

SE868-V3 Product User Guide

1VV0301205 r4 – 2016-01-20



APPLICABILITY TABLE

PRODUCT
SE868-V3



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1. Introduction

1.1. Purpose

The purpose of this document is to provide product information for the SE868-V3 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

TS-EMEA@telit.com

TS-APAC@telit.com

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.



2. Product Description

The SE868-V3 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 SE868-V3 module is based on the SiRFstar 5e (B02) flash GNSS chip.

The SE868-V3 is pin-compatible with the SE868-V2 and JF2 modules with some differences for drop-in replacement. See **Section 5 Product Compatibility** for details.

2.1. Product Overview

- Complete GNSS receiver module including memory, LNA, TCXO, and RTC
- Based on the SiRFstar 5e (B02) flash GNSS chip
- Same footprint as JF2 and SE868-V2 modules (see **Product Compatibility** section)
- 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, I²C, or SPI interface
- Second serial port is configurable for UART or I²C interface
- The Second port may be used for MEMS wakeup (with FW support)
- 16 Megabit built-in flash memory
- 70 mW typical power consumption (Full Power mode, GPS + GLONASS)
- 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
- 11 x 11 x 2.62 mm 32-pin QFN package
- Surface mountable by standard SMT equipment
- RoHS compliant design



2.2. Product Variants

2.2.1. Hardware

The first generation of SE868-V3 (Gen 1) was replaced by the second generation (Gen 2) variant in January 2016. SE868-V3 (Gen 2) is fully backward compatible and has a reduced power consumption of approximately ~35%.

Feature	SE868-V3 (Gen 1)	SE868-V3 (Gen 2 Low power)
Power Supply	Linear	Switching
P/N ID	SE868V3AxxxPyyy	SE868V3BxxxPyyy

Table 2.1 SE868-V3 Product Variants - Hardware

2.2.2. Firmware

The firmware has two variants:

Feature	High Gain	Low Gain
Internal Gain default	High	Low

Table 2.2 SE868-V3 Product Variants - Firmware



2.3. Block Diagram

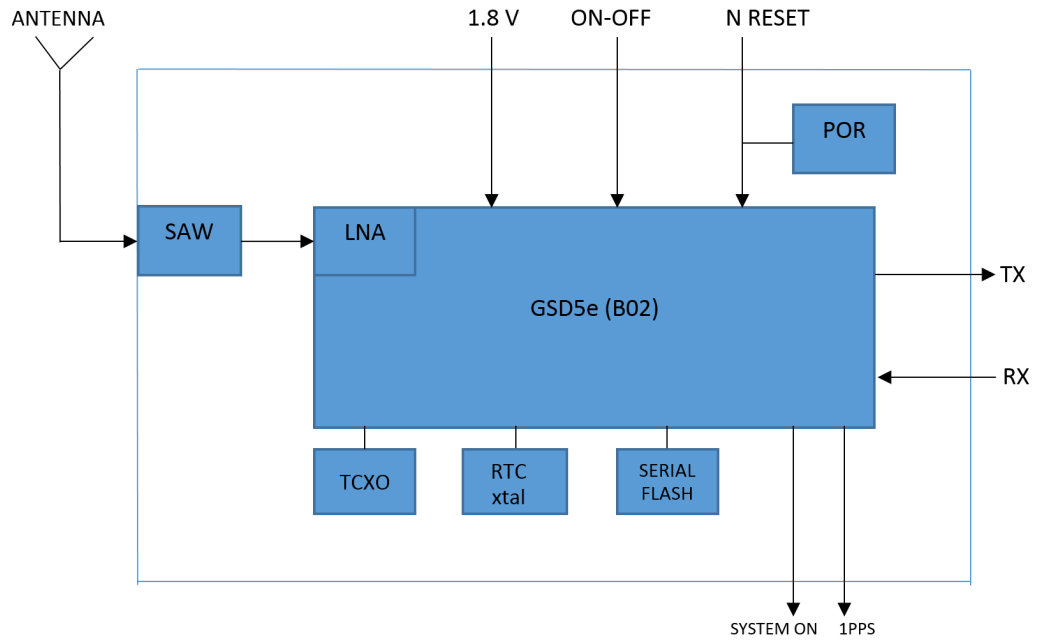


Figure 2-1 SE868-V3 Block Diagram



2.4. SE868-V3 Module Photo



Figure 2-2 SE868-V3 Module Photo





Figure 3-2 SE868-V3 Evaluation Kit



4.5. Assisted GPS (AGPS) - SiRFInstantFix™

Assisted GPS (or Aided GPS) is a method by which TTFF is improved (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 different from 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.



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):**

If an external LNA is used, 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 Setting	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

If the external gain is undetermined, use the low gain firmware build

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 5th 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

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 when the fix goes invalid. However, if Velocity DR (see **Section 4.8 Velocity Dead-Reckoning**) is enabled, the 1PPS pulse is disabled after the position fix becomes invalid and the Velocity DR timeout has expired.

The time mark is within 1 μ s of the GPS epoch and typically within 100 ns.

The 1PPS pulse width is 250 ms.

4.13. Device Wake-up (1st Port)

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

See **Section 9.7 Host I/O Port Configuration and Operation** for details.

Contact Telit support for implementation of this signal.

4.14. MEMS Wakeup (2nd Port - I²C)

If the 2nd port is operating as I²C, the module can configure a Kionix KXCJ9 MEMS accelerometer to generate a signal when a threshold is exceeded. This signal can be connected to a GPIO external interrupt which will cause the module to wake up from a low power state. Use of this feature will require a custom configured firmware build. Please contact Telit for further details.

See **Section 9.7 Host I/O Port Configuration and Operation** for details.

4.15. Message Waiting (Data Ready Indicator)

The module will raise the MW (DRI) signal when data is waiting to be transmitted on port 0 and it is configured for either UART (with flow control enabled) or SPI interface.

See **Section 9.7 Host I/O Port Configuration and Operation** for details.

4.16. I/O Communication Ports

The 1st host port can be configured to communicate using UART, I²C, or SPI interface and supports UART Device Wakeup.

The 2nd host port can be configured for UART or I²C interface and supports I²C MEMS wakeup.

See **Section 9.7 Host I/O Port Configuration and Operation** for details.



4.17. 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 modes save power based on satellite signal strength.
	SiRFSmartGNSS 1	
	SiRFSmartGNSS 2	
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

4.17.1. 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. This is the default.

4.17.2. 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.

4.17.2.1. SmartGNSS I

SmartGNSS I autonomously manages GNSS system usage based on signal conditions to save power.

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.



4.17.2.2. 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.

4.17.3. Trickle Power

This mode cycles between FULL POWER and STANDBY states. It provides GPS-only navigation updates based on a duty cycle which can be set from 100 ms to 900 ms ON time. The system runs in full power until it learns ephemeris and RTC calibration, then switches to the specified duty cycle periods. If signals are weak or the fix is lost, the receiver will go to the FULL POWER state. TricklePower mode yields significant power savings in strong signal conditions. 1PPS is not available.

4.17.4. 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 also allows QoS checks to be enabled or disabled.

4.17.5. 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.

4.17.6. 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 Compatibility

The SiRFstarV (B02)-based SE868-V3 module incorporates new technology compared to the previous SiRFstarIV and V-based designs. The SE868-V3 offers an upgrade path from existing Telit and competitive designs.

The SE868-V3 is footprint-compatible with the SE868-V2 & JF2 family but it is not a drop-in replacement. Some of the pins have a slightly different function. The designer will have to modify the antenna and possibly other components in the RF path to accommodate the GLONASS, BeiDou, and Galileo as well as the GPS signals. It may be possible to use the SE868-V3 in place of some JF2 variants (design guidelines specified must be followed).

5.1. Upgrading JF2 designs to the SE868-V3



The SE868-V3 is a footprint-compatible replacement or upgrade for the JF2 variants (Flash, EE, and ROM). However it is NOT design compatible. A SE868-V3 cannot be dropped into a JF2 design and operate properly. Listed below are differences between the JF2 and the SE868-V3 and the necessary external changes. There are other variations between the products that also prevent them from being drop in replacements (such as differences in software) that are not discussed here. Consult Telit support for more information.

- The ON-OFF signal for the SE868-V3 is level sensitive. High turns the module on; low puts the module into HIBERNATE. The ON-OFF signal on the JF2 is edge sensitive.
- The SE868-V3 adds a new DC power pin. For compatibility with the JF2 flash and ROM variants, a zero ohm jumper has been added internally so this pin will not need to be powered. However, we recommend that it be connected to 1.8 V. The previous JF2 variants had this pin as a no-connect. If the customer grounded this pin in their design, it will short the 1.8 volt supply directly to ground.
- The SE868-V3 does not support EEPROM. It uses internal SQIF flash memory.
- The SE868-V3 supports DR I²C for MEMs wakeup on the 2nd port, but the previous accelerometer (Kionix KXTF9) is deprecated and has been replaced by the Kionix KXCJ9.
- GPIO 3 is not supported and is not brought out to any module pin.
- For the SE868-V3, GPIO8 is an output signal to enable an external LNA. The external LNA should be enabled when GPIO8 is high. For passive antennas, GPIO8 can be left unconnected or connected to monitor the status of the receiver. The GPIO8 signal was used for LNA gain control in the JF2.
- The SE868-V3 is a complete GNSS receiver that is capable of using Satellites from the GLONASS or BEIDOU constellations. The JF2 module only used GPS signals (with a center frequency of 1575.42 MHz). The GLONASS frequency range is approximately 1598 to 1607 MHz. The BeiDou signal has a center frequency of 1561.098 MHz. Appropriate design consideration should be taken when selecting the antenna and any external LNA.



- For the JF2 module, the idle state of the host port I/O lines is logic high. Care must be used to prevent backdriving the RX line when the module is powered down. This is no longer a consideration with the SE868-V3.

5.2. Upgrading SE868-V2 designs to the SE868-V3



The SE868-V3 is a footprint compatible replacement or upgrade for the SE868-V2. However, an SE868-V3 cannot be dropped into a SE868-V2 design and operate properly without minor changes. Listed below are differences between the SE868-V2 and the SE868-V3 along with the necessary external changes. There are other variations between the products that also prevent them from being drop in replacements, such as variations in software, that are not discussed here. Consult Telit support for more information.

- The ON-OFF signal for the SE868-V3 is level sensitive. High turns the module on; low turns the module off. The ON-OFF signal on the SE868-V2 is edge sensitive.
- The SE868-V3 can use the BOOT pin to program the device, although SiRFLive does not require it. The Boot pin was a no connect on the SE868-V2 (which used ROM).
- The SE868-V2 uses an internal SPI flash connected to GPIO0, GPIO1, GPIO3 and GPIO4. The SE868-V3 uses internal SQIF memory. GPIO3 is not supported and is not brought out to any SE868-V3 module pin. The remaining GPIO lines are available for use depending upon software support.
- The SE868-V3 supports DR I²C for MEMs wakeup on the 2nd port, but the previous accelerometer (Kionix KXTF9) is deprecated and has been replaced by the Kionix KXCJ9.
The SE868-V2 does not support DR I²C for MEMs wakeup because the 2nd port is used by the internal SPI flash.
- For the SE868-V3, GPIO8 is an output signal that can be used to enable or disable an external LNA. The LNA should be enabled when GPIO8 is high and disabled when low. For passive antennas, GPIO8 can normally be left unconnected or connected to monitor the status of the receiver. For the SE868-V2, GPIO8 was an input to select LNA gain.
- Pin 6 is reserved on the SE868-V3 and should not be connected to any external circuit. It was a Ground on the SE868-V2.



6.2. Time to First Fix

Constellations(s)	Start Type	Max TTFF (s)
GPS	Hot	1.0
	Warm - Assisted	7.5
	Warm	30
	Cold	31
Glonass	Hot	3.2
	Warm	32.6
	Cold	53.9
GPS + GLO	Hot	1.1
	Warm	22.8
	Cold	27
GPS + BeiDou	Hot	1.1
	Warm	29.7
	Cold	32.2
Test Conditions: Static scenario, -130 dBm, Full Power mode		

Table 6-2 SE868-V3 Time To First Fix



6.3. Sensitivity

Constellation(s)	State	Minimum Signal Level (dBm)
GPS	Acquisition	-146
	Navigation	-161
	Tracking	-165
GLONASS	Acquisition	-145
	Navigation	-158
	Tracking	-162
BeiDou	Acquisition	-142
	Navigation	-150
	Tracking	-156
GPS + GLO	Acquisition	-146
	Navigation	-161
	Tracking	-165
GPS + BeiDou	Acquisition	-146
	Navigation	-161
	Tracking	-165

Test conditions: Static scenario under ideal lab conditions using a GNSS simulator.

Table 6-3 SE868-V3 Sensitivity



7. 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)

7.1. NMEA Output Messages

Defaults:

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

7.1.1. Standard Messages

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

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

Table 7-1 Default NMEA Output Messages



The following messages can be enabled by command:

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

Table 7-2 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 7-3 NMEA Talker IDs

7.1.2. Proprietary Output 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.



7.2. 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.

7.2.1. 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.

7.2.2. Change data rate

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

7.2.3. 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.

7.3. OSP Output Messages

Please refer to SiRF OSP documentation.

7.4. OSP Input Commands

7.4.1. Change output messages

Use OSP MID 166 to change the output messages.

7.4.2. Change data rate

Use OSP MID 134 to change the baud rate

7.4.3. 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.



8. Flash Upgradability

The firmware stored in the internal Flash memory of the SE868-V3 may be upgraded via the serial port TX/RX pads.

Please refer to the SE868-V3 Evaluation Kit User Guide to update the firmware.



9. Electrical Interface

9.1. Module Pin-out

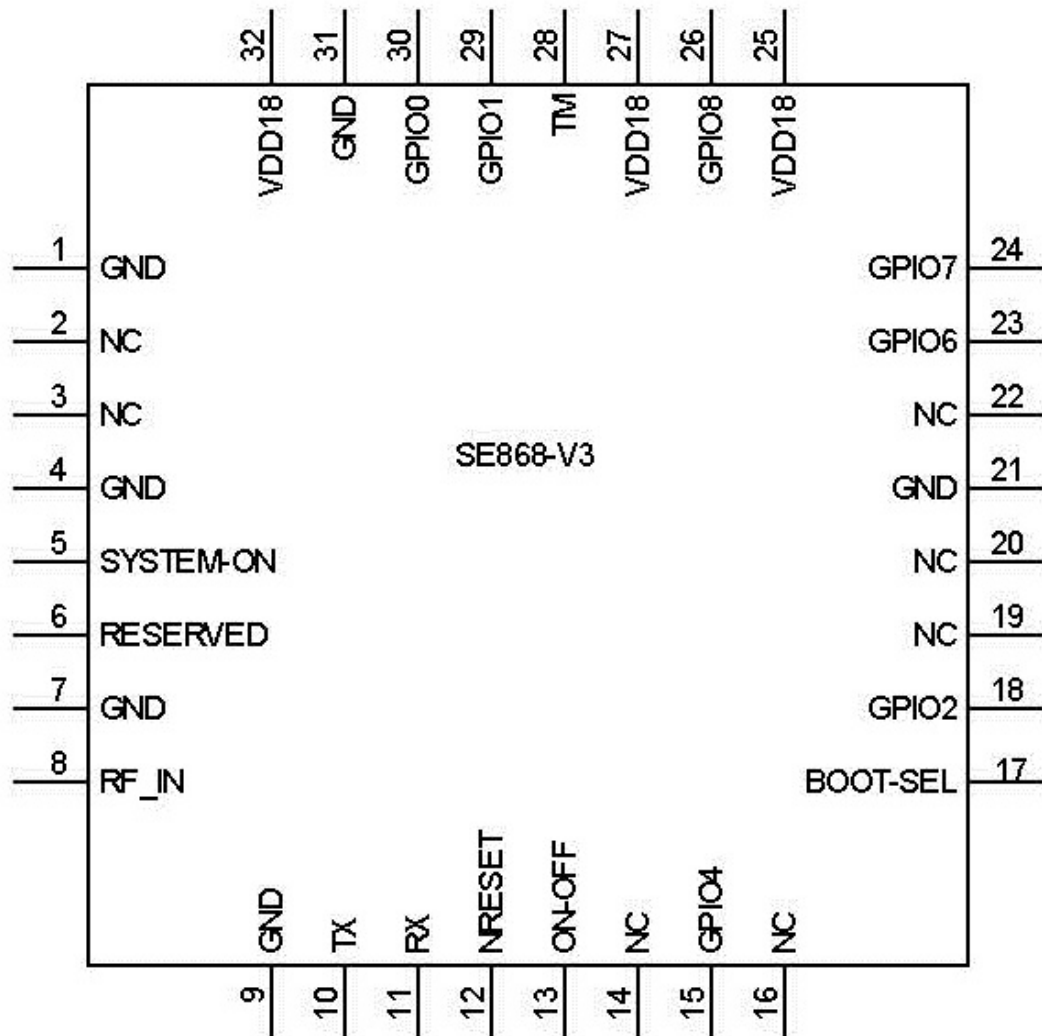


Figure 9-1 SE868-V3 Pin-out Diagram



Pin	Name	Type	Function
Power			
25, 27, 32	VDD18	P	Connect all pins to 1.8 V supply. See Section 9.4 Power Supply .
Ground			
1, 4, 7, 9, 21, 31	GND	G	Connect all pins to ground.
RF Input			
8	RF_IN	I	RF Input. See Section 9.8 RF Interface . No DC voltage may be applied.
Control Input			
13	ON-OFF	I	On/Off. See Section 9.4.4 ON-OFF (input) and SYSTEM-ON (output)
12	NRESET	I	Reset (active low). See Section 9.5 Reset . This signal is not necessary for normal operation and may be brought out to a test point or left unconnected.
17	BOOT-SEL	I	Low during normal operation. BOOT-SEL may be driven high to force the module into the programmable state. BOOT-SEL is read prior to the host select lines (GPIO 6 & 7). If not used, this pin should be left floating or (preferably) brought out to a test point. See Section 8 Flash Upgradability .
23	GPIO6	I	GPIO 6 & 7 are read only at powerup and reset events to configure the 1st host serial port. See Section 9.7.1 Host Port Configuration for 1st Port . After configuration, they may be enabled for UART or SPI signal lines, depending on the firmware configuration.
24	GPIO7	I	
Output			
5	SYSTEM-ON	O	Indicates the power state of the module. Also called Wakeup . See section 9.4.4ON-OFF (input) and SYSTEM-ON (output)
26	GPIO8	O	External LNA control. Also called GNSS_ON . See Section 4.10 Internal LNA .
28	TM	O	1 PPS time mark. See Section 4.12 1PPS
1st Host Communications Port I/O See Section 9.7.1 Host Port Configuration for 1st Port			
10	TX	I/O	1 st Port I/O: UART-Xmit (TX), I ² C- Clock (SCL), or SPI-Data Out (MISO)
11	RX	I/O	1 st Port I/O: UART-Recv (RX), I ² C- Data (SDA), or SPI-Data In (MOSI)
23	GPIO6	I/O	After configuration, may be used for 1 st port: UART-CTS or SPI-SCLK
24	GPIO7	I/O	After configuration, may be used for 1 st port: UART-RTS or SPI-nCS
2nd Host Communications Port I/O See Section 9.7.2 Host Port Configuration for 2nd Port			
29	GPIO1	I/O	2 nd Port I/O: UART-Recv (RX), MEMS I ² C Clock (SCL)
30	GPIO0	I/O	2 nd Port I/O: UART-Xmit (TX), MEMS I ² C Data (SDA)
GPIO			
15	GPIO4	I/O	Function depends on Firmware configuration. Leave unconnected.
18	GPIO2	I/O	Function depends on Firmware configuration. Leave unconnected.
No Connection			
2, 3, 14, 16, 20, 22	NC	NC	No Connection.
19	NC	NC	No Connection in SE868-V3. (Was GPIO3 in SE868-V2).
Reserved			
6	Reserved	R	Reserved - Do not connect to any external circuit. (Was GND in SE868-V2).

Table 9-1 SE868-V3 Pin-out Function Table



9.2. 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	50	86	157	kΩ
R _{PD}	Internal pull-down resistor equivalent	51	91	180	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 9-2 DC Characteristics

9.3. 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
1.8 V Supply Voltage	VDD_18	2.2	V
I/O Pin Voltage	All digital inputs	3.60	V

Table 9-3 Absolute Maximum Ratings



9.4. Power Supply

9.4.1. Voltage Supply Design

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

9.4.2. 1.8 V Supply Voltage

Unlike some previous GNSS receiver modules, the SE868-V3 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 state of the SE868-V3 can be determined by monitoring the “SYSTEM-ON” signal. See **section 9.4.4 ON-OFF (input) and SYSTEM-ON (output)**.

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, first 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 state.

To prevent the reset, the 1.8 volt supply must be regulated to be within ± 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.

9.4.3. 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 9-4 DC Supply Voltage



9.4.4. ON-OFF (input) and SYSTEM-ON (output)

The SE868-V3 module has three power states: OFF, RESET, and ON.
The ON state has three substates: HIBERNATE, STANDBY, and RUN.

The OFF state exists when power is removed from the module.

Upon initial application of power, the module enters the RESET state until the internal reset process is completed. It then transitions (at least briefly) to the ON state.

In the ON state, the module will transition to either the RUN or HIBERNATE substate depending on the status of the ON-OFF pin.

- If the ON-OFF pin is high, the module will transition to the RUN substate.
- If the ON-OFF pin is low, the module will transition to the HIBERNATE substate.

Note: The ON_OFF pin must not be tied to V18 because it must be brought low, then high to transition out of a commanded hibernate state.

The module will transition to the RESET state when external reset (nRESET) is pulled low, or upon internal reset (e.g. supply voltage out of spec). The external nRESET signal takes precedence over the state of the ON-OFF signal. SYSTEM-ON will be logic low.

While in the ON state, there are three substates, depending upon the status of the ON-OFF pin, commands or selected power management modes. The three substates are: HIBERNATE, STANDBY, and RUN.

The module transitions between RUN and STANDBY via TricklePower modes; and between RUN and HIBERNATE via PushToFix and SiRFaware modes. It can also transition from RUN to HIBERNATE by de-asserting the ON-OFF signal. The firmware is configured to transition from HIBERNATE to RUN when data is received on the RX pin. Note that the first character received is invalid in this case, so the command will not be acted upon.

- In the RUN substate, the SYSTEM-ON signal will be logic high.
- In the STANDBY OR HIBERNATE states, SYSTEM-ON will be logic low.

To execute an orderly shutdown, first place the module in the HIBERNATE substate, then remove power.

Also, see **Section 9.5 Reset**.



9.4.5. DC Power Consumption

9.4.5.1. SE-868-V3 Gen 1 (Linear Mode Power Supply)

The SE868-V3 Gen 1 has been replaced by SE868-V3 Gen 2. See § 9.4.5.2.

SE868-V3 Gen 1 (Linear)	Power Mode	Smart 2		Smart 1		Full Power		Units	
		Sym	Typ	Max	Typ	Max	Typ		Max
Acquisition									
GPS only					72	98	84	111	mW
GPS and Glonass					92	117	101	125	mW
GPS and BeiDou					94	122	100	130	mW
Navigation/Tracking									
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
Low Power – Trickle Power									
GPS only – Push to Fix					32				mW
GPS and Glonass – Push to Fix					42				mW
GPS and BeiDou – Push to Fix					44				mW
Low Power – Push To Fix									
GPS only – Push to Fix					27				mW
GPS and Glonass – Push to Fix					34				mW
GPS and BeiDou – Push to Fix					35				mW
Battery Backup (Hibernate)	Batt							62	uW
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 9-5 Power Consumption – SE868-V3 Gen 1



9.4.5.2. SE-868-V3 Gen 2 (Switching Mode Power Supply)

SE868-V3 Gen 2 (SMPS)	Power Mode	Smart 2		Smart 1		Full Power		Units
		Sym	Typ	Max	Typ	Max	Typ	
State & Constellation								
Acquisition								
GPS only	I _{cc}					58	80	mW
GPS and Glonass	I _{cc}	76	99	77	98	76	95	mW
GPS and BeiDou	I _{cc}					75	97	mW
Navigation/Tracking								
GPS Only	I _{cc}					53	82	mW
GPS and Glonass	I _{cc}	44	70	51	78	70	98	mW
GPS and BeiDou	I _{cc}					70	98	mW
Battery Backup (Hibernate)	I _{BATT}					69		uW
Operating temperature: 25°C. Supply voltages: 1.8 VDC nominal Low Power mode: 500 ms duty cycle. Periodic Mode: Default settings - asleep for 12 s, then awake for 3 s.								

Table 9-6 Power Consumption – SE868-V3 Gen 2



9.5. 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 9.4.4 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.

9.6. 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 (preferably) may be brought out to a test point.



9.7. 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 9.7.1 Host Port Configuration for 1st Port** for details of port configuration.

Device Wake-up (1st Port)

The module will wake up from a commanded HIBERNATE state if the ON_OFF signal remains high and there is a data transition on port 0 (the first port). The wake-up message will not be acted upon since the receiver is not operating until after wake-up. See Section 9.7 Host I/O Port Configuration and Operation for details.

Contact Telit support for implementation of this signal.

The second host port is configured in the firmware build with one of two options:

- UART for message and command communication
- I²C for MEMS wakeup

Note: SPI is not available because it requires 4 pins

The default is I²C for MEMS wakeup.

Please contact Telit support for details of port configuration. Also, see **Section 4.14 MEMS Wakeup (2nd Port - I2C)**.

9.7.1. Host Port Configuration for 1st 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 GPIO7 at start-up or reset (only). The following table gives the required input signals:

Pin	Pullup / Pulldown	UART	I ² 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 9-7 Host I/O Port Configuration – First port (port 0)

Note: GPIO6 and GPIO7 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.



9.7.2. Host Port Configuration for 2nd Port (port 1)

The second host port default configuration is determined in the firmware build.

9.7.3. UART Operation

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

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

After configuration, the pins are defined as follows:

Pin Name	UART Function
First Port	
TX0	Transmit Data (TX)
RX0	Receive Data (RX)
GPIO6	CTS (if enabled)
GPIO7	RTS (if enabled)
Second Port	
TX1	Transmit Data (TX1)
RX1	Receive Data (RX1)

Table 9-8 UART Pin Assignments

Note: Flow control is disabled by default.



9.7.4. I²C Operation

Upon power up, the module acts as a master transmitter and a slave receiver (multi-master mode) on the second port.



When used in I²C mode, external 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.

The default configuration is Multi-master. This can be changed to slave mode using an OSP command MID 178, SID 1.

Clock rates of 100 and 400 kbps are supported.

The operation of the I²C 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 I²C bus allows for contention resolution between module and host vying for the bus.

After configuration, the pins are defined below:

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

Table 9-9 I2C Pin Assignments



9.7.5. SPI Operation

See **Section 9.7.1 Host Port Configuration for 1st Port** to specify SPI interface.
The 2nd 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
First Port	
TX0	SPI Data Out (MISO)
RX0	SPI Data In (MOSI)
GPIO6	SPI Clock (SCLK)
GPIO7	SPI Chip Select (CS#)
Second Port	
Not Available	

Table 9-10 SPI Mode Pin Assignments



9.8. RF Interface

9.8.1. 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 RF input pin is ESD sensitive.

The SE868-V3 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.

9.8.2. 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.

9.8.3. Burnout Protection

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

9.8.4. 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.



9.8.5. Frequency Plan

Signal	Frequency (MHz)
TCXO Frequency	26.000
LO Frequency	1588.6

Table 9-11 Frequency Plan

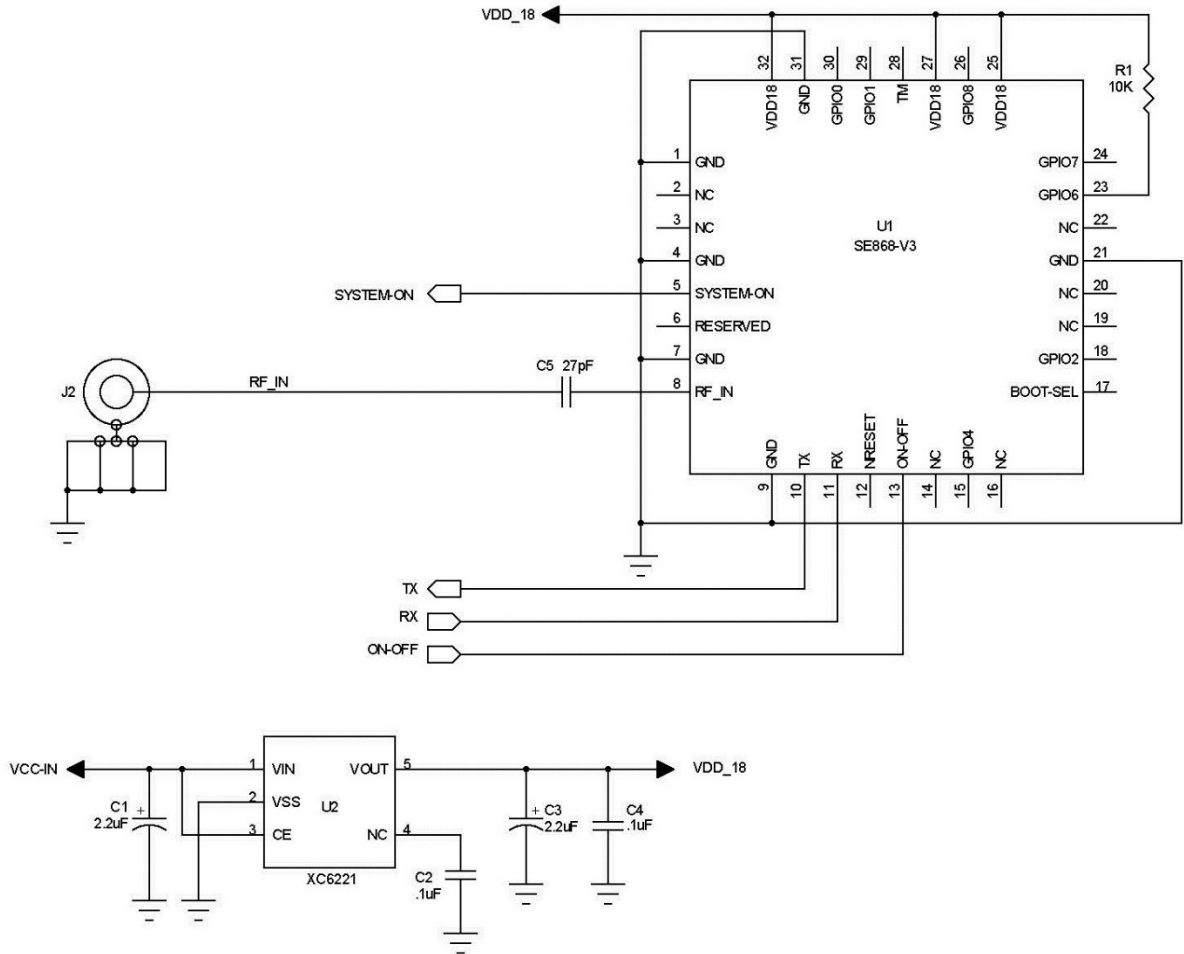
9.9. Local Oscillator Leakage

Signal	Level
LO Leakage	-70 dBm (typical)

Table 9-12 LO Leakage



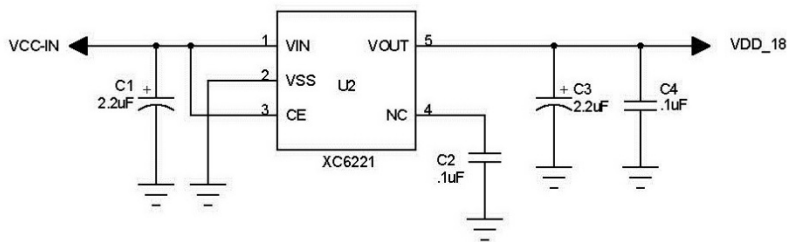
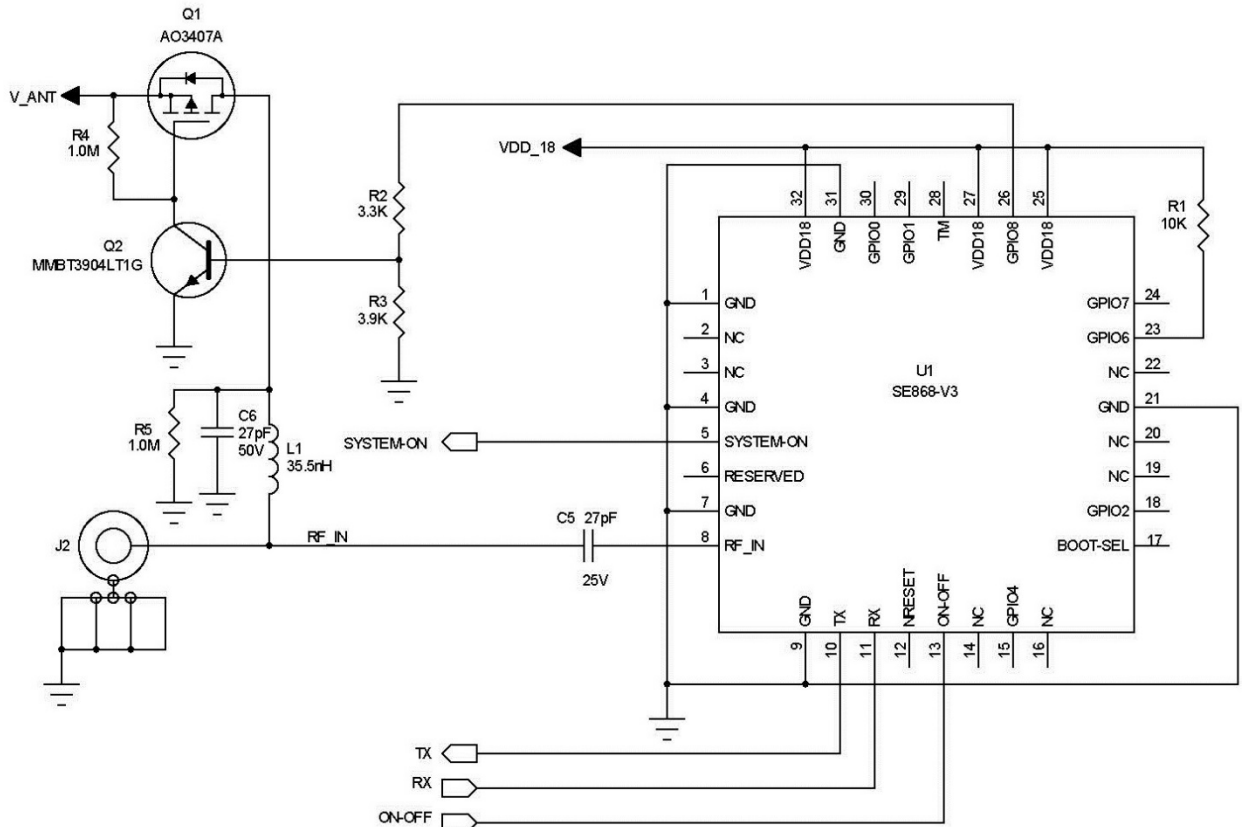
10. Reference Designs



Note: XC6221 is the DC voltage supply regulator

Figure 10-1 SE868-V3 Reference Design – Passive Antenna





Note: XC6221 is the DC voltage supply regulator

Figure 10-2 SE868-V3 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 I²C 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 (1.8 V), otherwise the logic level will be low.

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 9.7 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.



11. RF Front End Design

11.1. RF Signal Requirements

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

11.2. 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.



11.3. 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.

11.4. 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 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. 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.



11.5. 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 11-1 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.

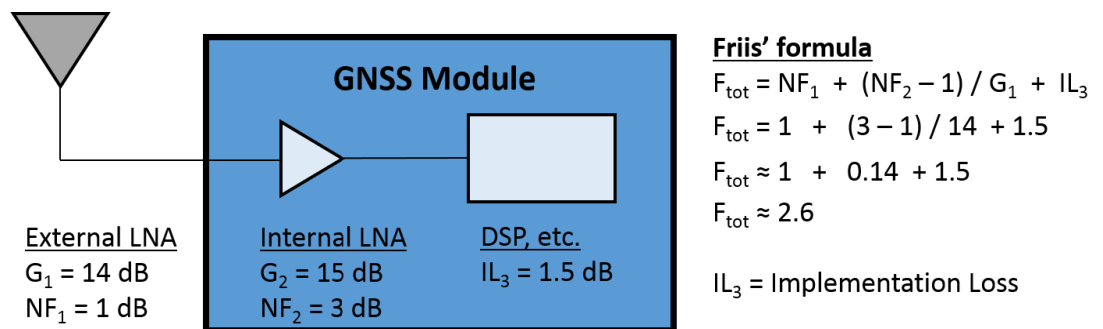


Figure 11-1 Cascade Noise Figure – example calculations with external LNA

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.

11.6. 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:

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

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

Equation 11-2 Carrier to Noise Ratio

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.

11.7. 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.

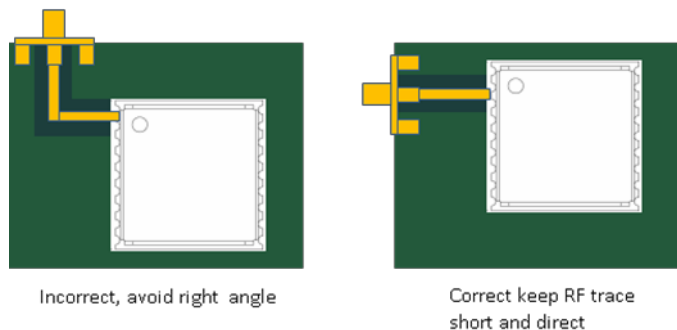


Figure 11-2 RF Trace Examples

11.8. 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 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.



11.9. Implications of the Pre-Select SAW Filter

The SE868-V3 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.

11.10. 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 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 11-1 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.

11.11. 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 a number of 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.

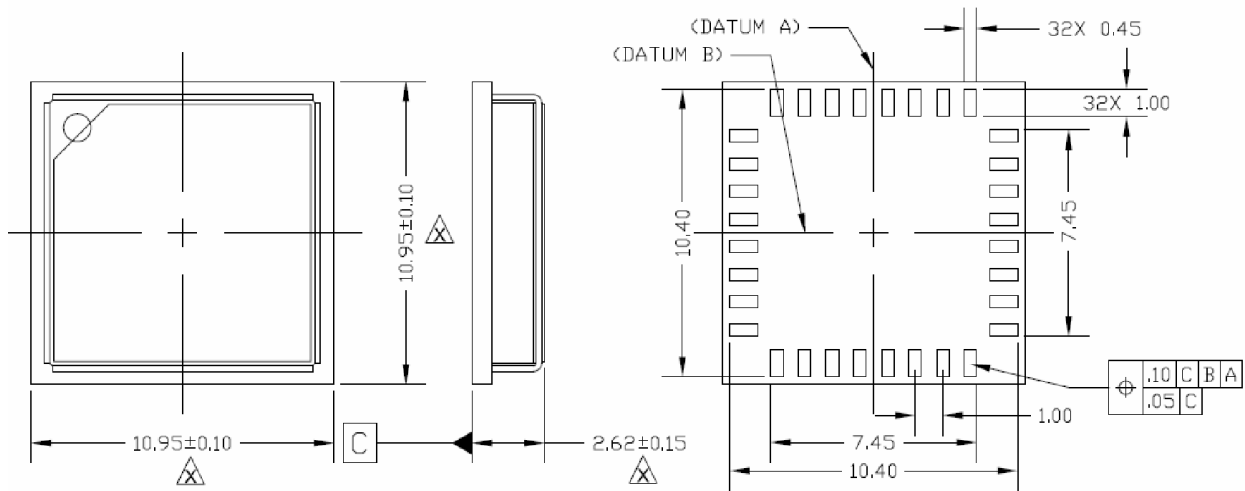
11.12. Shielding

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.



12. Mechanical Drawing



Notes:

1. Interpret this drawing per ASME Y14.5-2009.
2. All dimensions are in millimeters.
3. Critical dimensions are indicated by the symbol 

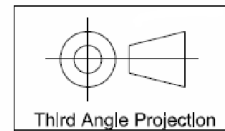


Figure 12-1 SE868-V3 Mechanical Drawing



13. PCB Footprint

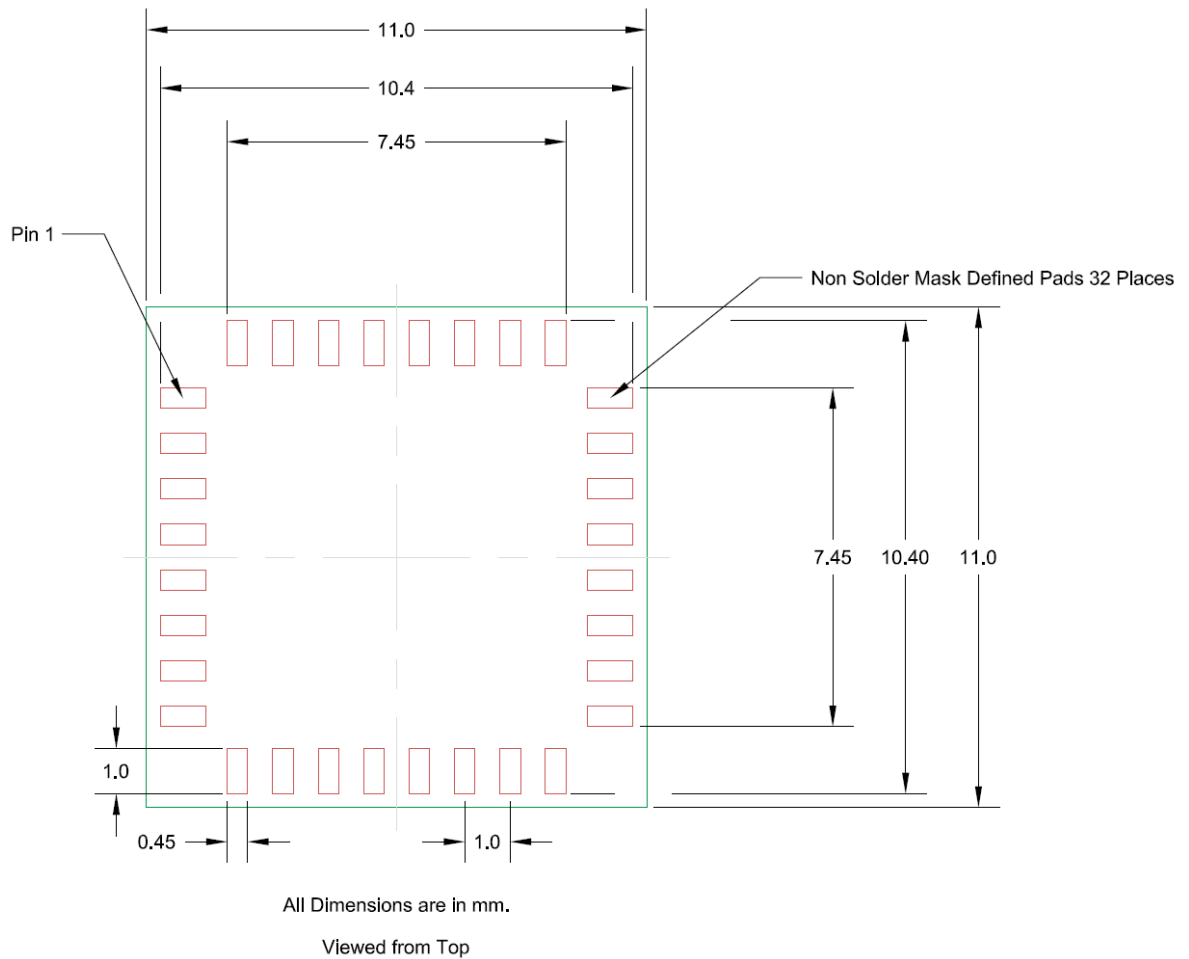


Figure 13-1 SE868-V3 PCB Footprint

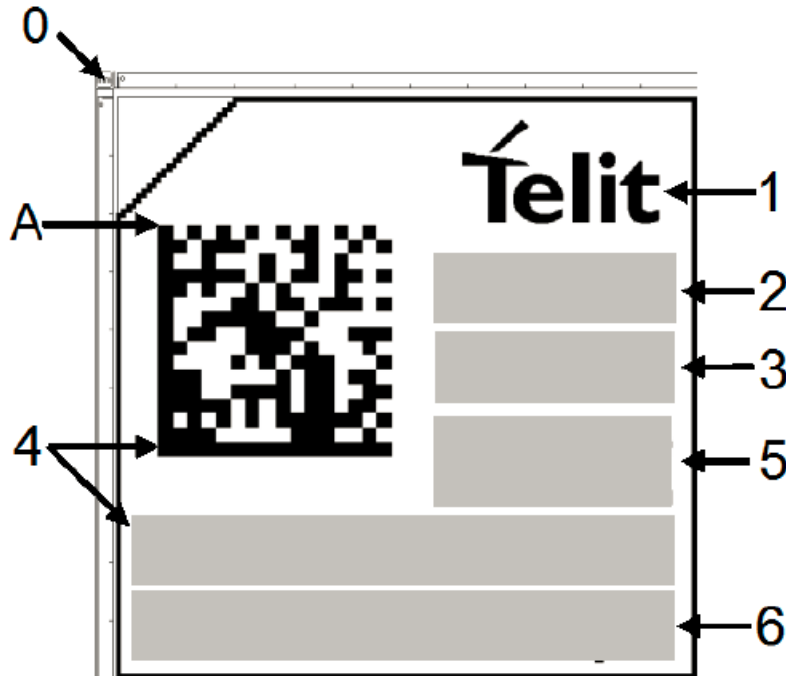
The module shall be mounted on a PCB which complies with V-0 flammability class.



14. Product Packaging and Handling

14.1. Product Marking and Serialization

The SE868-V3 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	Product ID
3	Product Variant (if any)
4	Barcode type 2D datamatrix and text of Telit Serial Number 11 digit (base 36 - 0 to 9 followed by A to Z)
5	CE logo
6	Sample text (if any)

Figure 14-1 Product Label



14.2. Product Packaging and Delivery

SE868-V3 modules are available in Trays or on Tape and Reel.
All packaging is ESD protective lined.

Modules shipped in tray form:

Each tray is 'dry' packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and then placed in a carton.

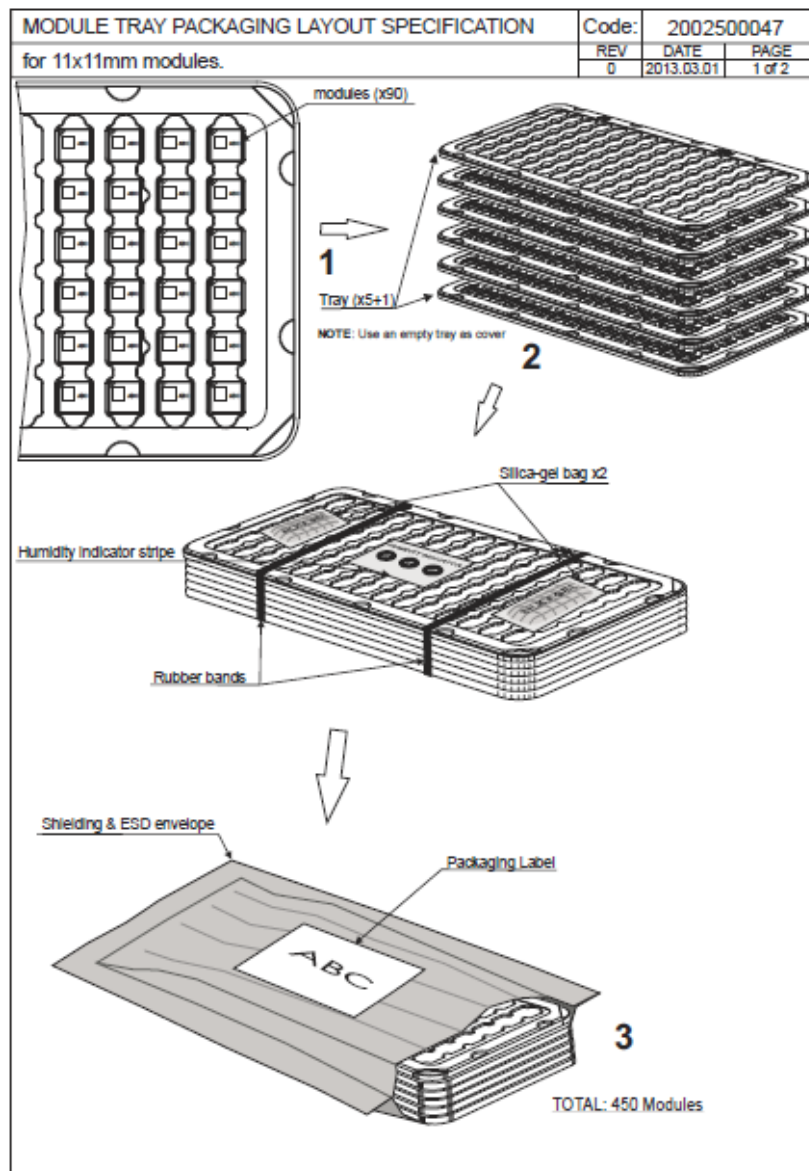


Figure 14-2 Product Packaging - Tray



Modules shipped in Tape and Reel form:

Each reel is 'dry' packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and a humidity indicator card which is then placed in a carton.

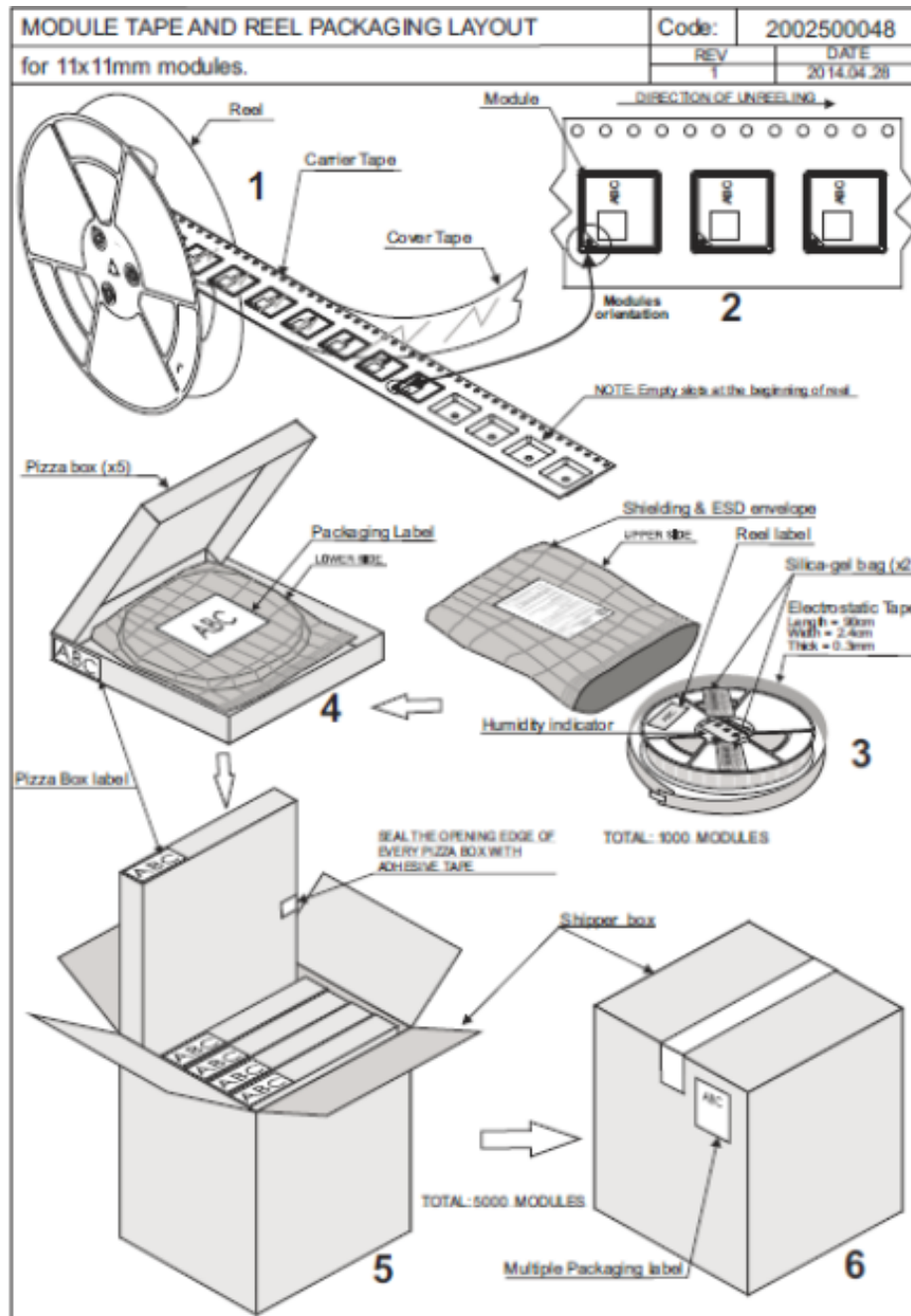


Figure 14-3 Product Packaging - Tape and Reel



14.3. Moisture Sensitivity

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



The receiver 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.

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


The SE868-V3 is supplied in trays or tape and reel and is hermetically sealed with desiccant and humidity indicator card. The SE868-V3 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% R. H. and the humidity indicator card indicates less than 10% relative humidity.

If the package has been opened or the humidity indicator card indicates above 10%, then the parts must be baked prior to reflow. The parts may be baked at +125°C ± 5°C for 48 hours. However, the tray or the tape and reel can NOT withstand that temperature. Lower temperature baking is feasible if the humidity level is low and time is available. Please see **IPC/JEDEC J-STD-033** “Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices” for additional information.

Additional information can be found on the MSL tag affixed to the outside of the hermetically sealed bag.

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 14-4 Moisture Sensitive Device Label

14.4. ESD Sensitivity

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

Telit recommends 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** which can be downloaded free of charge from: www.jedec.org.

14.5. 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 for free from the JEDEC website <http://www.jedec.org>.



Please note that the JEDEC document includes important information in addition to the above figure.

14.6. 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 singulation, pay careful attention to unwanted vibrations and resonances introduced into the board assembly by the board router.

14.7. Washing Considerations

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

14.8. Safety

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



14.9. Disposal

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



15. Environmental Requirements

15.1. 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 15-1 SE868-V3 Operating Environmental Limits

15.2. 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 15-2 SE868-V3 Storage Environmental Limits



16. Compliances

The SE868-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: 2000 accredited facility
- Manufactured to TS 16949 requirement (upon request)

The SE868-V3 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



16.1. CE Declaration of Conformity



EU DECLARATION OF CONFORMITY




1. **SE868-V3** (Product Name)
2. Telit Wireless Solutions Inc., 27422 Portola Parkway, Suite 320, Foothill Ranch, CA 92610 USA (manufacturer)
3. This declaration of conformity is issued under the sole responsibility of the manufacturer



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

EN 60950-1:2006 + A11:2009 +A1:2010+A12:2011+ AC:2011	For article 3.1 (a): Health and Safety of the User
EN 301 489-1 V1.9.2 EN 301 489-3 V1.6.1	For article 3.1 (b): Electromagnetic Compatibility
EN 300 440-1 V.1.6.1 EN 300 440-2 V.1.4.1	For article 3.2 : Effective use of spectrum allocated

7. The conformity assessment procedure referred to in Article 10 and detailed in Annex V of Directive 1999/05/EC has been followed with the involvement of the following Notified Body:
CETECOM ICT Services GmbH - Untertürkheimer Straße 6-10, D-66117 Saarbrücken, Germany .
Notified Body Number: 0682

Thus **CE 0682** is placed on the product
8. The Technical Construction File (TCF) relevant to the product described above and which supports this Declaration of Conformity, is held at: Telit Communications S.p.A. - Via Stazione di Prosecco, 5/b 34010 Sgonico, TRIESTE, ITALY
9. Signed for and on behalf of Telit Wireless Solutions Inc. and Telit Communications S.p.A.

Trieste, **2015-07-14**

Quality Director
Guido Walcher



VP R&D GNSS
Georgia Frousiakis

Technical Construction File:

Mod 0211 2012-11 Rev.3- This declaration is issued according to 768/2008/EC



16.2. RoHS Compliance

- The Telit SE868-V3 modules are fully compliant with Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)



17. Glossary and Acronyms

AGPS: Assisted (or Aided) GPS

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

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

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

Almanac:

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

BeiDou (BDS / formerly COMPASS):

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

Cold Start:

A cold start occurs when a receiver begins operation with unknown position, time, and ephemeris data, typically when it is powered up after a period on inactivity. 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 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, 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.



18. 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.

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/rte/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.



19. Document History

Revision	Date	Changes
0	2015-07-13	First issue
1	2015-07-15	Added Internal LNA information Added Table 4-1 Internal gain value and external gain range. Revised Table 7-1 Default NMEA Output Messages. Revised Table 7-2 Available NMEA Output Messages.
2	2015-07-28	Changes description of GPIO8 Changed module photo Updated glossary Minor text changes
3	2015-09-04	Clarified GLONASS glossary entry Corrected LNA Noise Figure example Text updates Clarified BOOT pin should be left floating Corrected SYSTEM_ON to ON_OFF in 9.4.4 Corrected active antenna reference design Added package description in 2.1 Changed default for Velocity DR to disabled Added NMEA and OSP command information Added DoC
4	2016-01-20	Gen 2: Added Switching Mode Power Supply Added FW variant section Updated Message Waiting (DRI) information Updated 2 nd Serial Port information Updated MEMS wakeup information Updated BOOT pin information Updated 1PPS description Corrected SYSTEM-ON description Minor text revisions

