

SL869-V3

Product User Guide

1VV0301217 r2 – 2016-09-22



APPLICABILITY TABLE

PRODUCT
SL869-V3



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1.4. Related Documents

- SL869-V3 Data Sheet
- SL869-V3 Evaluation Kit User Guide

A Non-Disclosure Agreement is required for the following documents:

- ST Antenna Sense App Note
- V33 Software Authorized User Guide



2. Product Description

The SL869-V3 is a 12.2mm x 16.0mm fully integrated GNSS module which includes an ST Micro Teseo III GNSS receiver with an ARM-9 core processor, flash memory, TCXO, RTC crystal, LNA and SAW filter.

2.1. Product Overview

- Complete GNSS receiver module including memory, TCXO, SAW, LNA, RTC and DC blocking capacitor
- Constellations supported:
 - GPS (L1), QZSS, and either Glonass (L1) or BeiDou (B1) signals, Galileo ready
 - SBAS capable (WAAS, EGNOS, MSAS, GAGAN) including ranging
- Assisted GPS (AGPS) support for extended ephemeris using local or server-based solutions:
 - Local: ST-AGPS
 - Server: PGPS, PGLO
- Differential GPS (DGPS) capable using the RTCM SC-104 protocol
- NMEA-0183 command input and data output
- Configurable fix reporting. Default: 1Hz, Max: 10 Hz
- 3 serial ports for input commands/data and output messages (see I/O Ports)
- 1PPS output
- Supports active or passive antenna
- Antenna on (output)
- Antenna sense (input)
- Memory -
 - 256 Kbyte embedded SRAM
 - 16 Megabit built-in SQI flash
- Low power consumption
- Power management modes for extended battery life
- 48 tracking channels + 2 fast acquisition channels
- Supported by evaluation kits
- -40°C to +85°C industrial temperature range
- Surface mountable by standard SMT equipment
- 24-pad 16.0 x 12.2 x 2.4 mm Industry Standard LCC castellated edge package
- RoHS compliant design



2.3. Module Photo



Figure 2-2 SL869-V3 Module Photo



3. Evaluation Kit

The Evaluation Kit (EVK) contains the necessary hardware, software, and documentation to assist the customer in evaluating the module for inclusion in a design.

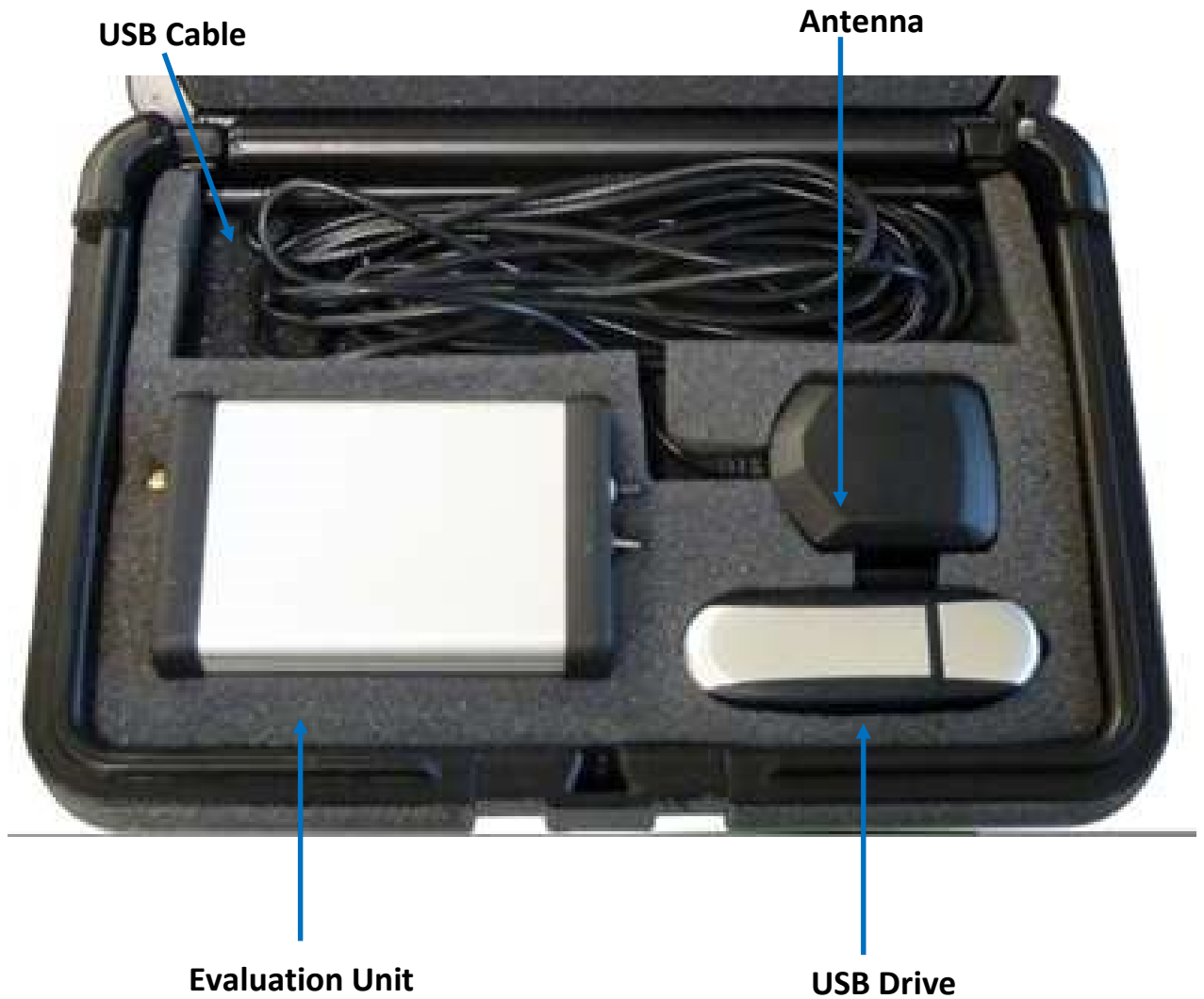


Figure 3-1 SL869-V3 Evaluation Kit



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 command. Using GLONASS or BDS alone may not give optimum positioning results depending on the region where the receiver is located.

4.2. Quasi-Zenith Satellite System (QZSS)

The satellites of the Japanese SBAS are in a highly inclined geosynchronous orbit, allowing continuous coverage over Japan using only three satellites. The signals may be used for ranging.

4.3. Satellite-Based Augmentation System (SBAS)

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

The module is disabled for SBAS by default, but can be enabled by command.

4.3.1. SBAS Corrections

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

4.3.2. SBAS Ranging

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

4.4. Assisted – or Aided - GPS (AGPS)

A GNSS receiver requires ephemeris data to calculate the precise position in space of each satellite to be used in the navigation solution. Since the satellites move at a speed of 3874 km/s along their orbits and are subject to gravitational perturbations from all masses in the solar system, this data must be both current and accurate. Each GPS satellite transmits a complete set of its ephemeris coefficients (called the broadcast ephemeris or BE) every 30 seconds. This is therefore the minimum time required for a cold start Time to First Fix (TTFF). The BE data is usually refreshed every 2 hours.

The minimum cold start TTFF can be reduced from 30 seconds to just a few seconds by implementing AGPS, which can provide Extended Ephemeris (EE) data by two methods -

1. Locally-generated: The receiver includes software to project the future positions of the satellites. This data may be calculated out to 14 days or even longer, depending on the resources available in the receiver, e.g. computation ability and memory.



2. Server-generated: A server calculates the future position projections and makes them available to a receiver, typically over the internet. This data may be good for 30 days, depending on available resources, e.g. communication links and storage.

This Extended Ephemeris (EE) data is then stored for use at the next restart, and can reduce cold start times to a few seconds.

If server-generated EE data is received and processed, locally-generated data is not used.

AGPS is on by default, but can be disabled by command.

4.4.1. **Locally-generated AGPS (ST-AGPS)**

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 5 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.

4.4.2. **Server-generated AGPS – PGPS/PGLO**

Telit AGPS servers maintain calculated extended ephemeris data. The predicted ephemeris file is obtained from the AGPS server and is transmitted to the module over serial port 1 (RX). These predictions do not require collection of broadcast ephemeris, and are valid for up to 14 days.

The SL869-V3 supports server-based AGPS as a standard feature.

An Application Note and example source code are available under NDA.

Contact TELIT for support regarding this service.

4.5. **Differential GPS (DGPS)**

Differential corrections can be supplied to the module from an RTCM beacon receiver. RTCM SC-104 Ver. 2.3 messages 1, 9, and 31 (both GPS and GLONASS) are supported. The module will indicate Differential mode when corrections are supplied. The use of DGPS corrections can substantially improve position accuracy.

4.6. **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 updated every 40 seconds while the receiver is in the Static Navigation mode.

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).

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.

4.7. Elevation Mask Angle

The default elevation mask angle is 5°. It can be changed by command.

4.8. 10 Hz Navigation

The default rate of 1 Hz can be changed by command to a maximum of 10 Hz.

4.9. Internal LNA

The SL869-V3 includes a built-in LNA to improve sensitivity.

4.10. 1PPS

The module provides a 1PPS output signal whenever the receiver has a valid fix (2D or 3D). Please see § 8.7.3 1PPS for detailed information.

4.11. Antenna Enable

The Antenna Enable output can be used to control an external power supply to an active antenna (or external LNA). It will be high when the receiver is operating, or low when it is in a low-power (standby) mode.

4.12. Antenna Sense

The Antenna Sense feature measures the current consumed by the external LNA or active antenna and reports its status as NORMAL, SHORT, or OPEN in an NMEA proprietary message. See § 8.6.3 Antenna Sense for details.

4.13. Serial I/O Ports

The SL869-V3 module includes three serial ports and an I²C port.

Please refer to § 8.8 I/O Port Operation for port details.

4.13.1. UART

The UART ports are used for sending data and receiving commands. UART ports are full-duplex with configurable baud rates. The signal input and output levels are LVTTTL compatible (see § 8.8.1 UART Port Operation). Note that the idle state of the interface lines is logic high. Care must be used to prevent backdriving the RX line(s) when the module is powered down or in a low-power state.



5.3. Sensitivity

Constellation(s)	State	Minimum Signal Level (dBm)
GPS	Acquisition	-147
	Navigation	-158
	Tracking	-162
GLONASS	Acquisition	-146
	Navigation	-157
	Tracking	-159
BeiDou	Acquisition	-147
	Navigation	-154
	Tracking	-161
Test Conditions: Static Scenario, Full Power mode		

Table 5-3 SL869-V3 Sensitivity



6. Software Interface

The primary UART port (TX/RX) supports full duplex communication between the receiver and the user.

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

Customers that have executed a Non-Disclosure Agreement (NDA) with Telit may obtain the V33 Software Authorized User Guide, which contains additional proprietary information.

6.1. NMEA Output Messages

The communication protocol is NMEA-0183 V3.01.

6.1.1. NMEA Standard Messages

Message ID	Description	Default
RMC	GNSS Recommended Minimum navigation data	ON
GGA	GNSS Position fix data	ON
GSA	GNSS Dilution of Precision (DOP) and active satellites	ON
GSV	GNSS Satellites in view.	ON

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	Description	Default
GNS	GNSS Fix data	OFF
GST	GNSS Pseudorange Error Statistics	OFF
GLL	Geographic Position – Latitude & Longitude	OFF
VTG	Course Over Ground & Ground Speed	OFF
ZDA	Time, Date, & Local Time Zone	OFF

Table 6-2 Available Messages



8. Electrical Interface

8.1. Pinout Diagram and Table

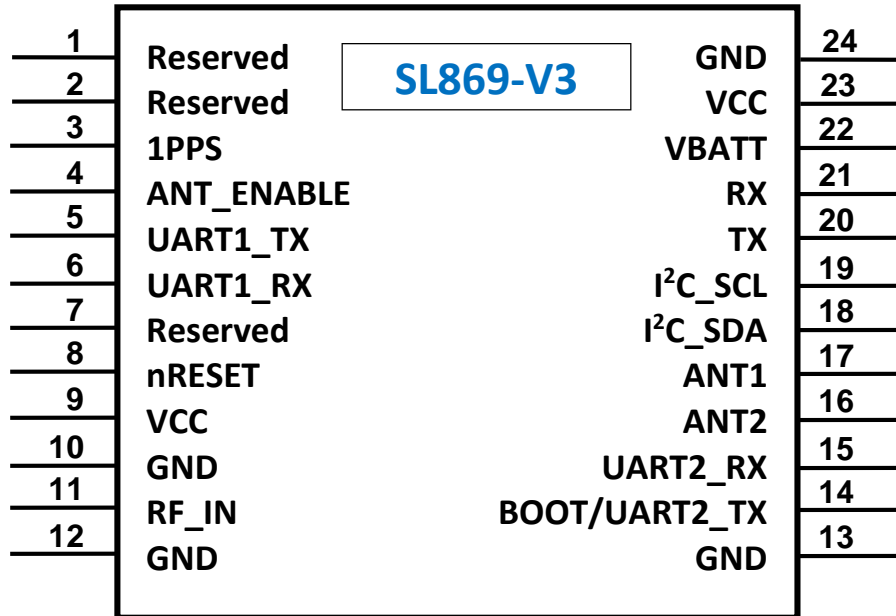


Figure 8-1 SL869-V3 Pin-out Diagram



Pad	Name	Type	Description
1	Reserved	Res	Reserved – Do not connect
2	Reserved	Res	Reserved – Do not connect
3	1PPS	O	Time Mark Pulse
4	ANT_ENABLE	O	Antenna Enable
5	UART1_TX	O	UART1 Transmit
6	UART1_RX	I	UART1 Receive
7	Reserved	Res	Reserved – Do not connect
8	nRESET	I	Reset (active low)
9	VCC	PWR	Internally connected to pin 23. May be externally connected to the Vcc power supply.
10	GND	GND	Ground
11	RF_IN	I	GNSS RF Input, 50 Ohm
12	GND	GND	Ground
13	GND	GND	Ground
14	UART2_TX BOOT	O I	UART2 Transmit BOOT (at power up)
15	UART2_RX	I	UART2 Receive
16	ANT2	I	Antenna sense 2
17	ANT1	I	Antenna sense 1
18	I ² C_SDA	I/O	I ² C Data
19	I ² C_SCL	I/O	I ² C Clock
20	TX	O	Main UART Transmit
21	RX	I	Main UART Receive
22	VBATT	PWR	Battery Backup Supply
23	VCC	PWR	Main 3.3 V Supply Voltage
24	GND	GND	Ground

Note: All GND pins must be connected to ground



Note: Pins 3, 14, and 20 must be LOW when power is applied (for normal operation)

Table 8-1 SL869-V3 Pinout Table



8.2. DC Characteristics

Signal	Description	Min	Typ	Max	Units
V _{OL}	Low level output voltage, I _{OL} 2mA	-	-	0.4	V
V _{OH}	High level output voltage, I _{OH} 2mA	0.75*V _{DD}	-	-	V
V _{IL}	Low level input voltage	-0.3	-	0.45	V
V _{IH}	High level input voltage, I _{IH} 2mA	0.7*V _{DD}	-	3.6	V
R _{PU}	Internal pull-up resistor equivalent		47		kΩ
R _{PD}	Internal pull-down resistor equivalent		47		kΩ
L _I	Input leakage at V _I = 1.8 V or 0 V	-10	-	10	μA
L _O	Tristate output leakage at V _O = 1.8 V or 0 V	-10	-	10	μA
C _I	Input capacitance, digital output	-	8	-	pF

Table 8-2 DC Characteristics

8.3. Absolute Maximum Ratings

Parameter	Pins	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
3.3 V Supply Voltage	VCC	3.6	V
I/O Pin Voltage	All digital inputs	3.60	V

Table 8-3 Absolute Maximum Ratings



8.4. Power Supply

The SL869-V3 module has two power supply pins VCC and VBATT.

8.4.1. VCC

This is the primary 3.3V power supply for the module.

The SL869-V3 includes a switching voltage regulator that supplies the required voltage to the GNSS device and other internal items. These power supply components (including capacitors) are internal to the module.

The external DC voltage supply (including regulators, capacitors, etc.) must be designed to ensure that stable power is maintained within the specifications listed below.

The supply voltage must be within specification within 10 milliseconds of initial application.

The power-up sequence must not be interrupted during the first second or the module may fail to start up. If the module does not initialize correctly due to improper application of VCC_IN, the module can be reset by:

- removing power from both Vcc and Vbatt and then reapplying it in the proper manner
- or
- asserting the nRESET pin (low).

See § 8.4.3 DC Power Requirements for power specifications.

Pin 9 is connected to pin 23 by an internal trace, and may (optionally) be connected to the external supply for pin 23.

8.4.2. VBATT

The Battery Backup supply voltage is used to power the RTC and BBRAM domains. It maintains critical data to enable HOT and WARM starts.

Internal diode OR'ing provides an internal source for VBATT even if this pin is not used.

An internal reset of the module is generated upon removal and reapplication of VBATT (not VCC_IN). If the module does not initialize correctly due to improper application of VCC_IN, the module can be reset by:

- removing power from both Vcc and Vbatt and then reapplying it in the proper manner
- or
- asserting the nRESET pin (low).

See § 8.4.3 DC Power Requirements for power specifications.



8.6. Antenna interface

8.6.1. External Active Antenna Voltage

If an active antenna or external LNA is used, an external source is required to provide voltage to it. This may be the same source that is used to supply the module or it may be a separate source.

A DC blocking capacitor is not required since it is built-in to the module.

8.6.2. Antenna Enable

The Antenna Enable output can be used to control an external power supply to an active antenna (or external LNA, etc.). It will be high when the receiver is operating, or low when it is in a low-power (standby) mode.

8.6.3. Antenna Sense

The Antenna Sense feature will measure the current consumed by the external LNA or active antenna using two comparators with hysteresis. With 3.3 V supplied, a 1 Ω sense resistor yields input voltages to indicate the state of the antenna. The FW reads these lines and provides an output message for antenna NORMAL, OPEN, or SHORTED. This message can be configured to be output periodically or whenever the status changes.

Please refer to § 9.2 SL869-V3 reference design with Antenna enable & antenna sense for details.

The **Antenna Sense application note** is available under a Non-Disclosure Agreement.

8.7. Control and Status signals

8.7.1. Startup Requirements



For normal startup, pins 3, 14, and 20 must be LOW. They have internal pulldowns

8.7.2. nRESET



Asserting nRESET (pull low, then release) will clear the contents of SRAM and RTC. The module will begin operation with a cold start after nRESET is released.

nRESET should not be held low.

Since the BOOT SELECT pin is read when nRESET is released, it must be set to the desired input level before nRESET is released.

8.7.3. Boot Select

Low for normal operation. This pin has an internal pulldown.

Pull high to load FW into flash memory.

See § 7 **Flash Upgradability** for usage.



8.7.4. 1PPS

1PPS is a one pulse per second signal which is enabled after the receiver has achieved a 2D or 3D position fix. It is disabled if the position fix is lost. The pulse is approximately 25% duty cycle.

8.8. I/O Port Operation

8.8.1. UART Port Operation

The SL869-V3 provides three UART ports which implement a standard asynchronous 8-bit interface.

- Main UART Port (RX/TX): Pins 20 & 21.
The UART can operate at rates from 4800 bps to 1.2288 Mbps.
This is the primary communications port which outputs data and accepts commands in NMEA format.
- Secondary - UART1 Port (RX1/TX1): Pins 5 & 6.
DGPS corrections input in the RTCM SC-104 format may be sent to this port.
- Tertiary - UART2 Port (RX2/TX2): Pins 14 & 15.
This port is not used by the SL869-V3 firmware.
Note that pin 14 is also used to select BOOT.



If the RX signal is used, it is important that it be either high impedance or logic low whenever VCC_IN has been removed from the device. Failure to follow this requirement can lead to improper receiver operation upon the next power-up.

8.8.2. I²C Operation

The I²C port on pins 18 and 19 may be used by custom firmware for proprietary data. Pull-ups are not included inside the module.



9. Reference Designs

9.1. SL869-V3 reference design

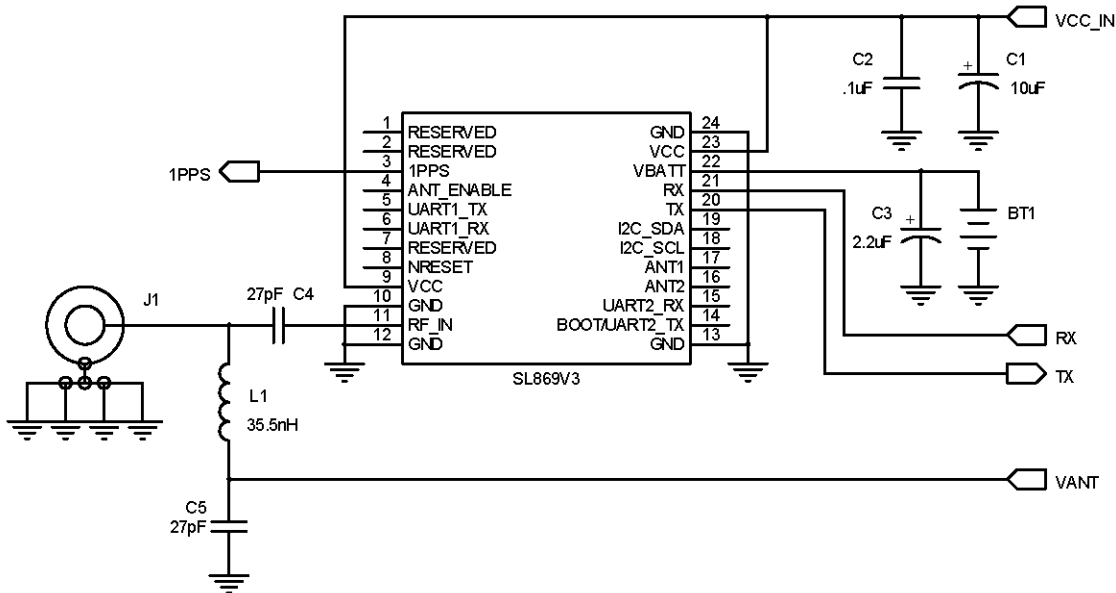


Figure 9-1 SL869-V3 Reference Design

Along with power and ground, the minimum signals required to operate the SL869-V3 properly are four digital signals and one RF signal.

The power supply shown is a minimal design for the SL869-V3 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 SL869-V3.

The RF input can be connected directly to a GNSS antenna. The reference design shows a DC power feed for an active antenna. The inductor L1 is chosen to be self-resonant at the GPS frequency, 1.57542 GHz, to minimize loading on the RF trace. Capacitor C5 is also chosen to be self-resonant at the GPS frequency such that it is close to an RF short at that frequency. V_ANT is the supply voltage for the external active antenna.

TX and RX are typical UART digital I/O lines.
As is the case with all RX lines, the idle state is logic one.
Be careful to tri-state this line if the module is turned off to avoid back-driving.



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 phenomenon where the signal from a particular satellite is reflected and is received by the GNSS antenna in addition to or in place of the line of sight signal. The reflected signal has a path length that is longer than the line of sight path and can either attenuate the original signal, or, if received in place of the original signal, can add error in determining a solution because the distance to the particular satellite is actually shorter than measured. It is this phenomenon 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 GNSS broadcast signals are 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.

In a multipath situation, the direct (line of sight) signal would show a higher signal level with an RHCP antenna than a linearly polarized antenna because the interfering signal is rejected.

However, in the case where the line of sight signal is obstructed, 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 (within 1 or 2 meters) 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 farther 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. Many active antennas also 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 when the firmware build and hardware configuration match the type of antenna used (active or passive). Most receivers automatically adjust the internal LNA gain to accommodate the incoming signal level.

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 the next section 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. However, 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 very weak signals, a good antenna could mean the difference between being able to use a particular satellite signal or not.



10.5. 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.

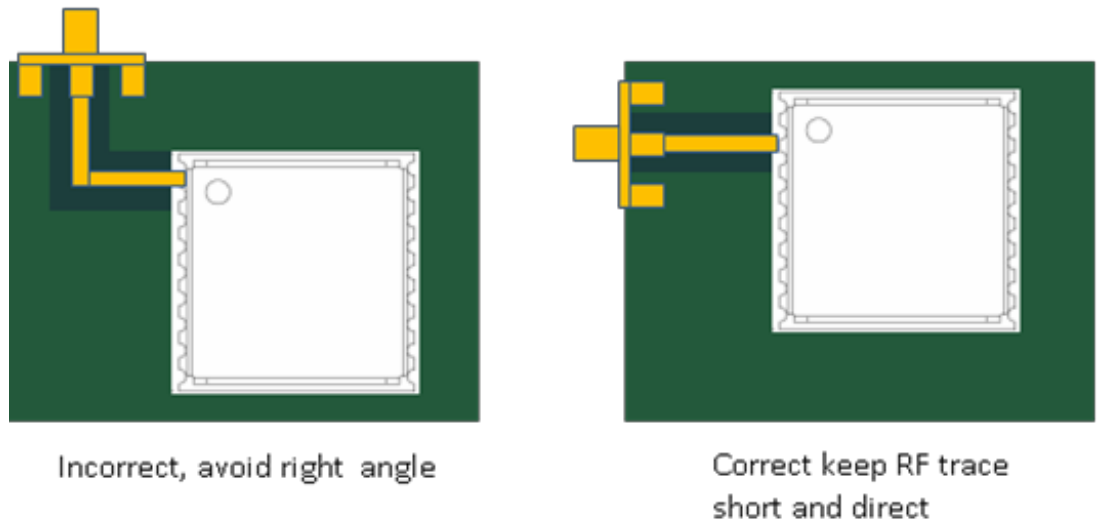


Figure 10-1 RF Trace Examples

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



10.7. Powering an External LNA (active antenna)

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 either by the inductor or by the 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.



10.8. 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 a level of -130 dBm and lower. If signals higher than this are presented to the receiver, the RF front end can be overdriven.

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.

10.9. Shielding

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

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



11. Mechanical Drawing

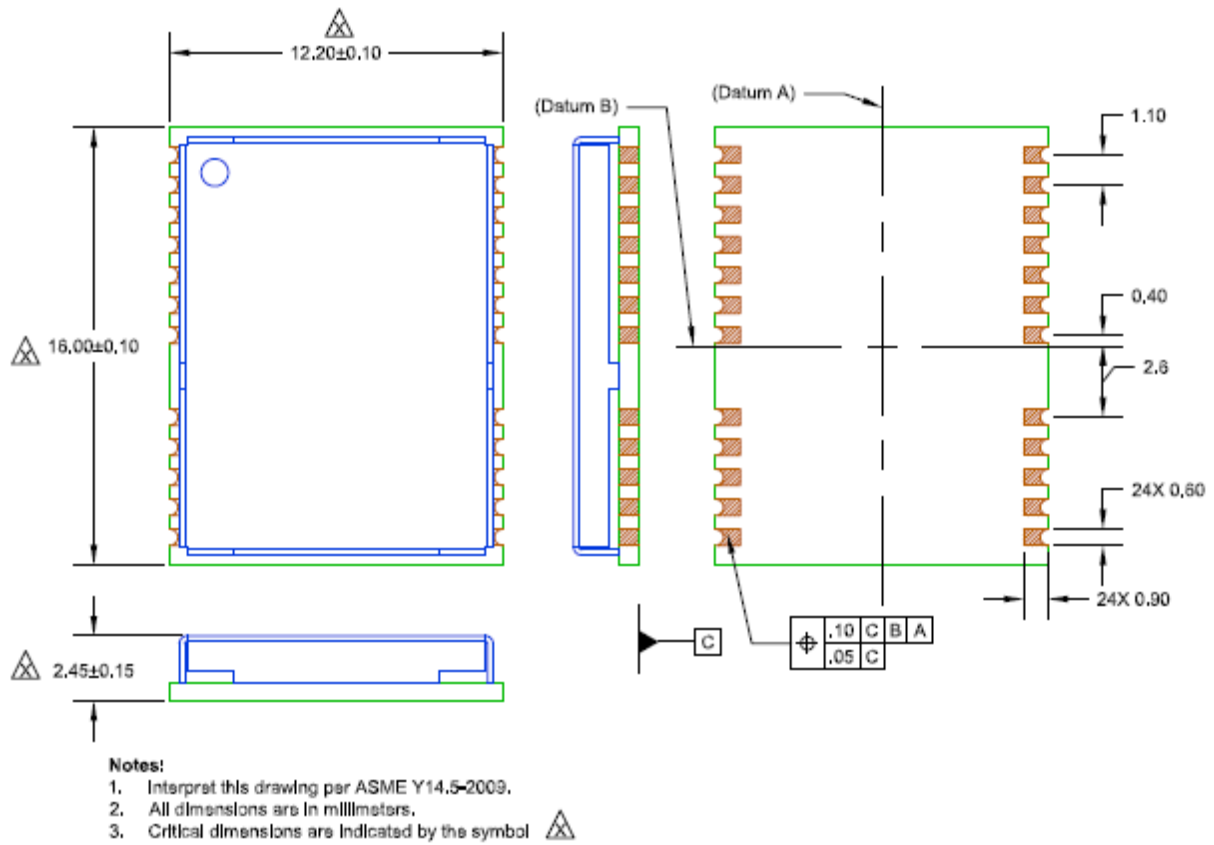


Figure 11-1 SL869-V3 Mechanical Drawing



13. Product Packaging and Handling

13.1. Product Marking and Serialization

The SL869-V3 module label has a 2D Barcode identifying the module and its serial number. Contact a Telit representative for information on specific module serial numbers.

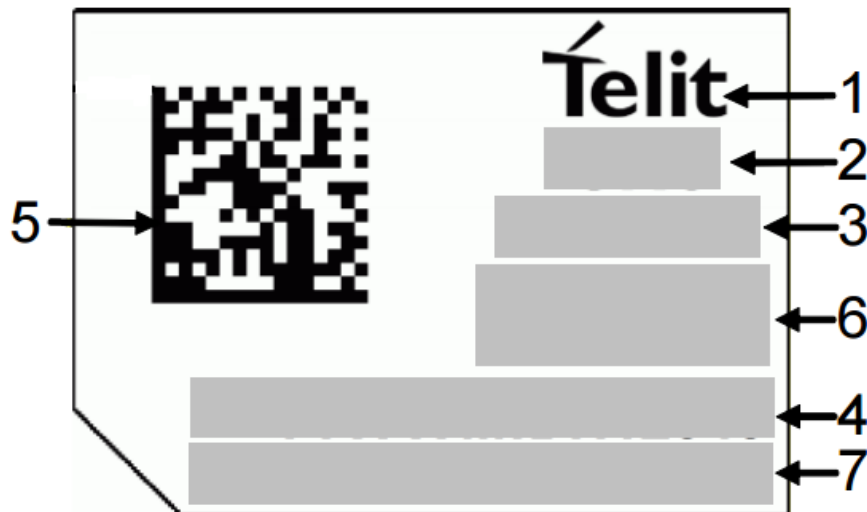


Figure 13-1 Product Label

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

Table 13-1 Product Label Description



13.2. Product Packaging

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

All packaging is ESD protective lined.

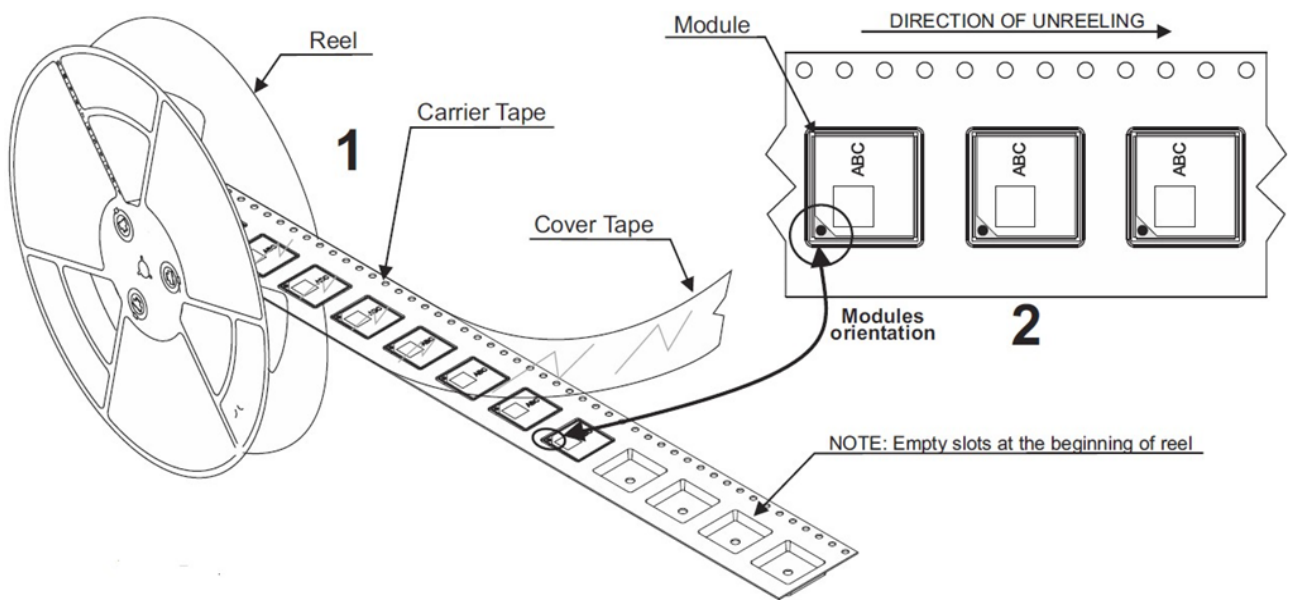


Figure 13-2 Tape and Reel Packaging



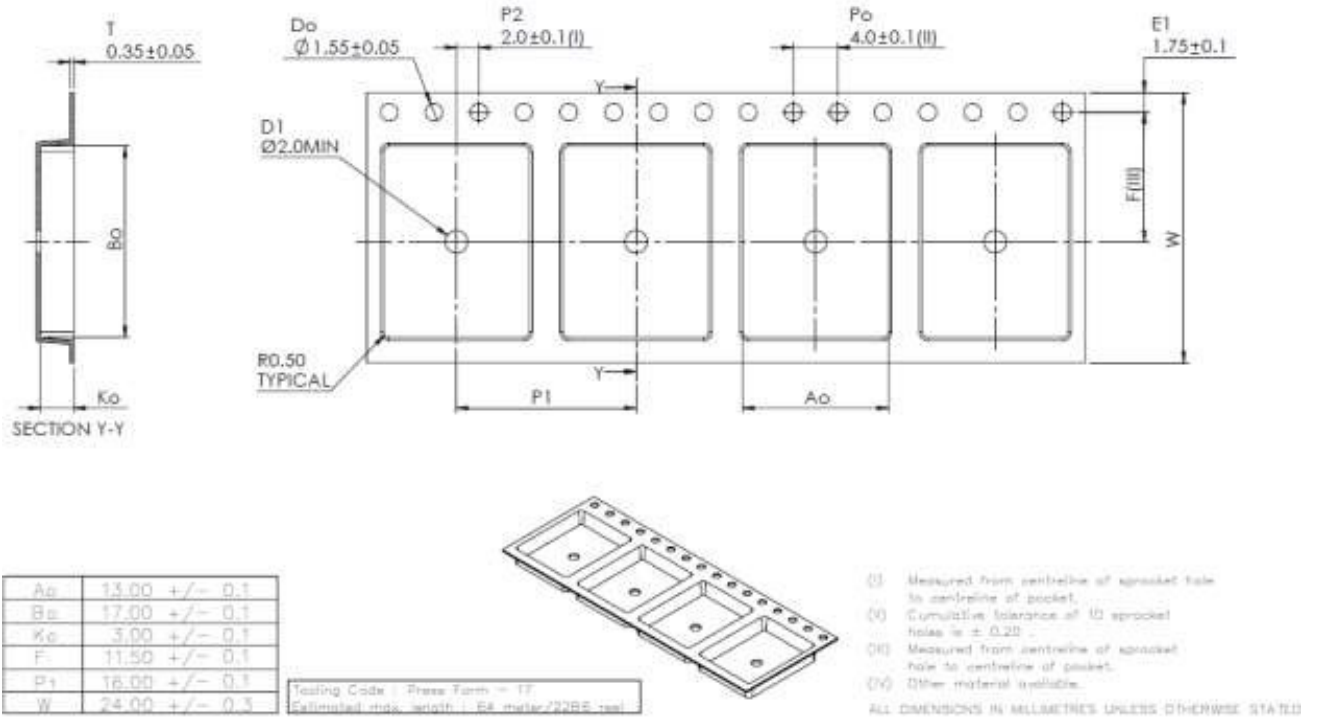


Figure 13-3 Tape and Reel – Tape detail



13.3. Moisture Sensitivity

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

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

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

If the package has been opened or the humidity indicator card indicates above 10%, then the parts will need to be baked prior to reflow. The parts may be baked at $+125^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 48 hours.




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

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

NOTE:

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





CAUTION

This bag contains
MOISTURE-SENSITIVE DEVICES

LEVEL

3

If Blank, see adjacent
bar code label

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

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

Bag Seal Date: _____
If Blank, see adjacent bar code label

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

Figure 13-5 Moisture-Sensitive Device Label



13.4. ESD Sensitivity

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

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

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

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

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

13.5. Reflow

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



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

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

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

13.6. Assembly Considerations

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

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



14. Environmental Requirements

14.1. Operating Environmental Limits

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

Table 14-1 SL869-V3 Operating Environmental Limits

14.2. Storage Environmental Limits

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

Table 14-2 SL869-V3 Storage Environmental Limits



15. Compliances

The SL869-V3 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: 2008 accredited facility
- Manufactured to TS 16949 requirement (upon request)

The module conforms to the following European Union Directives:

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



15.1. CE Declaration of Conformity

- SL869-V3 Certificate in process



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

BeiDou (BDS) - formerly COMPASS:

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

Cold Start:

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

Cold Start Acquisition Sensitivity:

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

EGNOS: European Geostationary Navigation Overlay Service

The European **SBAS** system.

Ephemeris (plural ephemerides):

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

ESD: Electro-Static Discharge

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

GAGAN:

The Indian **SBAS** system.



Galileo:

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

GDOP: Geometric Dilution of Precision

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

GLONASS: ГЛОБАЛЬНАЯ НАВИГАЦИОННАЯ СПУТНИКОВАЯ СИСТЕМА

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

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

GNSS: Global Navigation Satellite System

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

GPS: Global Positioning System

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

Hot Start:

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

LCC: Leadless Chip Carrier

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

LNA: Low Noise Amplifier

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

Local Ephemeris prediction data:

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

MSAS: MTSAT Satellite Augmentation System

The Japanese **SBAS** system.

MSD: Moisture sensitive device.

MTSAT: Multifunctional Transport Satellites

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



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

NMEA: National Marine Electronics Association

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

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

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

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

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

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

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

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

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

TCXO: Temperature-Compensated Crystal Oscillator

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



TTF: 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

PLEASE READ CAREFULLY

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

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

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

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

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

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

The European Community provides some Directives for electronic equipment introduced on the market. All the relevant information 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** and the module shall be mounted on a PCB which complies with V-0 flammability class.

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



18. Document History

Revision	Date	Changes
0	2016-08-22	First Issue
1	2016-09-02	Added requirements for normal startup to the Electrical Interface chapter
2	2016-09-22	Removed Power Management chapter.

