr Static, -130 dBm, Full Power mode		

Table 9: SL871-S and SL871L-S Position Accuracy

6.2.2. Time to First Fix - SL871-S and SL871L-S

Constellation	Start Type	Max TTFF (s)
GPS	Hot	1
	Warm Assisted	2.4
	Warm	32
	Cold	33
Test Conditions: -130 dBm, Full Power mode, Static scenario		

Table 10: SL871-S and SL871L-S Time to First Fix

6.2.3. Sensitivity - SL871-S and SL871L-S

Constellation	State	Minimum Signal Level (dBm)	
		SL871-S Gen 2	SL871L-S
GPS	Acquisition	-146	-148
	Navigation	-160	-163
	Tracking	-162	-165
Note: The above performance values were measured under ideal lab conditions using a GNSS simulator generating a static scenario.			

Table 11: SL871-S and SL871L-S Sensitivity

6.3. Jamming Mitigation Performance Example

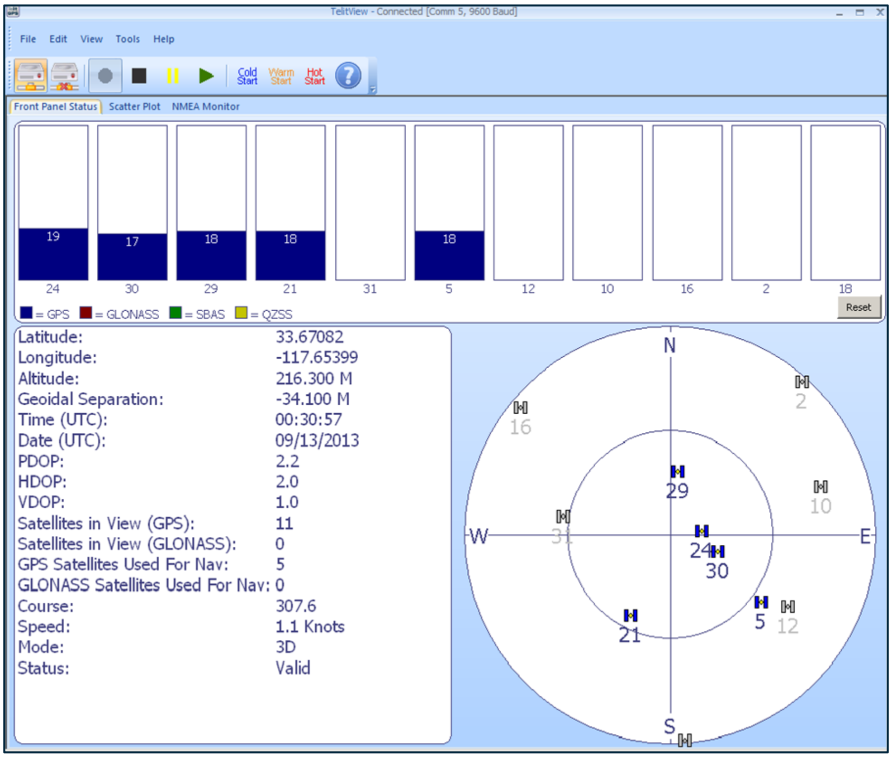


Figure 13: Jamming with AIC Disabled

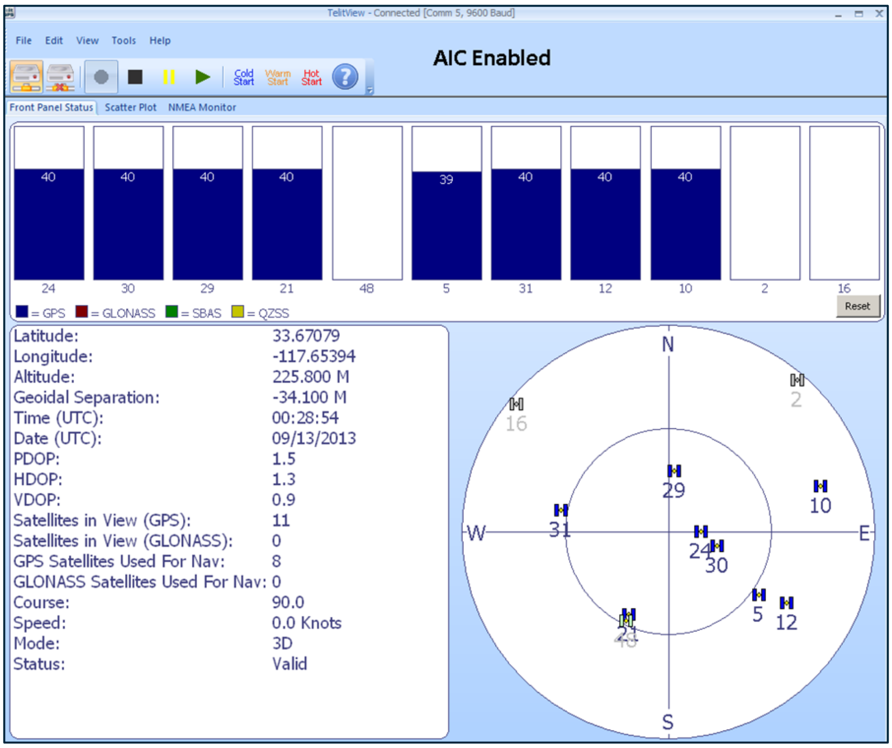


Figure 14: Jamming with AIC Enabled

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

7.1. NMEA Output Messages

Warning: Some sentences may exceed the NMEA length limitation of 80 characters.

Default: GPS constellation enabled.

GLONASS is also enabled for SL871 and SL871L.

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 modules 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: See Table 4: Power Management - Command Summary for power management commands.

Command	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. However, time is preserved.
$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 SL871-S modules	

Table 16: NMEA Input Commands

8. FLASH UPGRADABLITY

(SL871 and SL871L only)

Note: The SL871-S and SL871L-S have ROM and are not upgradable.

Please refer to the product EVK User Guide for more detailed information.

The firmware stored in the internal Flash memory of the SL871 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. Pinout Diagrams and Tables

9.1.1. SL871 (Gen 2) and SL871L Pin-out Diagram and Table

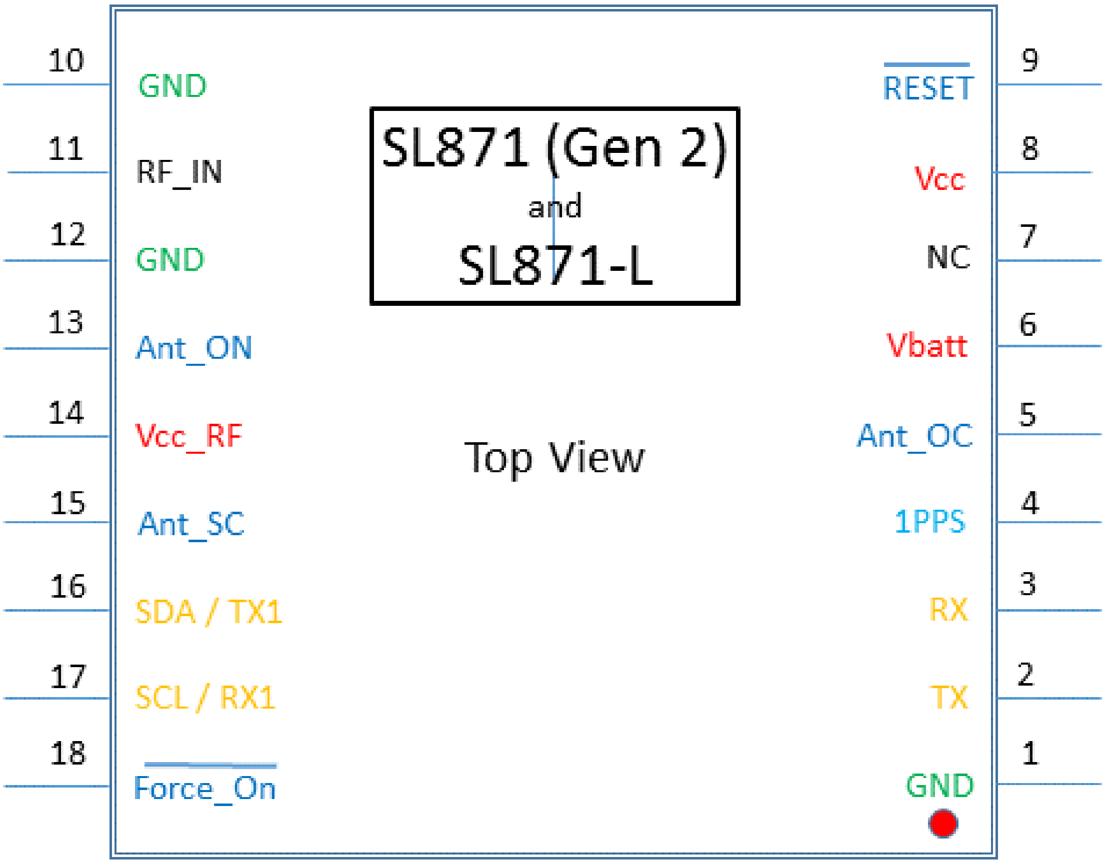


Figure 15: SL871 (Gen 2) and SL871L Pin-out Diagram

Pin	Name	Type	Description	Notes
1	GND	GND	Ground	
2	TX	O	TX0. See 9.4.2 UART Port Operation.	
3	RX	I	RX0. See 9.4.2 UART Port Operation.	
4	1PPS	O	Time mark Pulse, (1PPS). See 9.3.4.1 1PPS	
5	ANT-OC	I	Antenna-Open (high true). See 9.3.2.3 ANT-OC (SL871 and SL871L only) This pin can be re-configured as Data Ready Indicator.	
6	VBATT	PWR	Backup Voltage Supply. See 9.2 DC Power Supply	
7	NC	NC	Can be connected to VCC (for compatibility) or left unconnected.	
8	VCC	PWR	Supply Voltage. See 9.2 DC Power Supply	
9	RESET-N	I	RESET-N (Active Low, open drain) May be left unconnected. See 9.3.3.1 RESET-N	
10	GND	GND	Ground	
11	RF-IN	I	GNSS RF Input. 50 Ω. See 9.5 Antenna RF Interface Max DC voltage: ± 3.0 V (Gen 2)	1
12	GND	GND	Ground	
13	ANT-ON	O	Antenna On. See 9.3.2.2 ANT-ON (output)	
14	VCC-RF	PWR	Output Voltage for a bias-T (max 50 mA). See 9.3.2.1 VCC-RF (Active Antenna Supply Voltage) (SL871 and SL871-S only)	
15	ANT-SC-N	I	Antenna Shorted (low true). See 9.3.2.4 ANT-SC-N (SL871 and SL871L only)	
16	SDA / TX1	I/O	TX1 / SDA. See 9.4.3 I2C Port Operation (SL871 and SL871L only)	2
17	SCL / RX1	I/O	RX1 / SCL. See 9.4.3 I2C Port Operation (SL871 and SL871L only)	2
18	FORCE-ON-N	I	FORCE ON. See 9.3.3.2 FORCE-ON (SL871 and SL871L only).	

Notes:
1. DC Blocking capacitor and LNA have been added in SL871L.
2. Port 1 (pins 16 &17) is I^2C by default but can be configured for UART via command.

All GND pins must be connected to ground.

Table 17: SL871 (Gen 2) & SL871L Pin-out Table

9.1.2. SL871-S and SL871L-S Pin-out Diagram and Table

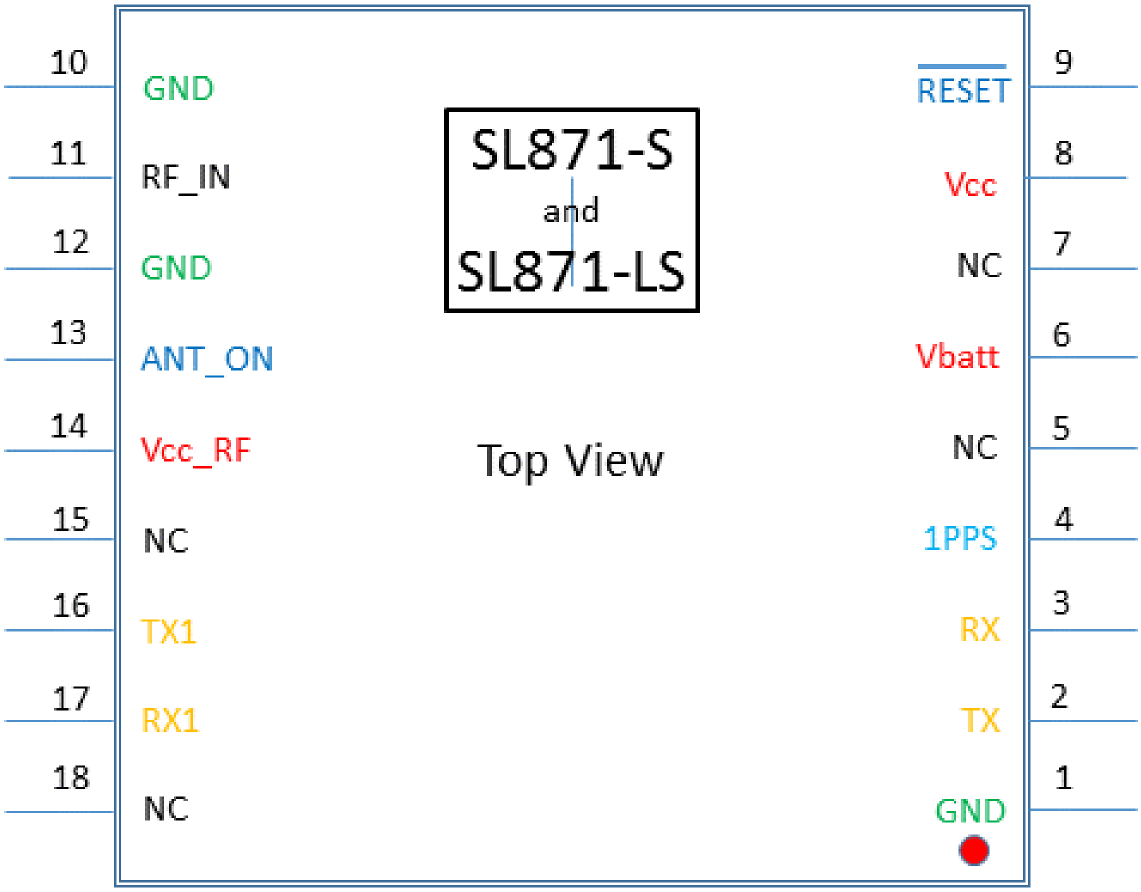


Figure 16: SL871-S and SL871L-S Pin-out Diagram

Pin	Name	Type	Description	Notes
1	GND	GND	Ground	
2	TX	O	TX0. See 9.4.2 UART Port Operation	
3	RX	I	RX0. See 9.4.2 UART Port Operation	
4	1PPS	O	Time mark Pulse, (1PPS). See 9.3.4.1 1PPS	
5	NC	NC	No Connection	
6	VBATT	PWR	Backup Voltage Supply. See 9.2 DC Power Supply	
7	NC	NC	Can be connected to VCC (for compatibility) or left unconnected	
8	VCC	PWR	Supply Voltage. See 9.2 DC Power Supply	
9	RESET-N	I	RESET-N (Active Low, open drain). May be left unconnected. See 9.3.3.1 RESET-N	
10	GND	GND	Ground	
11	RF-IN	I	GNSS RF Input. 50 Ω. See 9.5 Antenna RF Interface Max DC voltage: ± 3.0 V (Gen 2)	1
12	GND	GND	Ground	
13	ANT-ON	O	Antenna On. See 9.3.2.2 ANT-ON (output)	
14	VCC-RF	PWR	Output Voltage for a bias-T (max 50 mA). See 9.3.2.1 VCC-RF (Active Antenna Supply Voltage) (SL871 and SL871-S only)	
15	NC	NC	No Connection	
16	TX1	O	TX1 See 9.4.2 UART Port Operation.	
17	RX1	I	RX1. See 9.4.2 UART Port Operation.	
18	NC	NC	No Connection	
Note 1. DC Blocking capacitor has been added in SL871L-S. All GND pins must be connected to ground.				

Table 18: SL871-S & SL871L-S Pin-out Table

9.2. DC Power Supply

The modules have two power supply pins Vcc and Vbatt.

Warning: 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 19: DC Supply Voltage below.

Warning: Vcc does not supply the RTC domain, therefore Vbatt must be supplied (externally) any time that Vcc is powered up. This may be accomplished by tying VBATT to VCC.

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

Warning: Battery backup power input (as specified in the table below) must be supplied any time that Vcc is powered up. This may be accomplished by tying VBATT to VCC.

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.

9.2.3. VCC_RF

VCC_RF is directly connected to VCC internally 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	2.8	3.3	4.3	V
The drop from 2.7 V to 0 V must be > 1 ms. Also, keep the supply ripple as low as possible (< 50 mV)					

Table 19: DC Supply Voltage

9.2.5. DC Power Consumption - SL871 (Gen 2)

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	61	88	mW
GPS and Glonass	83	111	mW
GPS and BeiDou	78	104	mW
Navigation/Tracking			
GPS Only	48	80	mW
GPS and Glonass	66	99	mW
GPS and BeiDou	70	100	mW
Low Power - Always Locate (Standby)			
GPS Only	17		mW
GPS and (Glonass or BeiDou)	24		mW
Vbatt	50	99	µW
Operating temperature: 25°C. Supply voltages: 3.3 VDC nominal			

Table 20: SL871 (Gen 2) Power Consumption

9.2.6. DC Power Consumption – SL871L

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	71	98	mW
GPS + Glonass	93	121	mW
GPS + BeiDou	88	114	mW
Navigation/Tracking			
GPS Only	58	90	mW
GPS + Glonass	76	110	mW
GPS + BeiDou	81	110	mW
Low Power – Periodic (500 ms duty cycle)			
GPS Only	37		mW
GPS + Glonass	41		mW
GPS + BeiDou	40		mW
Low Power – AlwaysLocate (Standby)			
GPS Only	27		mW
GPS + Glonass	34		mW
GPS + BeiDou	33		mW
Vbatt	50	99	µW
Operating temperature: 25°C. Supply voltages: 3.3 VDC nominal			

Table 21: SL871L Power Consumption

9.2.7. DC Power Consumption - SL871-S

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	51	66	mW
Navigation/Tracking			
GPS Only	44	59	mW
Vbatt	25	66	µW
Operating temperature is 25°C. Supply voltages: 3.3 VDC nominal			

Table 22: SL871-S Power Consumption

9.2.8. DC Power Consumption - SL871L-S

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	61	76	mW
Navigation/Tracking			
GPS Only	54	69	mW
Vbatt	25	66	µW
Operating temperature is 25°C. Supply voltages were nominal 3.3 VDC.			

Table 23: SL871L-S Power Consumption

9.3. Digital Interface Signals

9.3.1. I/O Signal Levels

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

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

9.3.1.1. 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. Do not drive the Reset-N line high.					

Table 24: Input Logic Levels: RX and Reset-N, & Ant Sense

Force-On (SL871 and SL871L only)					
Signal	Symbol	Min	Typ	Max	Units
Input Voltage (L)	Vil	0		0.25	V

Force-On (SL871 and SL871L only)					
Input Voltage (H)	Vih	0.875		3.4	V
Note: Force-on is only available on the SL871 and SL871L. For typical applications, use a pulldown of 10k Ω.					

Table 25: Input Logic Levels: Force-On

9.3.1.2. 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 26: Output 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 27: Output Logic Levels: ANT_ON

9.3.2. Antenna Related Signals

9.3.2.1. VCC-RF (Active Antenna Supply Voltage) (SL871 and SL871-S only)

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

Warning: A DC blocking capacitor is also required to prevent out-of-range DC voltage from being applied to RF-IN except for SL871L and SL871L-S modules (which include an internal DC blocking capacitor).

9.3.2.2. ANT-ON (output)

Antenna on (ANT-ON) is an output logic signal 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.

This signal is not available on the SL871 Gen 1.

The logic levels are shown in Table 27: Output Logic Levels: ANT_ON.

9.3.2.3. ANT-OC (SL871 and SL871L 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 SL871 module. This signal is only available on the SL871 and SL871L.

The logic levels are shown in Table 24: Input Logic Levels: RX and Reset-N, & Ant Sense.

Note that this pin can be configured to be Data Ready Indicator for I2C.

9.3.2.4. ANT-SC-N (SL871 and SL871L 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 SL871 module. This signal is only available on the SL871 and SL871L.

The logic levels are shown in Table 24: Input Logic Levels: RX and Reset-N, & Ant Sense.

9.3.3. Control (Input) Signals

9.3.3.1. RESET-N

The Reset-N input is a low true input to reset the receiver to the default starting state.

Reset-N has an internal pullup.

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.

The logic levels are shown in Table 24: Input Logic Levels: RX and Reset-N, & Ant Sense.

9.3.3.2. FORCE-ON (SL871 and SL871L only).

For typical operation, connect this pin through a 10 KΩ resistor to ground to create a pulldown (which will prevent noise from accidentally activating this pin).

Upon command, the module will enter the backup (low power) state.

To exit this state, drive the Force-on signal high (true) to force the module to return to the full power state.

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

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

This signal is only available on the SL871 (Gen 2) and SL871L.

Warning: Note that this pin has a maximum input voltage of 3.4 V (which is lower than the max for Vcc or Vbatt).

The logic levels are shown in Table 25: Input Logic Levels: Force-On.

9.3.4. Output Signals

9.3.4.1. 1PPS

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

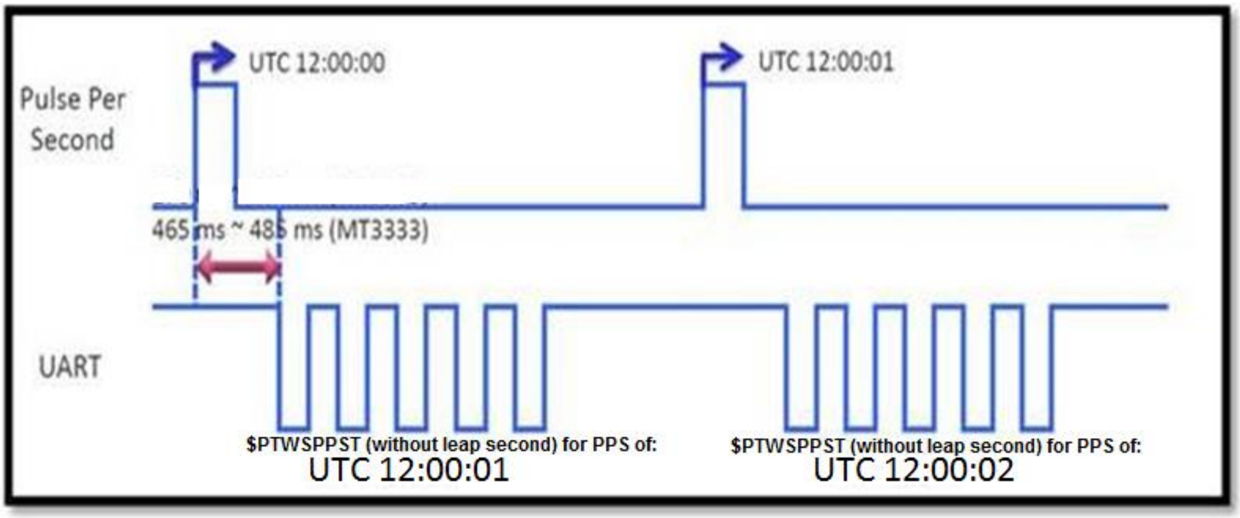
- Pulse duration: 100 ms
- Active: during 3D navigation.

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 26: Output Logic Levels: TX and 1PPS.

9.4. Serial I/O Ports

All modules include two serial ports. The primary port is UART interface on all modules.

The secondary port (TX1/SDA and RX1/SCL) interface depends on the module -

SL871 & SL871L: The secondary port is I^{2}C. It can be changed to UART via $PMTK258 command. Note that the module will reset when the interface is changed.

SL871-S & SL871L-S: The secondary port is UART only and cannot be changed.

9.4.1. Serial Port Usage

9.4.1.1. Primary (Port 0) Usage

TX: NMEA message output

RX:_NMEA proprietary commands, RTCM SC-104 input and EPO data.

TX/RX: Re-flash the module (SL871 and SL871L 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.

Warning: The interface is changed via the $PMTK258 command.

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

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 UART interface lines is logic high.

The input and output levels are LVTTL compatible. See section 9.3.1 I/O Signal Levels.

UART TX logic levels are shown in Table 26: Output Logic Levels: TX and 1PPS.

UART RX logic levels are shown in Table 24: Input Logic Levels: RX and Reset-N, & Ant Sense.

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

Warning: Care must be used to prevent backdriving the RX lines when the module is powered down or in a low-power state.

9.4.3. I2C Port Operation (SL871 and SL871L only)

The secondary port (SCA/RX1 & SDA/TX1) is I2C by default, but can be changed to UART via command $PMTK258.

The I^2C_Clock and I^2C_Data lines require external pullups (example value: 10 KΩ).

Data Ready Indicator (DRI) for I2C operation is available on custom FW where the ANT-OC pin is re-configured as DRI signal; the Antenna Sense feature is disabled in this case.

Please contact Telit Technical support for details.

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.

Warning: 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

Warning: 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 SL871-S) at a level between -125 dBm and -165 dBm into 50 Ohm impedance.

Warning: The RF input pin is ESD sensitive.

(SL871 (Gen 2) and SL871-S)

Warning: Max ± 3V DC can be applied to the RF input for "Gen 2" modules.

(SL871 and SL871-S)

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.

(SL871L and SL871L-S)

The SL871 (Gen 2) & SL871L and SL871L-S modules include a DC blocking capacitor, additional LNA, and a SAW filter. This provides improved performance in poor signal conditions or with passive antennas.

9.5.2. Frequency Plan

Signal	Frequency (MHz)
TCXO Frequency	26.000
LO Frequency	1588.6

Table 28: 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) for further details.

10. RF FRONT-END DESIGN

The SL871 and SL871-S modules contain a preselect SAW filter in front of the RF input. The SL871L and SL871L-S 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) should 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 navigation data (e.g. time and ephemeris) and compute its position within a period of 5 minutes. 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 Interface Specification 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 (currently 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.

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

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

- Satellite transmit power
- Satellite elevation angle
- Free space path loss
- Extraneous path loss (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 be worse (higher DOP) and will result in a lower position accuracy. The receiver reports this geometry effect in the form of PDOP, HDOP and VDOP numbers.

For example, in a vehicular application, the GNSS antenna may be placed on the dashboard or rear package tray of an automobile. The metal roof of the vehicle will cause significant blockage, 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 results when the signal from a particular satellite is reflected from a surface (e.g. a building or the roof of a car) and is received by the GNSS antenna either in addition to or in place of the line of sight signal. The reflected signal has a path length that is longer than the line of sight path 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 surrounded by high rise buildings) so challenging. In general, the reflection of a GNSS signal causes its polarization to reverse. The implications of this are covered in the next section.

10.2. GNSS Antenna Polarization

GNSS satellites all broadcast a 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 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.

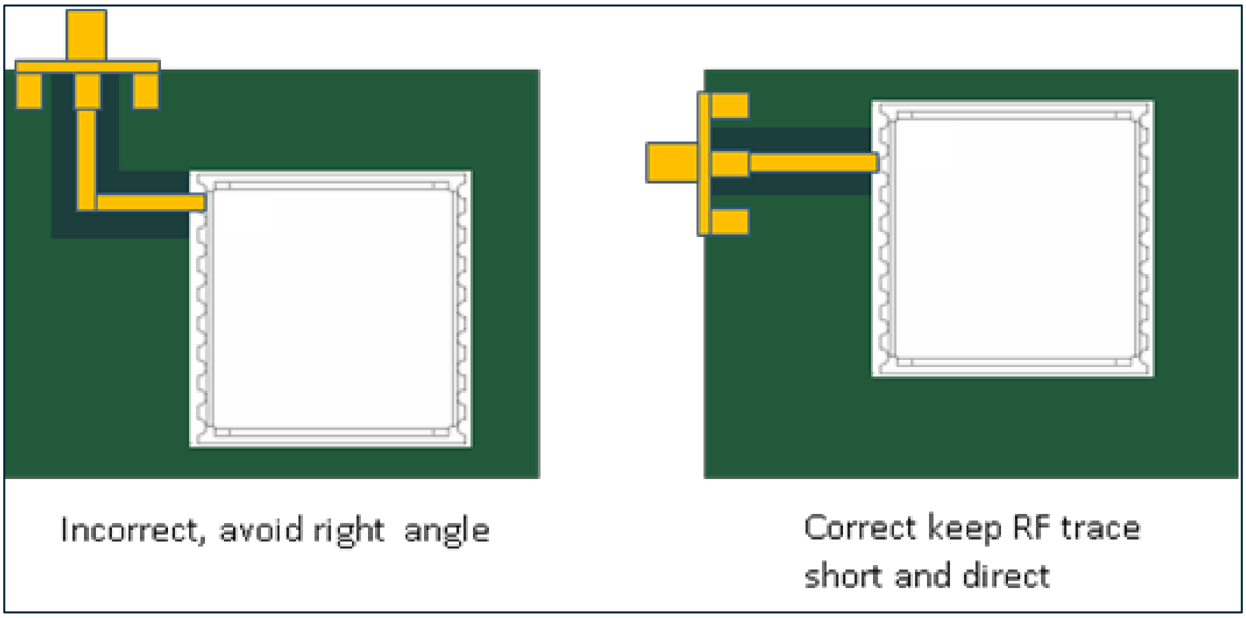


Figure 17: RF Trace Examples

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 minimal, 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 (SL8721 Gen 2 and SL871-S only)

The SL871 and SL871-S 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 LNA is to be used with the receiver, the overall design should be checked for RF stability to prevent the external LNA from oscillating. LNAs 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 (SL871L AND SL871L-S only)

The SL871L and SL871L-S 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 a 3 volt or

5 volt DC voltage that is impressed upon the RF signal line.

Two approaches can be used:

- 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.
- 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 29: 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 DESIGN

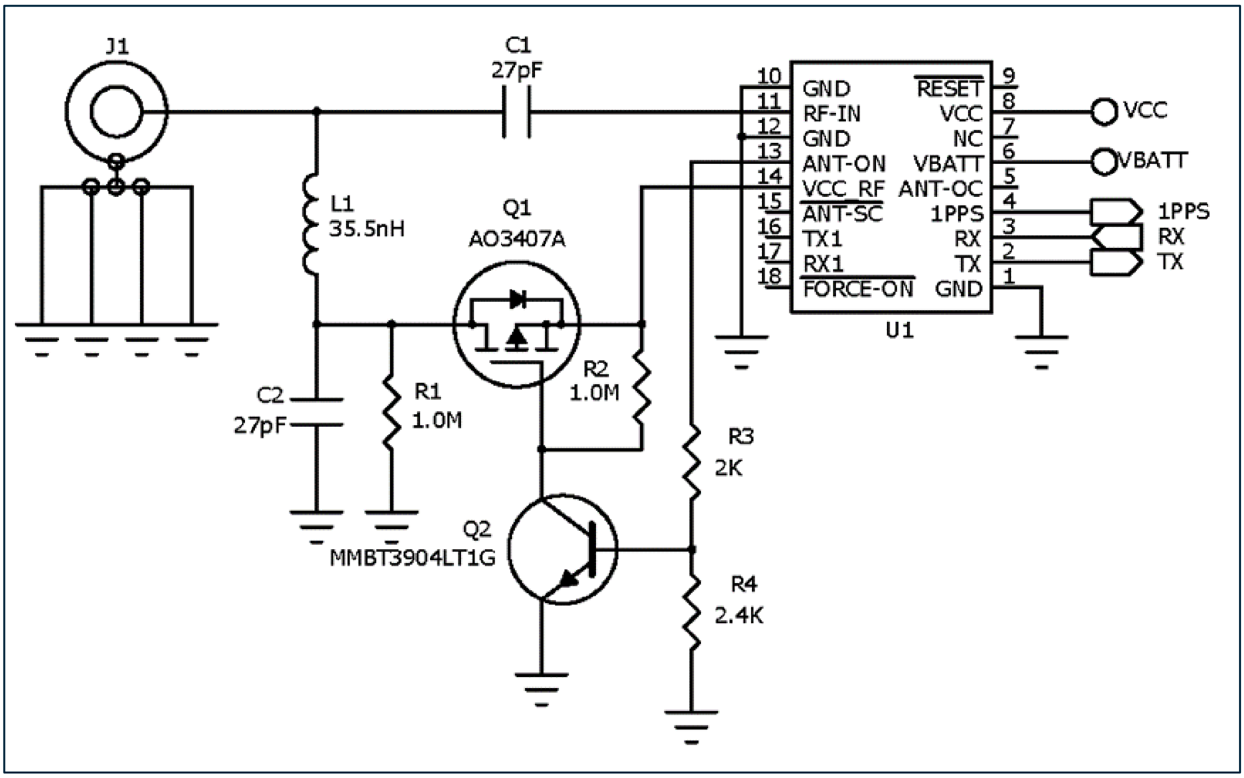


Figure 18: SL871 Family Reference Design

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.

Warning: C1 is used to block the DC voltage from entering the module, but is not required on SL871L 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 C2 is also chosen to be self-resonant so that it is close to an RF short at the GNSS frequency.

Warning: Note that the ANT-ON signal is not available on the SL871 Gen 1, so the reference design must be modified accordingly.

The circuit shown does not provide input to ANT-OC and ANT-SC-N (SL871 only).

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 logic levels.

Note that some pins are different for the SL871-S. See chapter 9 Electrical Interface.

12. MECHANICAL DRAWING

The SL871 modules use advanced miniature packaging with a base metal of copper and an Electroless Nickel Immersion Gold (ENIG) finish.

There are 18 interface pads with castellated edge contacts. The shield is tin-plated.

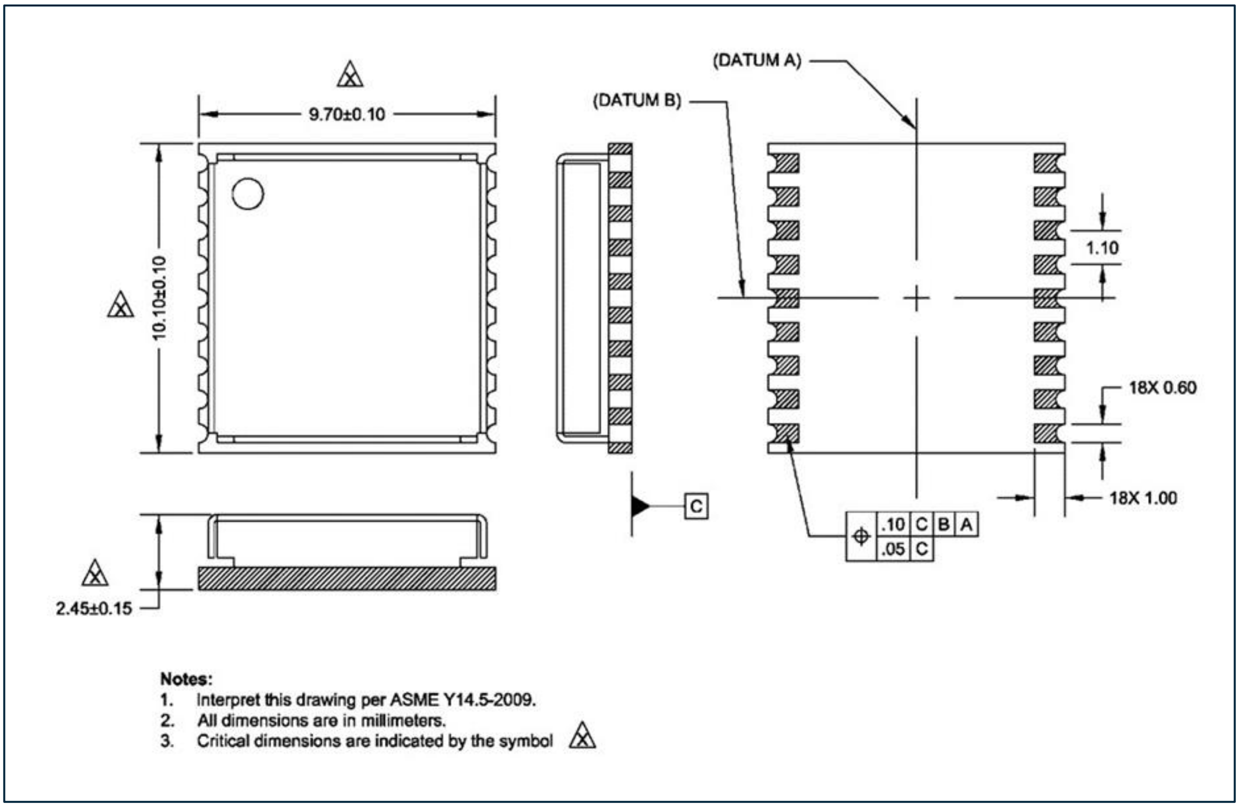


Figure 19: SL871 Family Mechanical Drawing

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.

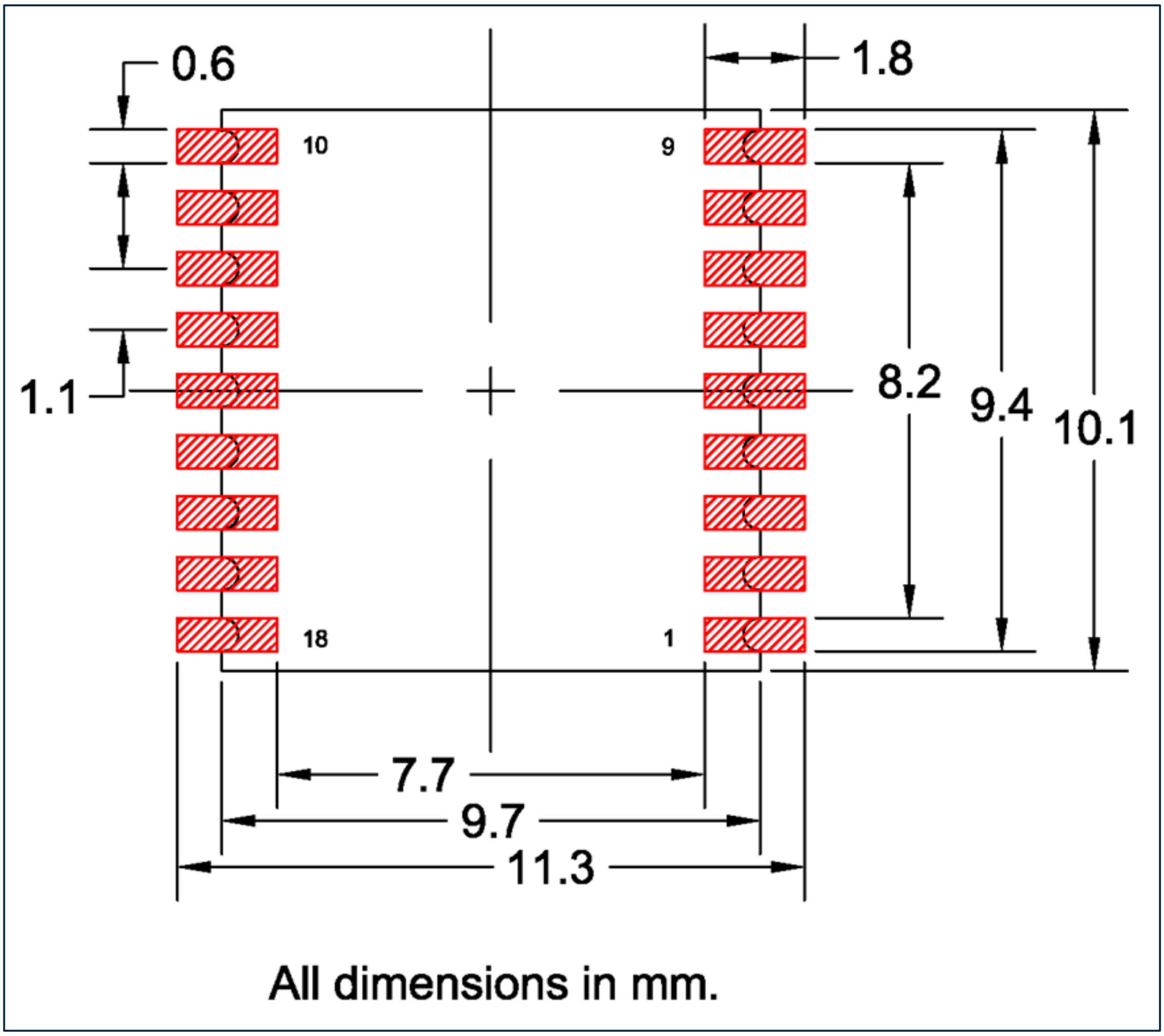


Figure 20: SL871 Family PCB Footprint

14. PACKAGING & HANDLING

14.1. Product Marking and Serialization

The SL871 modules have a 2D barcode label identifying the product (SL871, SL871L, SL871-S or SL871L-S) and its serial number.

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

The label format is as follows:

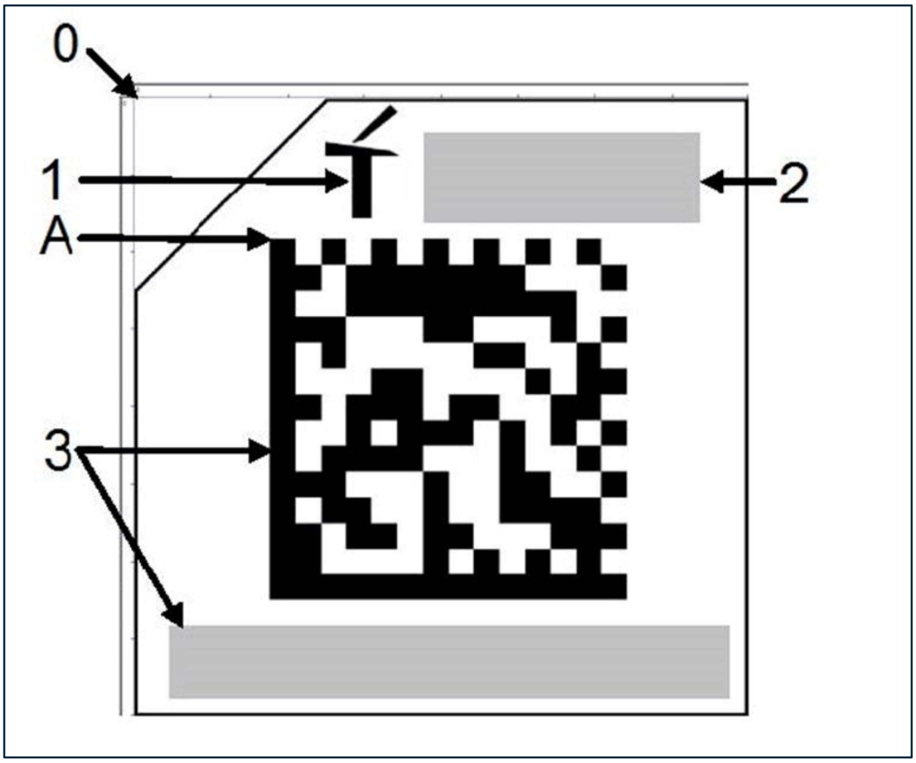


Figure 21: Product Label

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

Table 30: Product Label Description

14.2. Product Packaging

SL871 modules are shipped in Tape and Reel form on 24 mm reels with 1000 units per reel and mini-reels with 250 units per reel. Each reel is 'dry' packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and a humidity indicator card which is then placed in a carton.

All packaging is ESD protective lined.

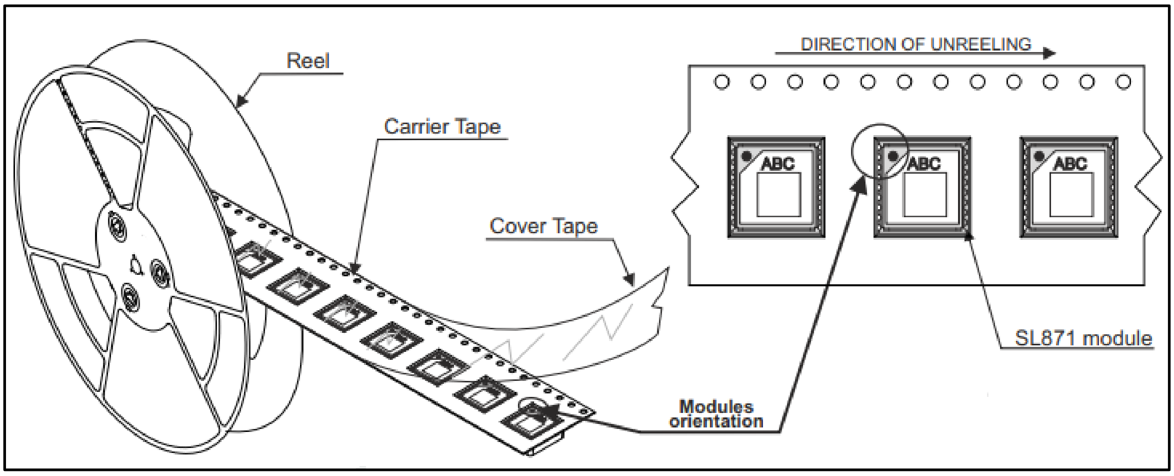


Figure 22: Tape and Reel Packaging

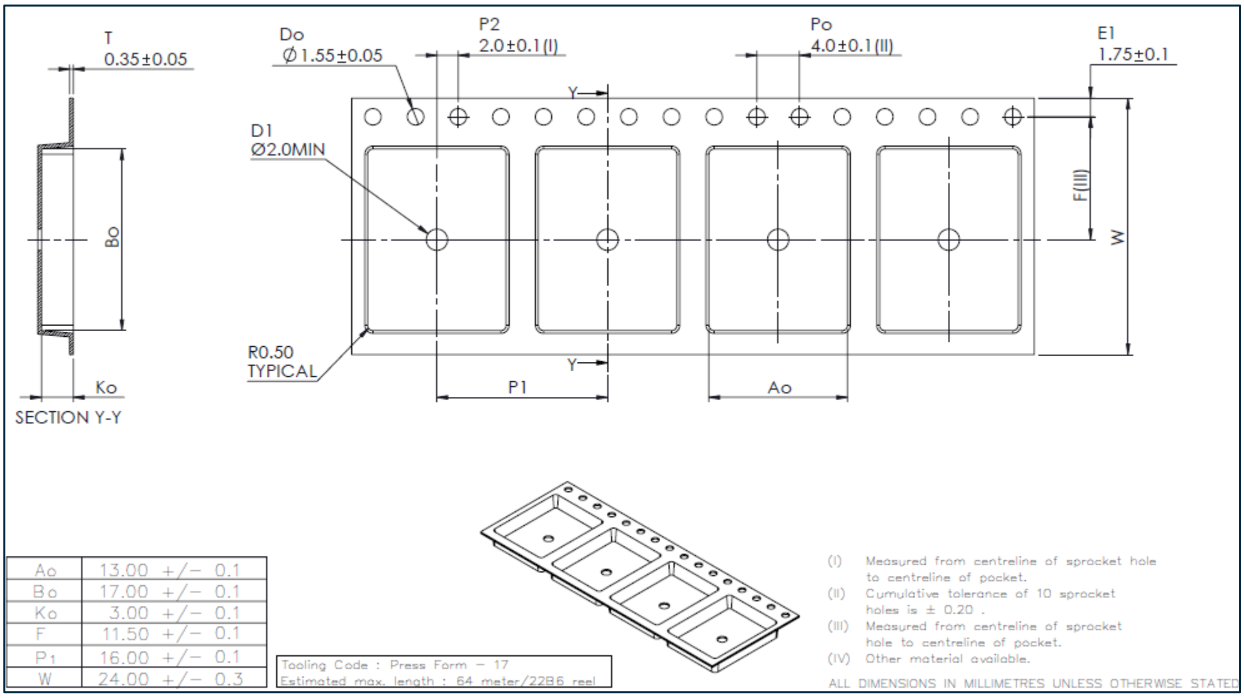


Figure 23: Tape and Reel Detail

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: 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.

Warning: However, the packaging materials (tape and reel or trays) can NOT withstand that temperature.

Lower temperature baking is feasible if the humidity level is low and time is available.

Please see 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: 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.

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

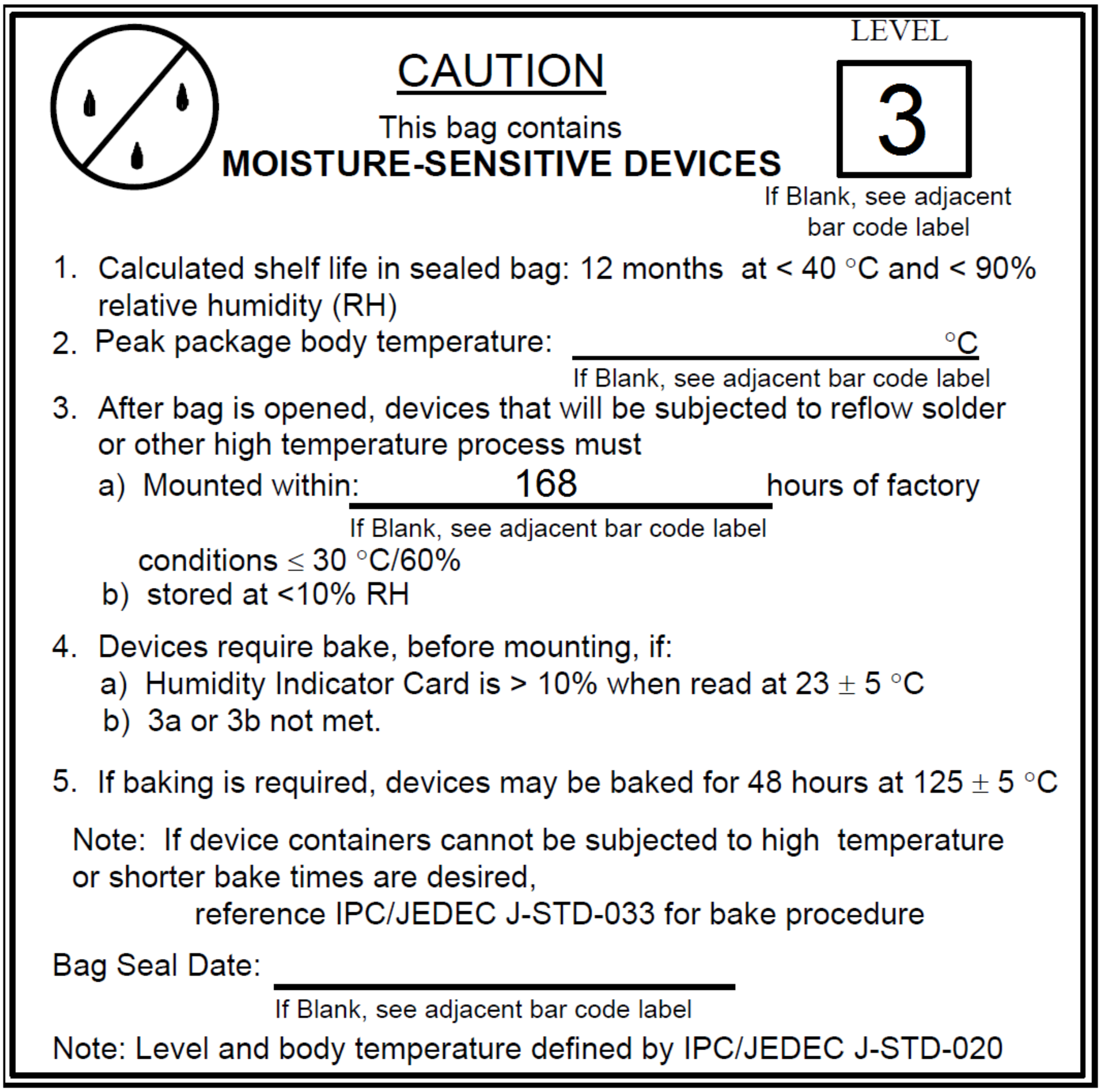


Figure 24: Moisture Sensitive Devices Label

14.4. ESD Sensitivity

Note: The 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.

Warning: 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, for exmple, 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. The 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

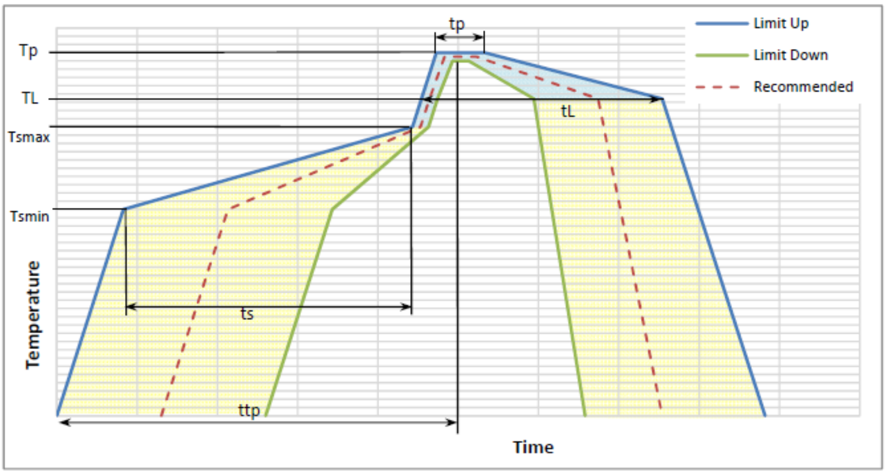
The modules are compatible with lead free soldering processes as defined in IPC/JEDEC J-STD-020. The reflow profile must not exceed the profile given IPC/JEDEC J-STD-020 Table 5-2, "Classification Reflow Profiles".

Warning: 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 https://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 25: Recommended Reflow Profile

Note: Please note that the JEDEC document includes important information in addition to the above figure. Please see: https://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 this 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 safety recommendations.

15. ENVIRONMENTAL REQUIREMENTS

15.1. Operating Environmental Limits

Operating Environmental Limits	
Temperature	-40°C to +85°C
Temperature Rate of Change	±1°C / minute maximum
Humidity	Up to 95% non-condensing or a wet bulb temperature of +35°C, whichever is less
Maximum Vehicle Dynamics	2G acceleration

Table 31: Operating Environmental Limits

15.2. Storage Environmental Limits

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

Table 32: 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

16.1.1. EU (RED) Declaration of Conformity – SL871

Telit

EU DECLARATION OF CONFORMITY [20434DOC00070A]

1 **SL871** (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 packaging label

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. 20170821095248

Technical Documentation: 30434TCF00050A

www.Telit.com/RED

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Cod.Fisc. 03711600266
Nr. R.E.A. TS-120027

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)

Mod 243 2017-02 Rev.1- This declaration is issued according to 768/2008/EC

Figure 26: EU RED Declaration of Conformity - SL871

16.1.2. EU (RED) Declaration of Conformity – SL871L

Telit

EU DECLARATION OF CONFORMITY [20434DOC00072A]

1 **SL871L** (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

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

Thus, CE is placed on the packaging label

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Trieste, **2017-10-16**

Group CFO/Corporate
Eran Edri

VP R&D GNSS
Georgia Frousiakis

EU-Type Examination Certificate No. 20170825082036

Technical Documentation: 30434TCF00057A

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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)

Mod 243 2017-02 Rev.1- This declaration is issued according to 768/2008/EC

Figure 27: EU RED Declaration of Conformity - SL871L

16.1.3. EU (RED) Declaration of Conformity – SL871-S

Telit

EU DECLARATION OF CONFORMITY [20434DOC00071A]

1 **SL871-S** (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 packaging label

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. 20170824075512

Technical Documentation: 30434TCF00048A

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Figure 28: EU RED Declaration of Conformity - SL871-S

16.1.4. EU (RED) Declaration of Conformity – SL871L-S

Telit

EU DECLARATION OF CONFORMITY [20434DOC00073A]

1 **SL871L-S** (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 packaging label

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**

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EU-Type Examination Certificate No. 20170825115917

Technical Documentation: 30434TCF00058A

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Figure 29: EU RED Declaration of Conformity - SL871L-S

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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
11	2021-12-14	Modified section 12.4 Product Packaging.
10	2021-08-19	Modified section 9.4.3 to add a note on DRI availability.
9	2021-07-15	Modified section 9.4.3 to document features supported via I2C port. Updated document to new Telit standard template.
8	2018-08-22	Added note that ANT-OC (pin 5) can be re-configured to DRI.
7	2018-07-20	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
6	2018-03-12	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) Corrected some information about the Force-On pin usage 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 Removed antenna/LNA Gain limits Rearranged Electrical Interface information Updated to EU RED Declarations of Conformity Minor text revisions
5	2017-04-11	New format Change voltage range from 2.8 – 4.3 to 3.0 – 3.6 Replaced Pinout Diagrams and RF Trace Examples figures

		Corrected 2nd port default for SL871L is I2C, not UART Correct the SL871-S block diagram Add CE certificates Minor text changes
4	2016-03-25	Change product name suffix form "Gen 3" to "L" Minor text changes
3	2016-03-11	Gen 2: SMPS, Ant-On, Ant Sense, Force-On Gen 3: LNA, DC block, 2nd Port -S Gen 3: LNA, DC block, 2nd port (UART only) Figure 3.1: Updated antenna description 4.2: Clarify Static Nav description 4.3.1.1: Correct EASY to off by default 4.6: Add note for RTCM 4.8: Add low-power state Table 8.1: Correct text in Footnote 1 4.13.5: Add BACKUP mode description 8.2.2: Correct description of VBATT pin 8.4.1.9: Correct FORCE-ON pin description Table 8-10: Change pin name from Force-On-N to Force-On Minor text changes
2	2015-02-20	4.9.1: Add information on data loss if all power is removed Table 8-4: Update SL871–S Power consumption values Table 8-8: Change RX, etc. INH Vmax from Vcc to 3.4 17.1: Add Electrical and Fire Safety section
1	2014-12-18	Text changes and updates
0	2014-11-18	First issue

From Mod.0809 rev.3

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