

# SE873 Product User Guide

1VV0301216 r1 – 2015-09-05



## APPLICABILITY TABLE

PRODUCT
SE873



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# 1. Introduction

## 1.1. Scope

The scope of this document is to provide product information for the SE873 GNSS module.

## 1.2. Contact Information, Support

For general contact, technical support, reporting documentation errors and to order manuals, contact Telit Technical Support Center (TTSC) at:

[TS-AMERICAS@telit.com](mailto:TS-AMERICAS@telit.com)  
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Alternatively, use:

<http://www.telit.com/en/products/technical-support-center/contact.php>

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

<http://www.telit.com>

To register for product news and announcements or for product questions contact Telit Technical Support Center (TTSC).

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

Telit appreciates feedback from the users of our information.

## 1.3. Text Conventions



***Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.***



***Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.***



**Tip or Information – Provides advice and suggestions that may be useful when integrating the module.**

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



## 1.4. Related Documents

- SE873 Data Sheet
- SE873 Evaluation Kit User Guide (1VV0301214)
  
- SiRFstarV B02 Designer's Guide (CS-319281-AN-2)
- SiRFstarV B02 Software User's Guide (CS-314345-UG-2)
- NMEA Reference Guide (CS-129435-MA8)
- SiRFstar One Socket Protocol Interface Control Document (CS-129291-DCP15)
- SiRFstarV OSP Extensions (CS-303979-7)



## 2. Product Description

The SE873 modules are complete multi-constellation position, velocity, and time (PVT) engines featuring high performance, high sensitivity, and low power consumption. These modules are capable of excellent performance in harsh environments. The inclusion of the GLONASS and BeiDou constellations yields better coverage, greater accuracy, and improved availability.

The SE873 module is based on the SiRFstar 5e (B02) flash GNSS chip.

### 2.1. Product Overview

- Complete GNSS receiver module including memory, LNA, TCXO, and RTC
- Based on the SiRFstar 5e (B02) flash GNSS chip
- GPS (L1), QZSS, and either Glonass (L1) or BeiDou (B1) simultaneous ranging
- Galileo ready
- SBAS capable (WAAS, EGNOS, MSAS, GAGAN), including ranging
- AGPS support for extended ephemeris using local or server-based solutions:
  - Client-Generated Extended Ephemeris (CGEE)
  - Server-Generated Extended Ephemeris (SGEE)
- Jamming Rejection
- Supports passive or active antenna
- 1PPS output
- Fix reporting at 1 Hz or 5 Hz
- NMEA v3.1 command input and data output
- OSP (binary) command input and data output
- Standard UART serial port for input commands and output messages
- The serial port is configurable for UART, I<sup>2</sup>C, or SPI interface
- Second serial port is configurable for I<sup>2</sup>C interface in the next future
- 16 Megabit built-in flash memory
- Less than 90 mW total power consumption (Full Power mode - typical)
- Power management modes for extended battery life
  - SiRFSmartGNSS I, SiRFSmartGNSS II
  - Push-to-Fix, Trickle Power, SiRFaware
- Supported by evaluation kits
- -40°C to +85°C industrial temperature range
- 7.0 x 7.0 x 1.85 mm (nominal) 20-pad QFN package
- Surface mountable by standard SMT equipment
- RoHS compliant design



## 2.2. Block Diagram

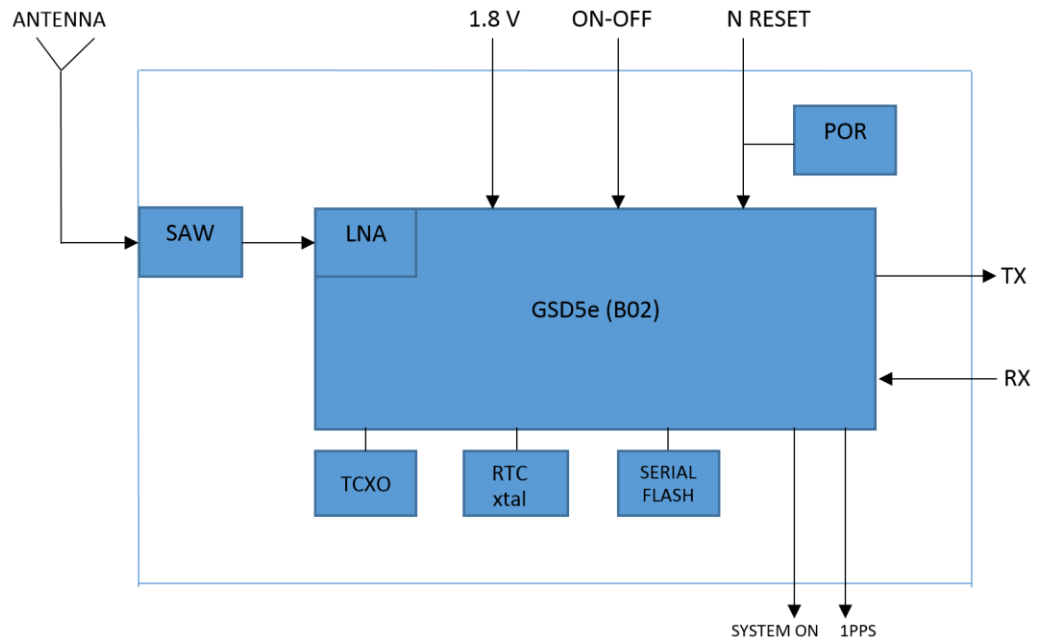


Figure 2-1 SE873 Block Diagram



## 2.3. SE873 Module



Figure 2-2 SE873 Module



### 3. Evaluation Kit (EVK)

#### 3.1. SE873 Evaluation Kit



**Note:** The antenna is included but not visible under the ground plane.

**Figure 3-1 SE873 Evaluation Kit Contents**





**Figure 3-2 SE873 Evaluation Kit**





## 4. Product Features

### 4.1. Multi-Constellation Navigation

GPS and GLONASS constellations are enabled by default.

The user may enable or disable GPS, GLONASS, and/or BDS constellations via OSP command MID 222,16. Use of GLONASS or BDS alone may not give optimum positioning results depending on the region that the receiver is located in.

### 4.2. QZSS support

The Japanese SBAS satellites are in a highly-inclined elliptical orbit which is geosynchronous (not geostationary) and has analemma-like ground tracks. This orbit allows continuous coverage over Japan using only three satellites.

QZSS ranging is disabled by default, but can be enabled via OSP command MID 222,16.

### 4.3. Satellite Based Augmentation System (SBAS)

The receiver is capable of using SBAS satellites both as a source of differential corrections and satellite ranging measurements. These systems (WAAS, EGNOS, GAGAN and MSAS) use geostationary satellites to transmit regional corrections via a GNSS-compatible signal.

#### 4.3.1. SBAS Corrections

The use of SBAS corrections can improve positioning accuracy.

SBAS corrections are disabled by default but can be enabled via OSP MIDs 133, 138, and 170 commands. Thereafter, the receiver will demodulate and use corrections data from the SBAS signal.

#### 4.3.2. SBAS Ranging

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

SBAS satellite ranging is disabled by default but can be enabled via a \$PSRF103 MNEA command or OSP Mode Control command (MID 136).

### 4.4. Elevation Mask

The default elevation mask angle is 5° which can be changed using OSP MID 139.



## 4.5. Assisted GPS (AGPS) - SiRFInstantFix™

Assisted GPS (or Aided GPS) is a method by which TTFF is reduced using information from a source other than current broadcast GPS signals. There are two sources of predicted (extended) ephemeris:

- Locally-predicted ephemeris: Client-Generated Extended Ephemeris (CGEE)
- Server-predicted ephemeris: Server-Generated Extended Ephemeris (SGEE)

Both CGEE and SGEE are available for GPS and GLONASS satellites.

### 4.5.1. Client-generated Extended Ephemeris (CGEE)

Extended ephemeris is computed in the receiver and then stored locally in the flash memory. Whenever the module receives ephemeris data for a satellite, it checks if it has computed CGEE for that satellite recently. If it has not, it computes EE for that satellite (for the next 3 days for GPS and 1 day for GLONASS) and stores it in flash memory. The next time the module turns on and broadcast ephemeris is not available for a visible satellite, the stored CGEE data is searched to see if it is still valid and can be used. If EE data is available for enough satellites, the receiver can obtain a first fix in 10 to 15 seconds (typical) rather than the usual 35 seconds without EE data. CGEE is enabled by default.

### 4.5.2. Server-generated Extended Ephemeris (SGEE)

Extended ephemeris is computed at the server and saved in a file which can then be downloaded to the receiver's flash memory. The server file contains 1, 3, 7, and 14, days of ephemerides. To use SGEE data, a file must be transferred using NMEA or OSP commands. Please contact Telit support for subscription details.

## 4.6. 2-D Positioning

By default, the module will compute a 2-D solution if possible when performing initial acquisition. In a 2-D solution, the receiver assumes a value for altitude and uses it to estimate the horizontal position. Under warm and hot start conditions, the receiver uses the last known value of altitude, which is a good assumption in most situations. However under cold start conditions, the last position is unknown, and the receiver assumes a value of 0. In situations where the true altitude is significantly higher than that, the horizontal position estimate will be noticeably impacted. 2\_D positioning is controlled by OSP MID 136.

## 4.7. Static Navigation

Static Navigation is an operational 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 is also frozen, and the speed is reported as 0. The navigation solution is unfrozen when the speed increases above a threshold or when the computed position exceeds a set distance from the frozen position (indicating that the receiver is again in motion). These thresholds cannot be changed by the user.



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 OSP command MID 143.

## 4.8. Velocity Dead-Reckoning

Velocity dead-reckoning is the use of the last known velocity to propagate the navigation solution when there are insufficient measurements to calculate an updated solution. It serves to mitigate the effects of blocked satellite signals by continuing to provide a position output. **Note:** The receiver outputs status information which indicates that a solution is being maintained using dead-reckoning.

This feature is disabled by default but can be enabled using the Mode Control message (MID 136). Valid timeout values are in a range from zero (which disables dead-reckoning) to two minutes.

## 4.9. Jamming Rejection – Continuous Wave (CW) Jamming Mitigation

Continuous Wave (CW) jamming mitigation improves performance in a system that is affected by these predictable jamming signals:

- Stable jamming signals generated by your system implementation, such as harmonics of digital clocks and logic switching
- Predictable jamming signals in the RF environment (e.g. from collocated transmitters)

When this feature is activated, the process for jamming mitigation is:

1. Detect jamming signals above the noise floor.
2. Isolate and filter frequencies containing jamming signals.

The GNSS signal is constantly monitored for CW jammers and up to eight are detected and cancelled in each band without any operator intervention.

GPS, GLONASS, and BDS band cancellers are activated and reported using OSP Message ID 92. This feature is useful both in the design stage and during the production stage for uncovering issues related to unexpected jamming. Use OSP MID 220,1 to configure this feature.



## 4.10. Internal LNA

The module has an adjustable gain internal LNA which allows the receiver to compensate for the use of various external antennas. The default gain (low or high) is determined by the version of firmware installed in the module. The chart below shows the internal gain modes and the allowable external gain.

Use the OSP command MID 178,71 to change the gain of the internal LNA.

- **Passive antenna:**  
For passive antenna operations, the internal LNA should be in high gain mode. GPIO8 should normally be left unconnected or connected to monitor the receiver status.
- **Active antenna (or External LNA) with High Gain firmware:**  
If an external LNA is used with the internal LNA in high gain mode, total RF gain should not exceed the recommend limit of 30dB.  
When GPIO8 is high, the external LNA should be enabled. When low, it should be disabled.
- **Active antenna (or External LNA) with Low Gain firmware:**  
If an external LNA is used with the internal LNA in low gain mode, total RF gain should not exceed the recommend limit of 30dB.  
When GPIO8 is high, the external LNA should be enabled. When low, it should be disabled.

Gain	Internal LNA gain	Internal LNA NF	External Gain Range
High	16 dB	2 dB (typical)	0 to 14 dB
Low	6 dB	6.5 dB (typical)	14 to 24 dB

**Table 4-1 Internal gain value and external gain range**



## 4.11. 5 Hz Navigation

When this feature is enabled, the receiver starts in 1 Hz mode and continues until it achieves an over-determined fix with 5 or more satellites. It then computes and outputs solutions 5 times per second. Each computation uses fewer, but more frequent satellite observations. In most situations this gives a better response to vehicle velocity and course changes but might cause slightly more erratic performance in stationary or low-dynamic situations.

The receiver also attempts to send out 5 times as many messages per second. The data rate may need to be increased or the set of scheduled messages be reduced to avoid overloading the available bandwidth.

For NMEA protocol, with default messages set on (GGA, GSA and RMC output once per cycle and GSV output once every 5 cycles) output is nearly 1300 characters per second. Including start and stop bits, at least 19200 bps is required to avoid running out of bandwidth.

For multi-constellation output, one GNGNS and one GNGSA would be added to each report cycle, and three GNGSV sentences every 5<sup>th</sup> cycle, requiring a minimum of 38,400 bps data rate. For OSP protocol, CSR recommends a minimum data rate of 115200 bps.

To enable 5 Hz Navigation, use a \$PSRF103 command or an OSP MID 136 command with bit 2 of the pos\_mode\_enable field set to 1.

## 4.12. 1PPS

The module provides a 1PPS timing pulse. See **Section 8.8 1PPS** for details.

## 4.13. Device Wake-up

The module will wake up from a commanded HIBERNATE state if the ON\_OFF signal remains high and there is data traffic on serial port 0 (first port). The wake-up message will not be acted upon since the receiver is not operating until after wake-up.

## 4.14. Host I/O Ports

The 1st host port can be configured to communicate using UART, I<sup>2</sup>C, or SPI interface. The 2nd host port can be configured as I<sup>2</sup>C interface.

See **Section 8.7 Host I/O Port Configuration and Operation** for details.



## 4.15. Power Management Modes

The receiver features several operating modes that provide reduced power consumption. Availability of GNSS signals in the operational 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.

Each of the power management modes can be commanded using the Power Mode Request Message (MID218,6). Please refer to the SiRFstarV OSP Extensions manual (CS-303979) for details.

Power Mode	Name	Description
Continuous Fixes	Full Power	Continuous operation in reporting position fixes optimized for the best all-around performance.
	SiRFSmartGNSS 1	
	SiRFSmartGNSS 2	SmartGNSS modes save power based on satellite signal strength.
Periodic Fixes	Trickle Power	Power cycling: RUN - STANDBY
	Push To Fix	Power cycling: RUN - HIBERNATE
	SiRFAware	Periodic data collection & updating
No Fixes	Hibernate	Only RTC and BBRAM are powered up.

Table 4-2 Power Management Modes

### 4.15.1. Full Power Mode

This mode has the highest average power consumption, but it is the most accurate navigation mode and supports the most dynamic motion scenarios. Full Power is required during initial satellite acquisition, tracking, & navigation and while receiving SGEE assistance data.

### 4.15.2. SmartGNSS

SmartGNSS modes are power saving alternatives for GNSS operation while maintaining complete functionality of the device similar to full power mode.

The module defaults to full power during the initial acquisition of the first fix, and will continue tracking in SmartGNSS if enabled. Therefore, all first fix metrics for SmartGNSS are equivalent to full power.

#### 4.15.2.1. SmartGNSS I

SmartGNSS I autonomously manages GNSS system usage based on signal conditions to save power. This is the default.

The adaptive mechanism uses fewer system resources during strong signal conditions and uses more resources during weak signal conditions in order to maintain navigation performance. Full constellation tracking is maintained while in this mode. 1PPS is available.



#### 4.15.2.2. **SmartGNSS II**

SmartGNSS II includes the benefits of SmartGNSS I and achieves further power reduction by minimizing the usage of the secondary GNSS constellation. The adaptive mechanism adjusts constellation usage based on signal conditions to maintain performance while minimizing power consumption. 1PPS is available.

#### 4.15.3. **Trickle Power**

This mode cycles between FULL POWER and STANDBY states. It provides GPS-only navigation updates at a fixed rate of 1 to 10 seconds, and retains good accuracy and dynamic motion response, but at a lower average power consumption than Full Power. The receiver will go to FULL POWER if signals are weak or the fix is lost. 1PPS is not available. TricklePower mode yields significant power savings in strong signal conditions.

#### 4.15.4. **Push-to-Fix**

This mode provides for even lower power consumption than TricklePower and is intended for applications that require relatively infrequent position reports. The position is reported periodically (once every 6, 12, 18, 24 seconds or 30 to 86400 seconds in 30 s increments) and also when requested by toggling the On-Off pin.

Push-to-FixII allows vehicle velocity to be taken into account for PTF period, and QoS checks to be enabled or disabled.

#### 4.15.5. **SiRFaware**

This is a power-saving mode that maintains GPS data by waking up at intervals (e.g. every 30 minutes) to collect signals. Time/and position estimates are updated (e.g. every 10 minutes). Extended Ephemeris will be used if available.

#### 4.15.6. **Hibernate**

The receiver can be commanded into the HIBERNATE state, which is the lowest power mode available. Only the RTC and BBRAM domains are powered up. Use the NMEA \$PSRF117,16 or OSP MID 205 command to transition to this state. The module will also transition to HIBERNATE when the ON-OFF pin is brought low.



## 5. Product Specifications



For best performance it is recommended that multi-constellation navigation be used.

### 5.1. Horizontal Position Accuracy

Constellation	CEP (m)
GPS	1.2
BeiDou	N/A
GPS + Glonass	1.5
GPS + BeiDou	2.5
Test Conditions: 24-hr Static, -130 dBm, Full Power mode	

Table 5-1 SE873 Horizontal Position Accuracy





## 5.2. Time to First Fix

Constellations(s)	Start Type	Max TTFF (s)
<b>GPS</b>	Hot	1.0
	Warm - Assisted	7.5
	Warm	22.3
	Cold	31
<b>Glonass</b>	Hot	3.2
	Warm	32.6
	Cold	53.9
<b>BeiDou</b>	Hot	2.1
	Warm	40.6
	Cold	80.7
<b>GPS + GLO</b>	Hot	1.1
	Warm	22.8
	Cold	27
<b>GPS + BeiDou</b>	Hot	1.1
	Warm	29.7
	Cold	32.2
Test Conditions: -130 dBm, Full Power mode, Static scenario		

**Table 5-2 SE873 Time To First Fix**



### 5.3. Sensitivity

Constellation(s)	State	Minimum Signal Level (dBm)
GPS	Acquisition	-146
	Navigation	-161
	Tracking	-165
GLONASS	Acquisition	-145
	Navigation	-157
	Tracking	-162
BeiDou	Acquisition	-142
	Navigation	-150
	Tracking	-154
GPS + GLO	Acquisition	-146
	Navigation	-161
	Tracking	-165
GPS + BeiDou	Acquisition	-146
	Navigation	-161
	Tracking	-165
<p>Test conditions: In-line LNA with 1 dB noise figure (NF).</p> <p>Note: The above performance values were achieved under ideal lab conditions using a GNSS simulator.</p>		

**Table 5-3 SE873 Sensitivity**



## 6. Software Interface

The host serial I/O port (UART, I2C, or SPI) supports full duplex communication between the receiver and the user.

The default UART configuration is: NMEA, 9600 bps, 8 data bits, no parity, 1 stop bit.

Two protocols are available for command input and data output:

- NMEA-0183 V3.10
- SiRF One Socket Protocol (OSP)

See **Section 6.3.1 Change output sentences and their rates**

Use the Query/Rate Control (\$PSRF103) command to enable and disable output NMEA messages and set their output rates.

### 6.1.1. Change data rate

Use the Set Serial Port (\$PSRF100) command to change the port data rate.

Switch to OSP protocol



## 6.2. NMEA Output Messages

Defaults:

- NMEA-0183
- 1 Hz fix rate. Maximum is 5 Hz.

### 6.2.1. Standard Messages

Message ID	Description	Frequency
<b>RMC</b>	GNSS Recommended minimum navigation data	1
<b>GGA</b>	GNSS position fix data	1
<b>GSA</b>	GNSS Dilution of Precision (DOP) and active satellites	1
<b>GSV</b>	GNSS satellites in view.	1 / 5

**Note:** Multiple GSA and GSV messages may be output per cycle.

**Table 6-1 Default NMEA Output Messages**

The following messages can be enabled by command:

Message ID	Description
<b>GLL</b>	Geographic Position – Latitude & Longitude
<b>VTG</b>	Course Over Ground & Ground Speed
<b>ZDA</b>	Time and Date
<b>GNS</b>	GNSS Fix Data

**Table 6-2 Available NMEA Output Messages**



The following Talker IDs are used:

Talker ID	Constellation
GA	Galileo
GB	BeiDou
GL	GLONASS
GP	GPS
GN	Solutions using multiple constellations

**Table 6-3 NMEA Talker IDs**

### 6.2.2. Proprietary Messages



- The receiver can issue several proprietary NMEA output messages (\$PSRF) which report additional receiver data and status information.
- Some of these messages exceed the 80-character limitation of the NMEA-0183 standard.



## 6.3. NMEA Input Commands

The receiver uses NMEA proprietary messages for commands and command responses. This interface provides configuration and control over selected firmware features and operational properties of the module.

The format of a command is:

```
$<command-ID>[,<parameters>]*<cr><lf>
```

Commands are NMEA proprietary format and begin with “\$PSRF”. Parameters, if present, are comma-delimited as specified in the NMEA protocol.

### 6.3.1. Change output sentences and their rates

Use the Query/Rate Control (\$PSRF103) command to enable and disable output NMEA messages and set their output rates.

### 6.3.2. Change data rate

Use the Set Serial Port (\$PSRF100) command to change the port data rate.

### 6.3.3. Switch to OSP protocol

Use the Set Serial Port (\$PSRF100) command to switch to the OSP protocol. It may be necessary to change the data rate since OSP can generate a much larger volume of output per reporting cycle.

## 6.4. OSP Output Messages

Please refer to SiRF OSP documentation.

## 6.5. OSP Input Commands

### 6.5.1. Change output messages

Use OSP MID 166 to change the output messages.

### 6.5.2. Change data rate

Use OSP MID 134 to change the baud rate

### 6.5.3. Switch to NMEA protocol and data rate

Use the OSP MID 129 command to switch to the NMEA protocol and change the port data rate.



## 7. Flash Upgradability

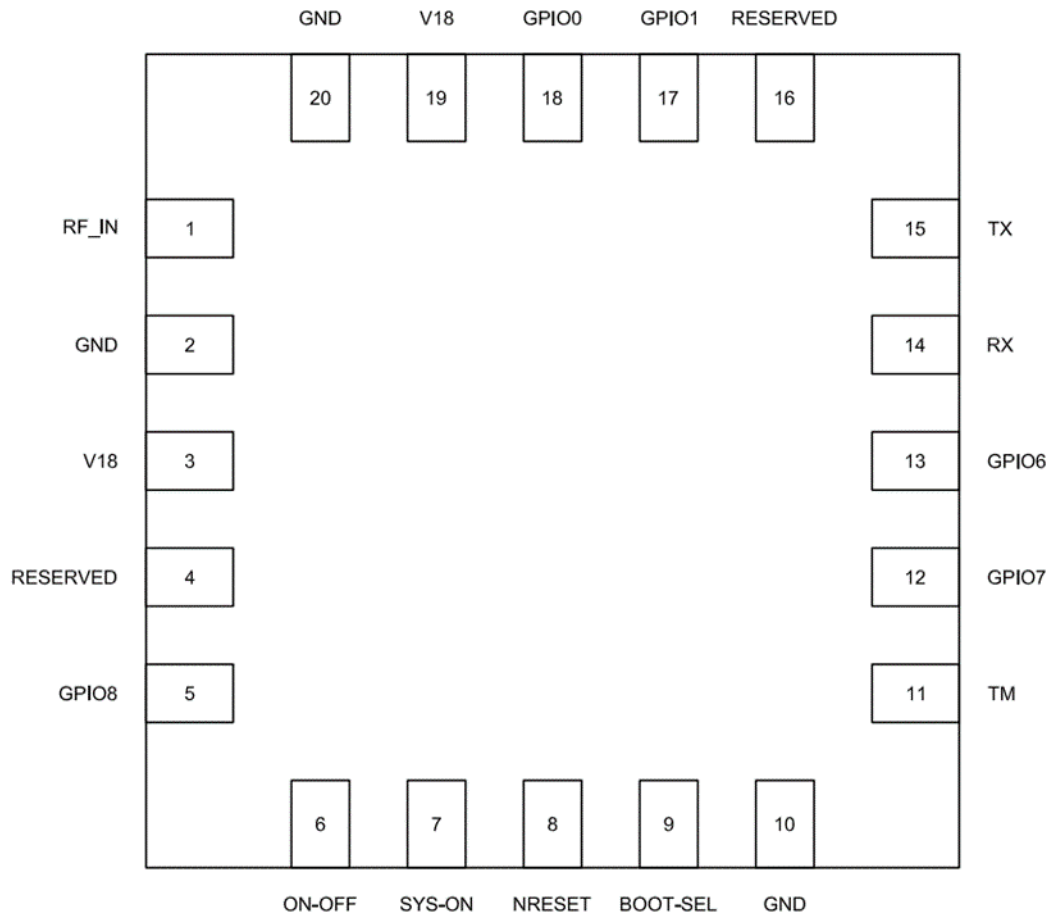
The firmware stored in the internal Flash memory of the SE873 may be upgraded via the serial port TX/RX pads.

Please refer to the SE873 Evaluation Kit User Guide to update the firmware.



## 8. Electrical Interface

### 8.1. Module Pin-out



Viewed from top

Figure 8-1 SE873 Pin-out Diagram







SE873 Pin	Name	Type	Function
<b>Power</b>			
3, 19	V18	P	Connect all pins to 1.8 V supply. See <b>Section 8.4 Power Supply</b> .
<b>Ground</b>			
2, 10, 20	GND	G	Connect all pins to ground.
<b>RF Input</b>			
1	RF_IN	I	RF Input. See <b>Section 8.9 RF Interface</b> . <b>No DC may be applied.</b>
<b>Control Input</b>			
6	ON-OFF	I	On/Off. See <b>Section 8.4.4 ON-OFF (input) and SYSTEM-ON (output)</b> .
8	NRESET	I	Reset (active low). See <b>Section 8.5 Reset</b> . This signal is not necessary for normal operation and may be brought out to a test point or left unconnected.
9	BOOT-SEL	I	Low during normal operation. BOOT-SEL may be pulled high to force the module into the programmable state. BOOT-SEL is read prior to the host select lines (GPIO 6 & 7). This pin should be left floating or brought out to a test point. See <b>Section 7 Flash Upgradability</b> .
13	GPIO6	I	GPIO 6 & 7 are read only at powerup and reset to configure the host port. See <b>Section 8.7 Host I/O Port Configuration and Operation</b> . After configuration, they may be used for UART or SPI signal lines depending on the firmware options enabled. Also called <b>Wakeup</b> .
12	GPIO7	I	
<b>Output</b>			
7	SYSTEM-ON	O	Indicates the power state of the module. See <b>Section 8.4.4 ON-OFF (input) and SYSTEM-ON (output)</b> .
5	GPIO8	O	External LNA control. See <b>Section 4.10 Internal LNA</b> . Also called <b>GNSS_ON</b> .
11	TM	O	1PPS time mark. See <b>Section 8.8 1PPS</b> .
<b>Host Communications Port I/O</b> See <b>Section 8.7 Host I/O Port Configuration and Operation</b>			
15	TX	O	Host Port Output. UART: TX, I <sup>2</sup> C: CLK, or SPI: Data Out (MISO).
14	RX	I	Host Port Input. UART: RX, I <sup>2</sup> C: DIO, or SPI: Data In (MOSI).
13	GPIO6	I/O	After configuration, may be used for UART: CTS or SPI: CLK.
12	GPIO7	I/O	After configuration, may be used for UART: RTS or SPI: nCS.
<b>Reserved</b>			
17	Reserved	R	Reserved - Do not connect to any external circuit.
18	Reserved	R	Reserved - Do not connect to any external circuit.
4	Reserved	R	Reserved - Do not connect to any external circuit.
16	Reserved	R	Reserved - Do not connect to any external circuit.

**Table 8-1 SE873 Pin-out Function Table**



## 8.2. DC Characteristics

Signal	Description	Min	Typ	Max	Units
V <sub>OL</sub>	Low level output voltage, I <sub>OL</sub> 2mA	-	-	0.4	V
V <sub>OH</sub>	High level output voltage, I <sub>OH</sub> 2mA	0.75*V <sub>DD</sub>	-	-	V
V <sub>IL</sub>	Low level input voltage	-0.3	-	0.45	V
V <sub>IH</sub>	High level input voltage, I <sub>IH</sub> 2mA	0.7*V <sub>DD</sub>	-	3.6	V
R <sub>PU</sub>	Internal pull-up resistor equivalent	50	86	157	kΩ
R <sub>PD</sub>	Internal pull-down resistor equivalent	51	91	180	kΩ
L <sub>I</sub>	Input leakage at V <sub>I</sub> = 1.8 V or 0 V	-10	-	10	μA
L <sub>O</sub>	Tristate output leakage at V <sub>O</sub> = 1.8 V or 0 V	-10	-	10	μA
C <sub>I</sub>	Input capacitance, digital output	-	8	-	pF

Table 8-2 DC Characteristics

## 8.3. Absolute Maximum Ratings

Parameter	Pins	Absolute Max Rating	Units
RF Input Voltage	All RF inputs	1.5	V
RF Input Power	All RF inputs	10	dBm
ESD Voltage CDM JESD22-C101E	All Pins	+/- 1100	V
ESD Voltage HDM JEDEC JS-001-2012	All Pins	+/-500	V
1.8 V Supply Voltage	VDD_18	2.2	V
I/O Pin Voltage	All digital inputs	3.60	V

Table 8-3 Absolute Maximum Ratings



## 8.4. Power Supply

### 8.4.1. 1.8 V Supply Voltage

Unlike previous GNSS receiver modules, the SE873 requires a single always-on 1.8 V supply. Rather than having a “split” power supply design of main and backup, the module manages all of its power modes internally. The module will power up into the state determined by the ON-OFF pin (High: RUN; Low: HIBERNATE).

The current power state of the SE873 can be determined by monitoring the “SYSTEM-ON” signal. A logic low indicates the module is in OFF, RESET, HIBERNATE, or STANDBY; whereas logic high indicates the module is in RUN state.

If the 1.8 volt DC supply is removed from the module (regardless of power state) it will lose current RTC time and the contents of the internal SRAM. To execute an orderly shutdown, place the module into the HIBERNATE state, then remove power. To prevent improper startup, keep the power removed for approximately 10 seconds to reliably clear the SRAM contents.

The module monitors the 1.8 volt supply and issues an internal hardware reset if the supply drops below 1.7 volts. This reset protects the memory from accidental writes during a power down condition. The reset forces the module into a low power stand-by state.

To prevent the reset, the 1.8 volt supply must be regulated to be within  $\pm 50$  mV of nominal voltage (including load regulation and power supply noise and ripple). Noise and ripple outside of these limits can affect GNSS sensitivity and also risk tripping the internal voltage supervisors, thereby shutting down the module unexpectedly. Regulators with very good load regulation are strongly recommended along with adequate power supply filtering to prevent power supply glitches as the module transitions between power states.

The power supply voltage, noise and ripple must be between 1.75V and 1.85V for all frequencies. To help meet these requirements, a separate LDO for the module is suggested.

### 8.4.2. DC Power Requirements

Name	Min	Typ	Max	Units
V18	1.75	1.8	1.85	V
Max ripple: 54 mV (0 to 3 MHz), 15 mV (> 3 MHz)				

Table 8-4 DC Supply Voltage





### 8.4.5. DC Power Consumption

State & Constellation	Power Mode	Smart 2		Smart 1		Full Power		Units
		Typ	Max	Typ	Max	Typ	Max	
<b>Acquisition</b>								
GPS only				72	98	84	111	mW
GPS and Glonass				92	117	101	125	mW
GPS and BeiDou				94	122	100	130	mW
<b>Navigation/Tracking</b>								
GPS Only				51	83	63	91	mW
GPS and Glonass		59	87	62	92	94	124	mW
GPS and BeiDou				71	111	93	135	mW
<b>Low Power – Trickle Power</b>								
GPS only – Push to Fix				32				mW
GPS and Glonass – Push to Fix				42				mW
GPS and BeiDou – Push to Fix				44				mW
<b>Low Power – Push To Fix</b>								
GPS only – Push to Fix				27				mW
GPS and Glonass – Push to Fix				34				mW
GPS and BeiDou – Push to Fix				35				mW
<b>Battery Backup (Hibernate)</b>								
62								
Operating temperature: 25°C. Supply voltage: 1.8 VDC nominal Trickle Power mode: On 100 ms, Off 30 s Push To Fix mode: 6 s								

Table 8-5 Power Consumption



## 8.5. Reset

The module will generate an internal reset as appropriate. Therefore, no external signal is required for the module to operate properly and this pin may be left unconnected.

If an external reset is desired, the signal must be either open collector or open drain without any form of pull up. Do not pull this line high with either a pull up or a driven logic one. When this line is pulled low, the module will immediately transition into reset mode.

When the external reset is released, the module will go through its normal power up sequence provided the V18 supply is within specifications. See **Section 8.4.4 ON-OFF (input) and SYSTEM-ON (output)**.

Pulling NRESET low at any time forces the module into the reset state irrespective of the ON-OFF signal. In the reset state, the SYSTEM-ON signal is low.

Once the NRESET signal is released the module will transition to the HIBERNATE state or to the ON state as determined by the ON-OFF signal input.

## 8.6. Boot Select

It is not necessary to use the Boot Select pin to re-flash the receiver since SiRFlive can use commands to perform this task. This pin should be left floating or may be brought out to a test point.



## 8.7. Host I/O Port Configuration and Operation

The receiver module includes two serial ports which are configured for the desired interface.

The first host port can be configured to communicate using a UART, I2C, or SPI interface. See **Section 8.7.1 Host Port Configuration for 1st Port** for details of port configuration. Also, see **Section 4.13 Device Wake-up** for this port.

The second host port is configured to communicate using an I<sup>2</sup>C interface. SPI is not available because it requires 4 pins. See **Section 8.7.2 Host Port Configuration for 2nd Port** for details of port configuration.

Default port configurations are UART:

- First port (port 0): NMEA at 9600 bps
- Second Port (port 1): I<sup>2</sup>C (in the future)

### 8.7.1. Host Port Configuration for 1<sup>st</sup> Port (port 0)

The receiver module includes a full-duplex serial interface which is configured for UART, I2C or SPI interface by reading GPIO6 and 7 at startup or reset (only). The following table gives the required input signals:

Pin	Pullup / Pulldown	UART	I <sup>2</sup> C (multi-master)	SPI (slave)
GPIO6	Weak internal pulldown	Pullup 10 kΩ to +1.8 V (may become CTS)	Float	Float (becomes SCLK)
GPIO7	Weak internal pullup	Float (may become RTS)	Pulldown 10 kΩ to ground	Float (becomes SPI_CS)

**Table 8-6 Host I/O Port Configuration**

**Note:** The GPIO6 and GPIO7 lines are read for configuration purposes at power up or reset only. Afterwards, they may be used for UART or SPI signal lines depending on firmware options.

### 8.7.2. Host Port Configuration for 2nd Port (port 1)

The second host port default configuration can be changed by loading a different Firmware build.



### 8.7.3. UART Operation

See **Section 8.7.1 Host Port Configuration for 1st Port** to specify UART interface.

Upon power up, the module will communicate using a standard asynchronous 8 bit protocol with output messages appearing on the TX line and input commands and data being received on the RX line. The UART can operate at baud rates from 4800 bps to 1.2288 Mbps, however speeds above 115,200 bps have not been fully tested and verified.

If the module is operated in TricklePower mode, a baud rate of at least 38,400 is recommended. This reduces the time required to empty the output buffer and allows the receiver to drop into the low power state for a longer period of time.

The minimum recommended baud rate for OSP is 38400, or 115200 if debug data messages are enabled.

Use the Query/Rate Control (PSRF103) to enable and disable output NMEA messages and set their output rates.

After configuration, the pins are defined below:

Pin Name	UART Function
<b>First Port</b>	
TX0	Transmit Data (TX)
RX0	Receive Data (RX)
GPIO6	CTS
GPIO7	RTS

**Table 8-7 UART Pin Assignments**

Note: Flow control is disabled by default.

Use the OSP MID 178,70 command to enable/disable flow control on the first port.





## 8.7.4. I<sup>2</sup>C Operation

See **Section 8.7.1 Host Port Configuration for 1st Port** to specify I<sup>2</sup>C interface. Upon power up, the module acts as a master transmitter and a slave receiver (multi-master mode).



When used in I<sup>2</sup>C mode, pull-ups in the range of 1K to 2.2K to a 1.8V to 3.6V power supply are required on the RX and TX lines.

Clock rates of 100 and 400 kbps are supported.

The operation of the I<sup>2</sup>C with a master transmit and slave receive resembles a UART operation, where both the module and the host can independently freely transmit. It is possible to enable the master transmit and slave receive at the same time, as the I<sup>2</sup>C bus allows for contention resolution between module and host vying for the bus.

After configuration, the pins are defined below:

Pin Name	I <sup>2</sup> C Function
<b>First Port</b>	
TX0	I2C Clock (SCL)
RX0	I2C Data (SDA)
GPIO6	Not used
GPIO7	Not used
<b>Second Port</b>	
TX1	I2C Data (SDA)
RX1	I2C Clock (SCL)

**Table 8-8 I2C Pin Assignments**



### 8.7.5. SPI Operation

See Section 8.7.1 Host Port Configuration for 1st Port to specify SPI interface. The 2<sup>nd</sup> port cannot be configured for SPI interface since there are only two pins available. SPI is supported in the slave mode. The MicroWire format is not supported.

Maximum speed is 6.8 MHz.

After configuration, the pins are defined below:

Pin Name	SPI Function
<b>First Port</b>	
TX0	SPI Data Out (MISO)
RX0	SPI Data In (MOSI)
GPIO6	SPI Clock (SCLK)
GPIO7	SPI Chip Select (CS#)
<b>Second Port</b>	
Not Available	

Table 8-9 SPI Mode Pin Assignments

### 8.8. 1PPS

1PPS is a one pulse per second signal which is enabled after the receiver has achieved a 5-satellite Kalman filter position fix. It is disabled 5 seconds after the position fix becomes invalid. The time mark is within 1  $\mu$ s of the GPS epoch and normally within 100 ns. Pulse width is 250 ms.



## 8.9. RF Interface

### 8.9.1. RF INPUT

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



No DC voltage can be applied to the RF input.

The SE873 contains an integrated LNA and pre-select SAW filter. This allows the module to work well with a passive GNSS antenna. If the antenna cannot be located near the module, then an active antenna (that is, an antenna with a built in low noise amplifier) should be used.

Antenna Characteristics:

- Passive antenna: isotropic gain of greater than -6 dBi.
- Active antenna: noise figure of less than 1.0 dB will offer the best performance.

See **Section 4.10 Internal LNA** for recommendations and maximum ratings for active antenna (or external LNA) gain.

### 8.9.2. External Active Antenna Voltage

If an active antenna (or external LNA) is used, an external bias-T is required to provide voltage to it. A DC blocking capacitor is also required to prevent DC voltage from being applied to RF-IN pin.

### 8.9.3. 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.

### 8.9.4. Jamming Rejection

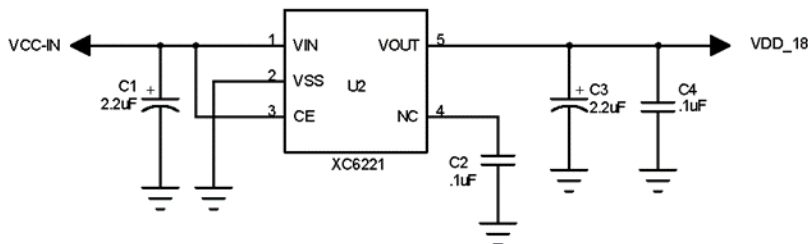
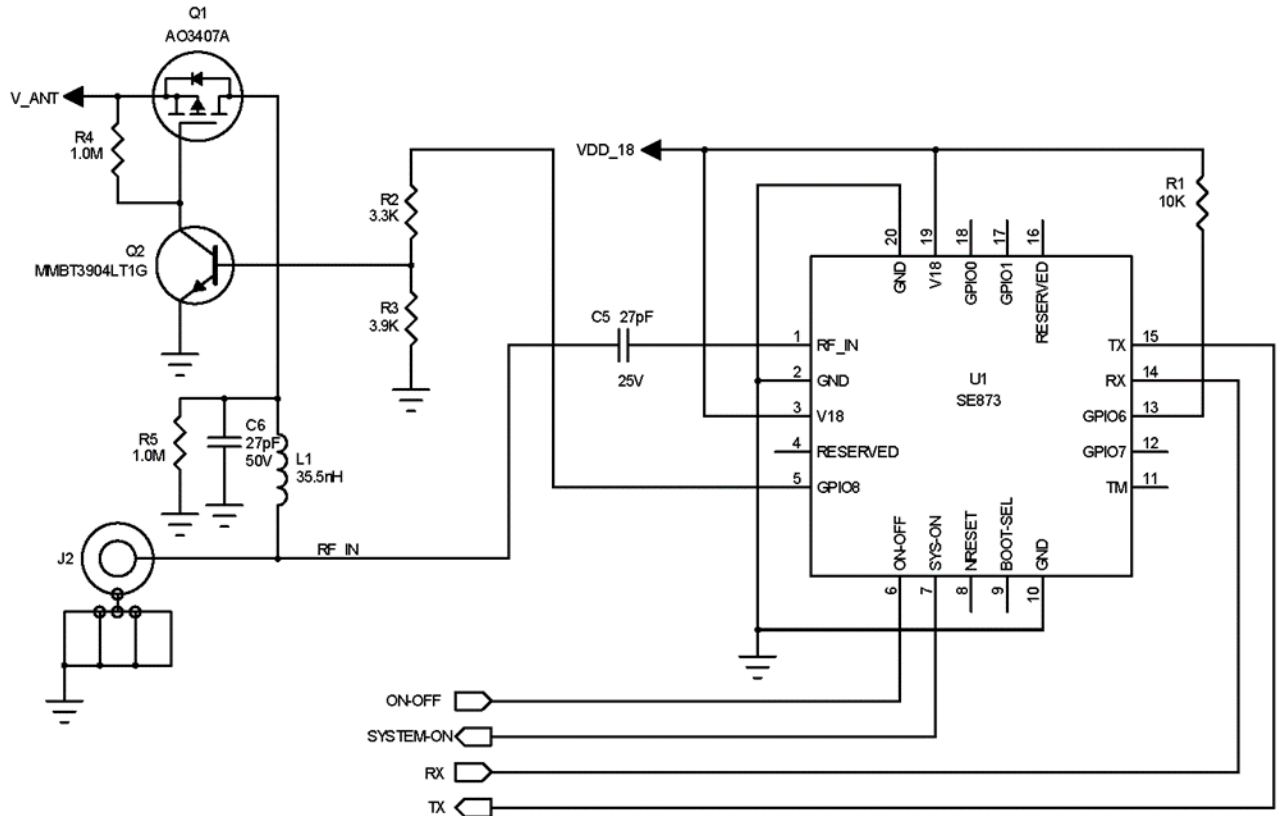
Jamming Rejection can be used for solving narrow band (CW) EMI problems in the customer's system. It is effective against narrow band clock harmonics. Jamming Rejection is not effective against wide band noise, e.g. from a host CPU memory bus or switching power supply because these sources typically 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** for further details.









Note: XC6221 is the DC voltage supply regulator

**Figure 9-2 SE873 Reference Design – Active Antenna**



Along with power and ground, the minimum signals required to operate the module properly are: one RF input and four digital lines.

The RF input can be connected directly to a passive GNSS antenna. C5 is used to block DC voltage from entering the module. The active-antenna reference design shows a DC power feed for its LNA. The inductor L1 is chosen to be self-resonant at the GPS L1 frequency (1.57542 GHz) to minimize loading on the RF trace. Capacitor C6 is chosen to be self-resonant at the GPS L1 frequency such that it is close to an RF short at that frequency. V\_ANT is the supply voltage for the external active antenna.

TX0 is a standard serial output - usually a UART with a default bit rate of 9600 bps, 8 data bits, 1 stop bit, and no parity. As is the case with all UART data, the idle state is logic one. This is a 1.8 volt logic level signal. Note that it can be configured for I2C or SPI interface.

RX0 is a standard serial input - usually a UART with a default bit rate of 9600 bps, 8 data bits, 1 stop bit and no parity. As is the case with all UART data, the idle state is logic one. This is a 1.8 volt logic level signal, but is tolerant to 3.6 volts. Note that it can be configured for I2C or SPI interface.

TX1 and RX1 can be configured for I<sup>2</sup>C interface, but not SPI interface.

SYSTEM-ON is an output indicating the power state of the module. If the module is in the RUN state, the logic level will be high, otherwise the logic level will be low. This is a 1.8 volt signal.

ON-OFF is an input to control the power state of the module. After power-up, the module will enter the RUN state if it is high, or the HIBERNATE state if it is low. SYSTEM- ON will then indicate the system's state.

**Note:** ON-OFF must not be tied to V18 or the module will not be able to exit a commanded HIBERNATE state.

Resistor R1 as shown pulls GPIO6 high, which specifies the host port configuration to be serial UART.

See **Section 8.7 Host I/O Port Configuration and Operation** for details.

The power supply shown is a minimal design for power requirements. The power supply must have tight voltage regulation under varying line and load conditions to prevent falsely tripping the internal voltage supervisor within the module.



## 10. RF Front End Design

### 10.1. RF Signal Requirements

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

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

The GLONASS signal is defined by GLONASS ICD 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 5 degrees or more above the horizon.

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

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

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

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





The GNSS signal is relatively immune to attenuation from rainfall. However, the GNSS signal is heavily influenced by attenuation due to foliage (such as tree canopies, etc.) as well as outright blockage caused by buildings, terrain or other items near the line of sight to the specific GNSS satellite. This variable attenuation is highly dependent upon satellite location. If enough satellites are blocked, say at a lower elevation, or all in one general direction, the geometry of the remaining satellites will 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 is a phenomena where the signal from a particular satellite is reflected and is received by the GNSS antenna in addition to or in place of the line of sight signal. The reflected signal has a path length that is longer than the line of sight path and can either attenuate the original signal, or, if received in place of the original signal, can add error in determining a solution because the distance to the particular satellite is actually shorter than measured. It is this phenomenon 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 the polarization to reverse. The implications of this are covered in the next section.

## 10.2. GNSS Antenna Polarization

The GPS broadcast signal 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).

Optimum performance is realized only if the firmware build and hardware configuration match the type of antenna used (active or passive). The firmware must set the internal LNA gain to correspond to the installed antenna.

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, or directly overhead) and antenna pattern curves specifying gain as a function of elevation, and gain at a fixed elevation as a function of azimuth. Pay careful attention to the requirement 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 (Refer to section 10.5 for more details on external LNA gain).

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. External LNA Gain and Noise Figure

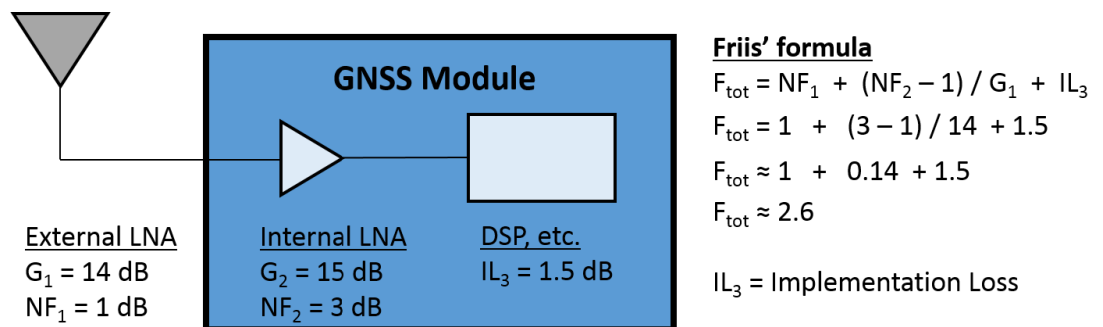
The modules can be used with an external LNA (usually built into an active antenna). Because of the internal LNA, the overall external gain (including signal losses past the external LNA) should conform to the specification in **Table 4-1 Internal gain value and external gain range** for best performance. Using an external LNA may require setting the internal LNA to low gain mode, which requires a firmware change. Levels higher than specified may affect the jamming detection capability and overall performance of the receiver. Contact Telit for details.

The external LNA should have a noise figure better than 1 dB. This will give an overall system noise figure of around 2 dB (assuming the LNA gain is 14 dB) or higher if a low gain mode is selected within the module. The overall system noise figure can be calculated using the Friis formula for cascaded noise figure. The simplified formula is:

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} + \frac{F_4 - 1}{G_1 G_2 G_3} + \dots + \frac{F_n - 1}{G_1 G_2 G_3 \dots G_{n-1}}$$

**Equation 10-1 Cascade Noise Figure**

Where F is the total system noise figure, F1 is the noise figure of the external LNA, F2 is the noise figure of the internal LNA, and G1 is the gain of the external LNA. In the GNSS receiver, digital noise is an additive number and cannot be reduced by reducing the System Noise figure.



**Figure 10-1 Cascade Noise Figure – example calculations with external LNA**

If the external LNA has no pre-select filter, it must be able to accommodate signals outside the GNSS passband, which are typically at much higher levels than GNSS. The amplifier must stay in the linear region when presented with these other signals. Again, the system designer needs to determine all of the unintended signals and their possible levels that can be presented making sure the external LNA will not be driven into compression. If this were to happen, the GNSS signal itself would start to be attenuated and the GNSS performance would suffer.

## 10.6. 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:

$$C/No = \text{GNSS Signal level} - \text{Thermal Noise} - \text{System NF}$$

**Equation 10-2 Carrier to Noise Ratio**

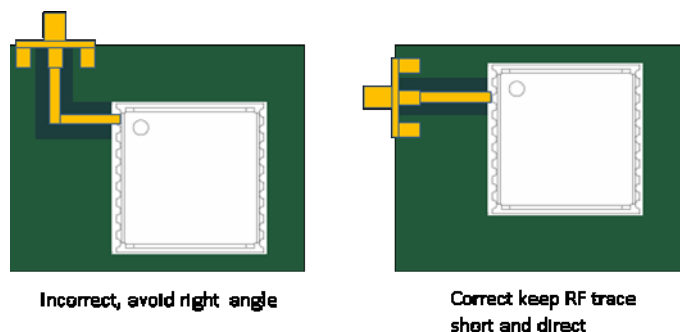
Thermal noise is -174 dBm/Hz at 290K.

We can estimate a 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.

## 10.7. 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 ohm impedance, and don't contain any sharp bends.



**Figure 10-2 RF Trace Examples**

## 10.8. 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 50 Ω impedance.



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

## 10.9. Implications of the Pre-Select SAW Filter

The SE873 modules include a pre-select SAW filter 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 bad return loss.

If an external amplifier is to be used with the receiver, the overall design should be checked for RF stability to prevent the external amplifier from oscillating. Amplifiers that are unconditionally stable at their 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  $\Omega$  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.

## 10.10. Powering an External LNA

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

Two approaches can be used:

1. Use an inductor to tie directly to the RF trace. This inductor should be at self-resonant at L1 (1.57542 GHz) and should have good Q for low loss. The higher the inductor Q, the lower the loss will be. The side of the inductor connecting to the antenna supply voltage should be bypassed to ground with a good quality RF capacitor, again with self-resonance at the L1 frequency.
2. Use a quarter wave stub in place of the inductor. The length of the stub is designed to be exactly  $\frac{1}{4}$  wavelength at L1, 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 a high 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:

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

**Table 10-1 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 CW jamming signals in each band (GPS, GLONASS, and BeiDou), but would still be affected by non-CW signals.

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

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

## 10.12. 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 it could not then receive the GNSS signals.

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



## 11. Mechanical Drawing

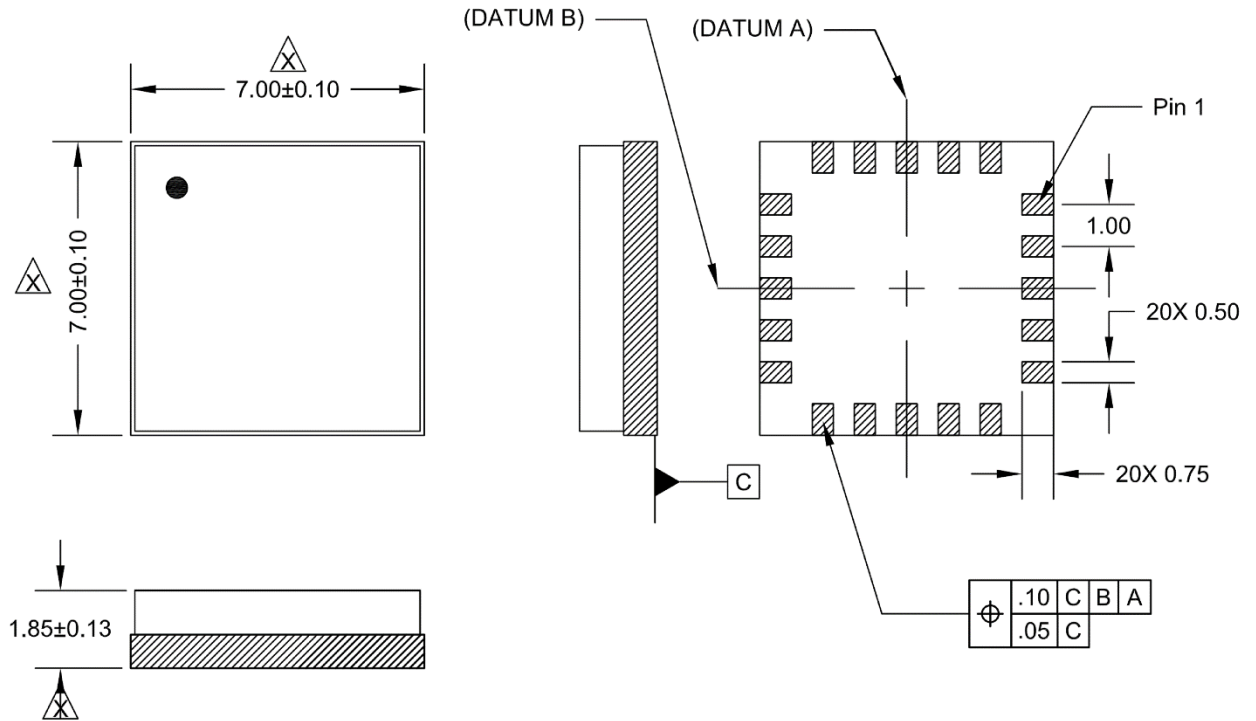
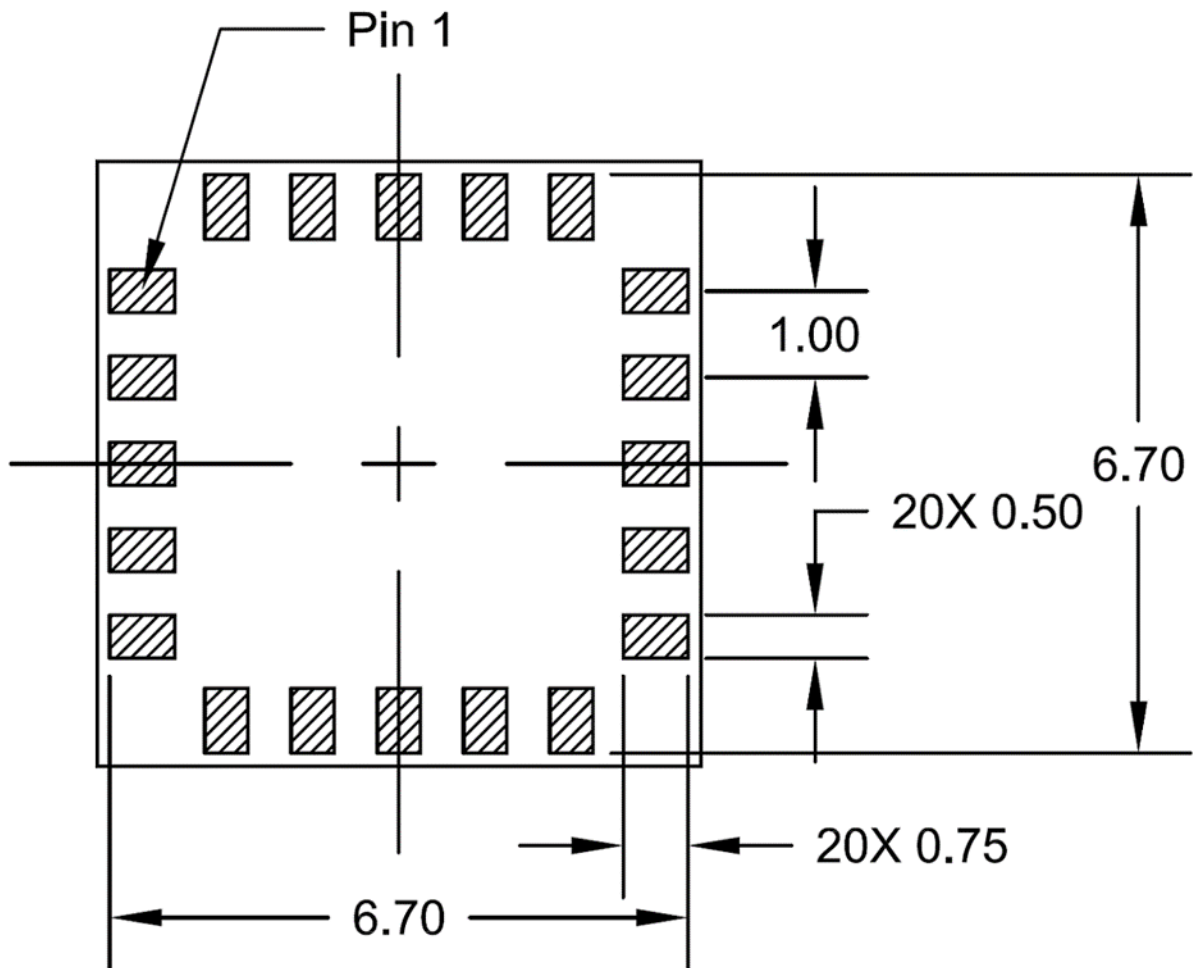


Figure 11-1 SE873 Mechanical Drawing



## 12. PCB Footprint



**Figure 12-1 SE873 PCB Footprint**

The module shall be mounted on a PCB which complies with V-0 flammability class.

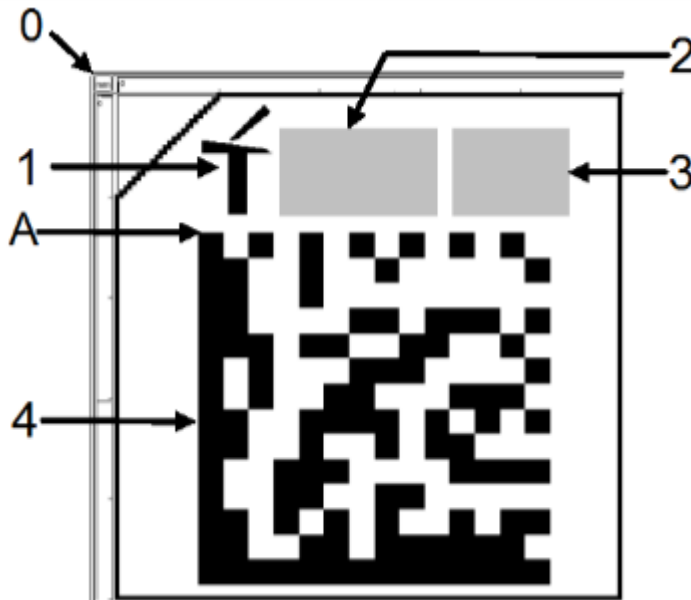




## 13. Product Packaging and Handling

### 13.1. Product Marking and Serialization

The SE873 module label has a 2D Barcode with the module serial number. Contact a Telit representative for information on specific module serial numbers.



Key	Description
0	Pin 1 identification
1	Telit Logo
2	Model No.
3	Reserved for Product Variant
4	Barcode type 2D datamatrix and text of Telit Serial Number

Figure 13-1 Product Label



## 13.2. Product Packaging and Delivery

SE873 modules are available in two different Tape and Reel packaging of 250 pcs and 1000 pcs respectively.

Each reel is ‘dry’ packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and placed in a carton. All packaging is ESD protective lined.

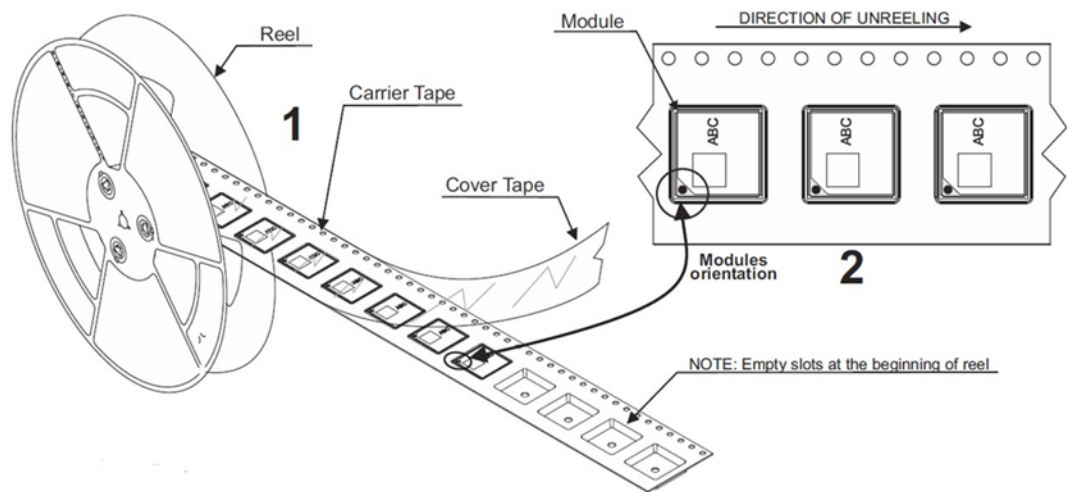


Figure 13-2 Product Packaging - Tape and Reel

## 13.3. 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.

The SE873 module has a moisture sensitivity level rating of 3 as defined by **IPC/JEDEC J-STD-020**. This rating is assigned due to some of the components used within the module.

The SE873 packaging is hermetically sealed with desiccant and humidity indicator card. The SE873 parts must be placed and reflowed within 168 hours of first opening the hermetic seal provided the factory conditions are less than 30°C and less than 60% and the humidity indicator card indicates less than 10% relative humidity.

If the package has been opened or the humidity indicator card indicates above 10%, then the parts must be baked prior to reflow. The parts may be baked at +125°C ± 5°C for 48 hours. However, the tape and reel cannot 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** for additional information.







## 14. Environmental Requirements

### 14.1. Operating Environmental Limits

Temperature	-40°C to +85°C
Temperature Rate of Change	±1°C / minute maximum
Humidity	Up to 95% non-condensing or wet bulb temperature of +35°C, whichever is less
Altitude	-1500 m to 100,000 m
Maximum Vehicle Dynamics	600 m/s (acquisition and navigation) 2 G acceleration
ITAR Limits	515 m/s <u>and</u> altitude greater than 18,000 m

Table 14-1 SE873 Operating Environmental Limits

### 14.2. Storage Environmental Limits

Temperature	-40°C to +85°C
Humidity	Up to 95% non-condensing or wet bulb temperature of +35°C, whichever is less
Altitude	-1500 m to 100,000 m
Shock	18G peak, 5 millisecond duration
Shock (in shipping container)	10 drops from 75 cm onto concrete floor

Table 14-2 SE873 Storage Environmental Limits



## 15. Compliances

The SE873 module complies with the following:

- Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
- Manufactured in an ISO 9000: 2000 accredited facility
- Manufactured to TS 16949 requirement (upon request)

### 15.1. CE Declaration of Conformity

SE873 Certificate in process

### 15.2. RoHS Certificate

The Telit SE873 modules are fully compliant with the EU RoHS Directives.



## 16. Glossary and Acronyms

**AGPS:** Assisted (or Aided) GPS

AGPS provides ephemeris data to the receiver to allow faster **cold start** times than would be possible using only broadcast data.

This extended ephemeris data could be either server-generated or locally-generated.

See **Local Ephemeris prediction data** and **Server-based Ephemeris prediction data**

**Almanac:**

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

**BeiDou (BDS / formerly COMPASS):**

The Chinese **GNSS**, currently being expanded towards full operational capability.

**Cold Start:**

A cold start occurs when a receiver begins operation with unknown position, time, and ephemeris data, typically when it is powered up after a period on inactivity. Almanac information may be used to identify previously visible satellites and their approximate positions. See **Restart**.

**Cold Start Acquisition Sensitivity:**

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

**EGNOS:** European Geostationary Navigation Overlay Service

The European **SBAS** system.

**Ephemeris** (plural ephemerides):

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

**ESD:** Electro-Static Discharge

Large, momentary, unwanted electrical currents that can cause damage to electronic equipment.

**GAGAN:**

The Indian **SBAS** system.



**Galileo:**

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

**GDOP:** Geometric Dilution of Precision

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

**GLONASS:** ГЛОБАЛЬНАЯ НАВИГАЦИОННАЯ СПУТНИКОВАЯ СИСТЕМА

GLOBAL'NAYA NAVIGATSIONNAYA SPUTNIKOVAYA SISTEMA  
(Global Navigation Satellite System)

The Russian **GNSS**, which is operated by the Russian Aerospace Defense Forces

**GNSS:** Global Navigation Satellite System

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

**GPS:** Global Positioning System

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

**Hot Start:**

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

**LCC:** Leadless Chip Carrier

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

**LNA:** Low Noise Amplifier

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

**Local Ephemeris prediction data:**

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

**MSAS:** MTSAT Satellite Augmentation System

The Japanese **SBAS** system.

**MSD:** Moisture sensitive device.

**MTSAT:** Multifunctional Transport Satellites

The Japanese system of geosynchronous satellites used for weather and aviation control.





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

**NMEA:** National Marine Electronics Association

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

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

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

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

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

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

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

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

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

**TCXO:** Temperature-Compensated Crystal Oscillator

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



**TTFF:** Time to First Fix

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

**UART:** Universal Asynchronous Receiver/Transmitter

An integrated circuit (or part thereof) which provides a serial communication port for a computer or peripheral device.

**WAAS:** Wide Area Augmentation System

The North American **SBAS** system developed by the US FAA (Federal Aviation Administration).

**Warm Start:**

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

**Restart.**



## 17. Safety Recommendations

### READ CAREFULLY

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

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

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

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

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

The European Community provides some Directives for electronic equipment introduced on the market. All the relevant information are available on the European Community website: <http://ec.europa.eu/enterprise/sectors/rtte/documents/>

The text of the Directive 99/05 regarding telecommunication equipment is available, while the applicable Directives (Low Voltage and EMC) are available at: <http://ec.europa.eu/enterprise/sectors/electrical/>

The power supply used shall comply the clause 2.5 (Limited power sources) of the standard EN 60950-1

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



