SE878Kx-Ax Family
Product User Guide

Telit Technical Documentation

APPLICABILITY TABLE

PRODUCTS
SE878K3-A
SE878K7-A

CONTENTS

1. INTRODUCTION

1.1. Scope

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

For details of the members of the product family refer to chapter 2. Product Description.

1.2. Audience

This document is intended for Telit customers, especially system integrators, about to implement their applications using the Telit SE878Kx-Ax family.

1.3. Contact Information, Support

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

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

Alternatively, use:

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

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

https://www.telit.com

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

Telit appreciates the user feedback on our information.

1.4.   Symbol Conventions

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

Table 1: Symbol Conventions

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

1.5.   Related Documents

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

1.6.   Related Documents Requiring a Non-Disclosure Agreement

- Authorized Software User Guides
- Product firmware

2. PRODUCT DESCRIPTION

The SE878Kx-Ax GNSS antenna module family provides complete multi-constellation position, velocity, and time (PVT) engines featuring high performance, high sensitivity, and low power consumption.

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

- Multi-constellation (MT3333): SE878K3-A

- GPS-only (MT3337): SE878K7-A

Special features

- Built-in SMT 17 x 17 mm patch antenna

- Antenna switch to allow an external antenna to be selected for RF input

2.1.   Product Overview

- Complete GNSS receiver module including memory, LNA, TCXO, and RTC plus a built-in patch antenna and an RF input switch for an external antenna

- MT3333-based: GPS L1 C/A, Glonass L1, BeiDou B1, and QZSS with 99 search and 33 tracking channels. Galileo ready.

- MT3337-based: GPS(L1) and QZSS ranging with 66 search and 22 tracking channels

- MT3333-based: SBAS corrections capable (WAAS, EGNOS, MSAS, GAGAN)

- DGPS capable using the RTCM SC-104 protocol

- AGPS support for extended ephemeris using local or server-based solutions:

  o   Local: Embedded Assist System (EASY)

  o   Server: Extended Prediction Orbit (EPO)

- Jamming Rejection: Active Interference Cancellation (AIC)

- 1PPS output

- Fix reporting at 1 Hz (default). Maximum: 10Hz

- NMEA command input and data output

- Two serial ports for input commands and output messages:

o MT3333-based: The secondary serial port is I2C and is configurable for SPI or UART interface

o MT3337-based: The secondary port is UART

- MT3333-based: 8 Megabit built-in flash memory

- MT3337-based: ROM memory

- Less than 80 mW total power consumption (Full Power mode - typical)

- Power management modes for extended battery life

- Supported by evaluation kits

- -40°C to +85°C industrial temperature range

- (-A) 18 x 18 x 6.2 mm (nominal) 32-pad LGA package.

- Surface mountable by standard SMT equipment

- RoHS compliant design.

2.2. SE878Kx-Ax Product Naming

SE878Kx-Ax Product Naming
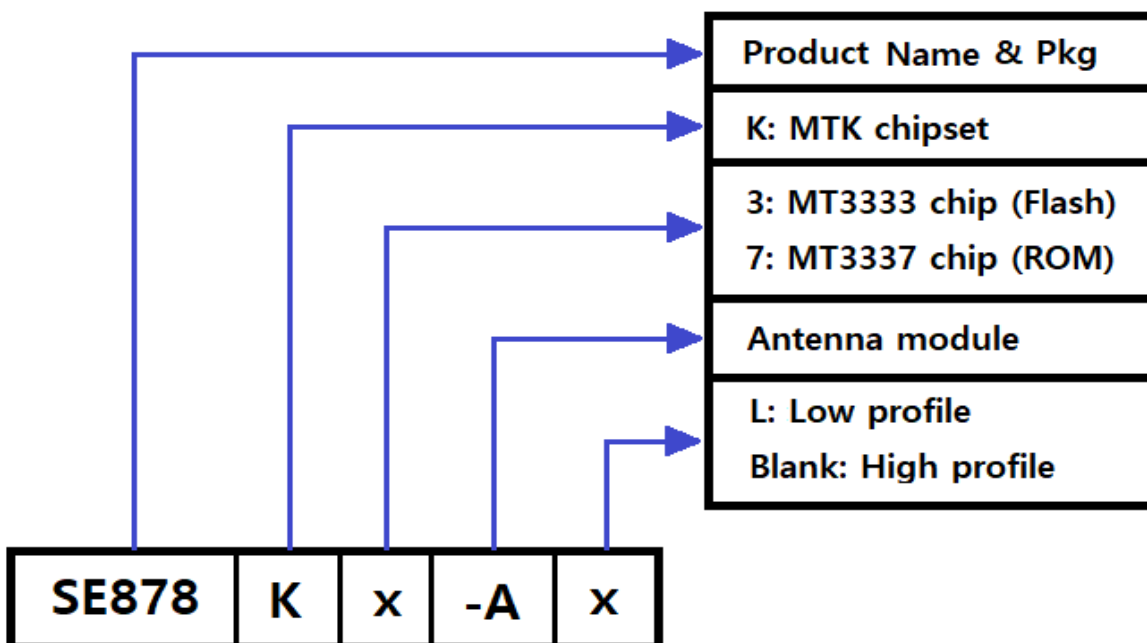
Figure 1: Product Naming

2.3. Product Variants

Module	Chipset	Constellations	Memory	Antenna	Notes
SE878K3-A	MT3333	Multi	Flash	High	
SE878K7-A	MT3337E	GPS only	ROM	High	

Table 2: Product Variants

2.3.1. Multi-Constellation Modules Features (MT3333-based)

- MediaTek MT3333 engine

- GPS, GLONASS BeiDou, Galileo, and QZSS satellite signals

- SBAS satellite signals

- Low noise amplifier (LNA) on patch antenna interface

- RF switch for external antenna interface

- Flash memory with upgradable firmware

- AGPS: Local (EASY) and server-based (EPO)

- Force-On pin

- I2C (default) on the 2nd port. May be configured for UART or SPI

2.3.2. GPS-Only Modules Features (MT3337E-based)

- MediaTek MT333E (enhanced) engine

- GPS and QZSS satellite signals

- Low noise amplifier (LNA) on patch antenna interface

- RF switch for external antenna interface

- ROM memory

- AGPS: Local (EASY) and host-based (EPO)

- No Force-On pin

- Only UART on the 2nd port

2.4. Related Products

The SE868Kx-Ax is a similar module with three major differences:

- Smaller module size (11mm x 11 mm)

- The antenna is smaller (9mm x 9 mm)

- There is no RF switch or support for an external antenna.

2.5. Block Diagrams
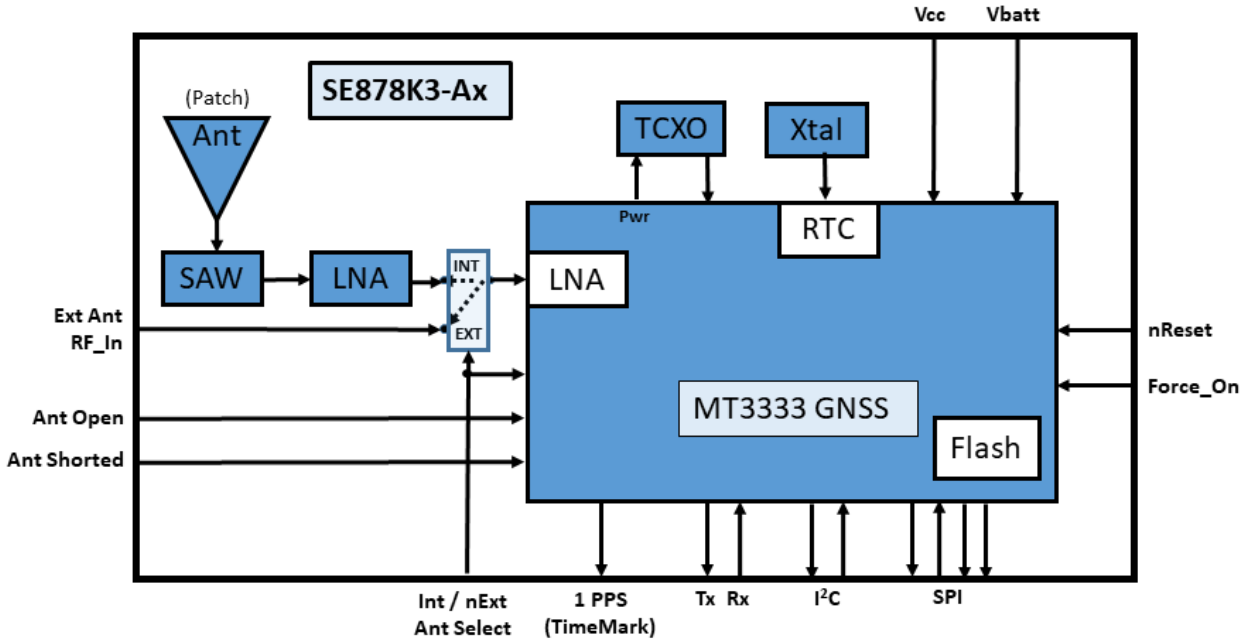
Figure 2: SE878K3-Ax Block Diagram
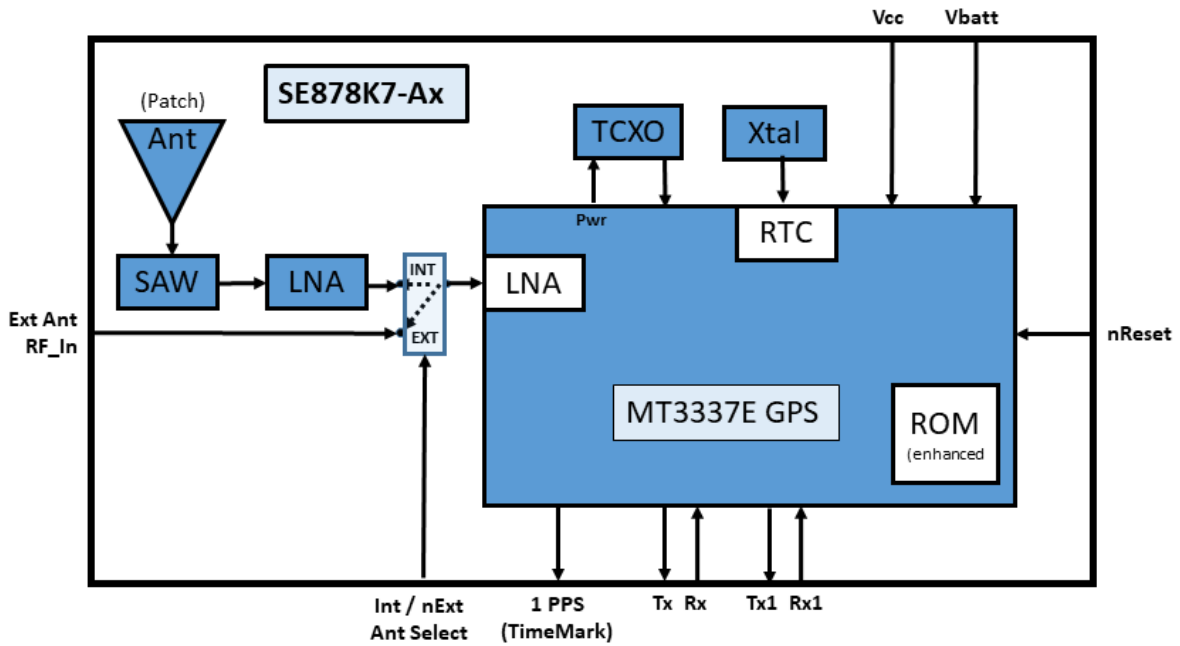
Figure 3: SE878K7-Ax Block Diagram

2.6. Module Photos

Figure 4: SE878Kx-Ax Top View
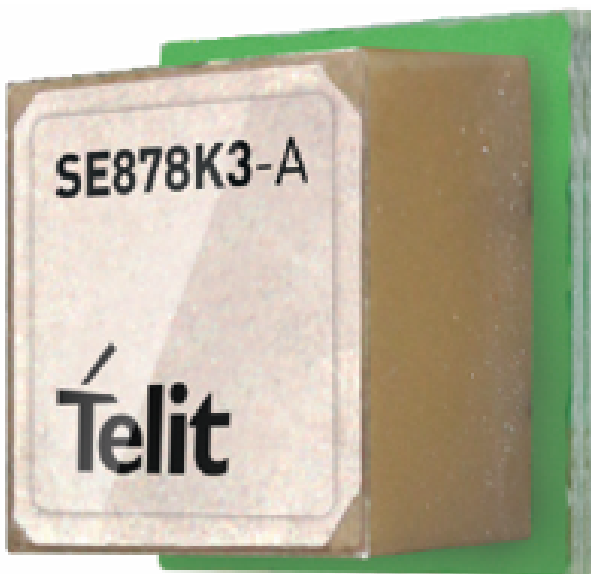
Top
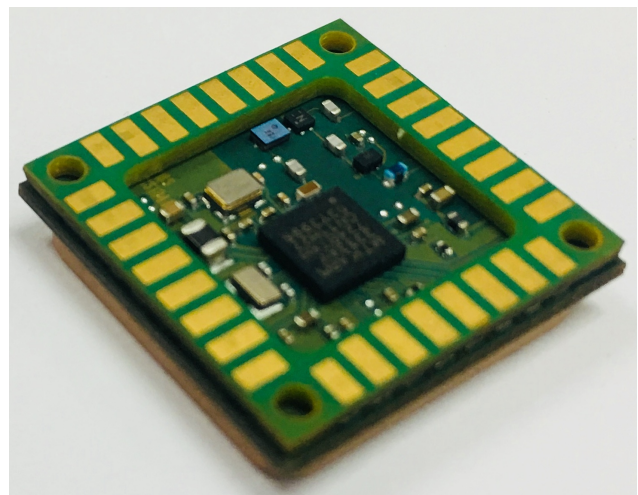
Bottom

Figure 5: SE878Kx-Ax 3D Views

3. EVALUATION BOARD (EVB)

The EVB contains the module mounted on a PC Board to facilitate development and testing.

Please refer to the product Evaluation Board User Guide for detailed information.
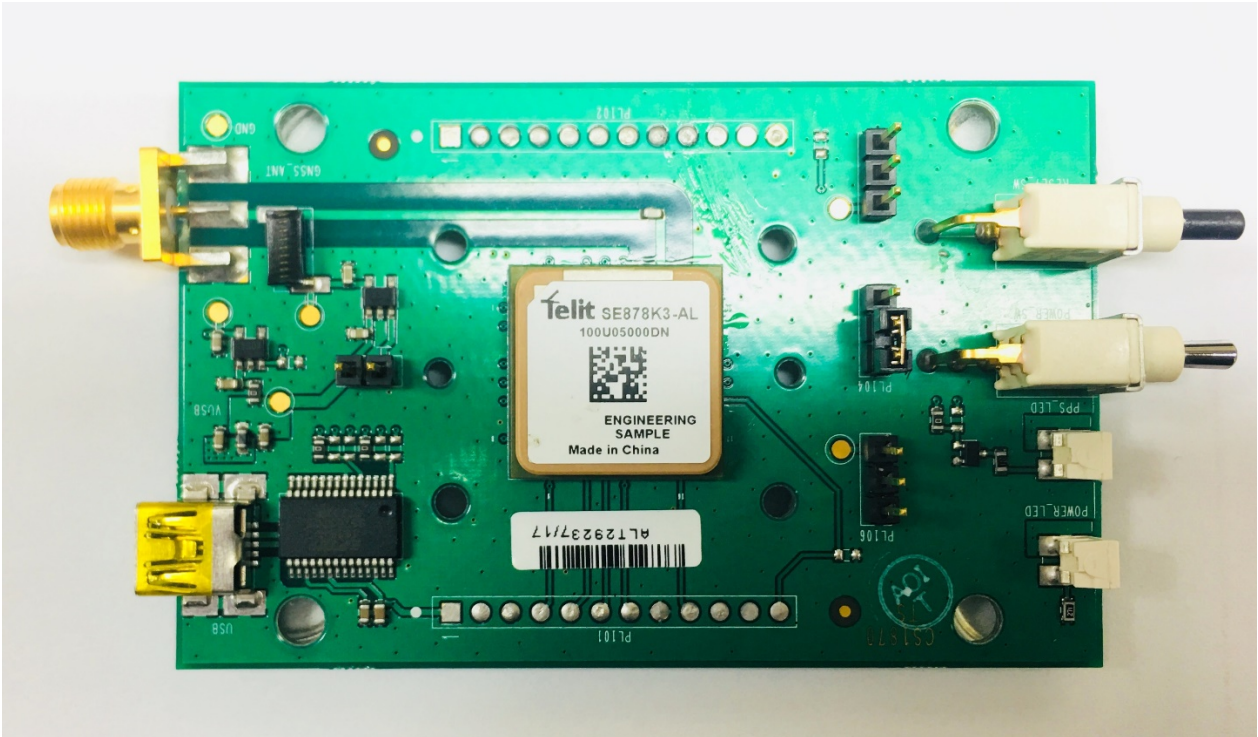
Figure 6: SE878Kx-Ax Evaluation Board

Not Subject to NDA

4. PRODUCT FEATURES

4.1. Onboard (built-in) Antenna and RF switch (Built-in/External)

The module includes an RF switch which allows the user to select the onboard antenna or an external antenna as the GNSS signal source. See section 2.5 Block Diagrams.

4.2. Multi-Constellation Navigation (MT3333-based modules only)

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

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

4.3. Quasi-Zenith Satellite System (QZSS)

The satellites of the Japanese regional system are in a highly inclined, elliptical geosynchronous orbit, allowing continuous high-elevation coverage over Japan and other countries using only three satellites plus one geostationary satellite. SV IDs 193, 194, & 195 are supported. They provide additional ranging signals to augment the GNSS systems.

QZSS constellation usage is controlled by the $PMTK352 command and is disabled by default. NMEA reporting for QZSS may be enabled/disabled by the $PMTK351 command.

4.4. Satellite-Based Augmentation System (SBAS)

SBAS is not supported on MT3337E-based modules.

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

Enabling SBAS limits the maximum fix rate to 5 Hz. If disabled, the maximum is 10 Hz.

The module is enabled for SBAS by default but can be disabled by command PTMK313.

The MT3333-based modules can accept either SBAS or DGPS corrections which are configured by the PMTK301 command.

4.4.1. SBAS Corrections

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

4.5. Differential GPS (DGPS)

DGPS is a Ground-Based Augmentation System (GBAS) for reducing position errors by applying corrections from a set of accurately surveyed ground stations located over a wide area. These reference stations measure the range to each satellite and compare it to the known-good range. The differences can then be used to compute a set of corrections which are transmitted to a DGPS receiver, either by radio or over the internet.

The DGPS receiver can then send them to the module's serial port using RTCM SC-104 protocol. Message types 1, 2, 3, and 9 are accepted.

The corrections can significantly improve the accuracy of the position reported to the user.

MT3333-based modules can accept either the RTCM SC-104 messages or SBAS differential corrections via command PMTK301.

4.6. Assisted GPS (AGPS)

Assisted GPS (or Aided GPS) is a method by which information from a source other than broadcast GPS signals is used to improve (i.e. reduce) TTFF.

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

4.6.1. Locally Generated AGPS - Embedded Assist System (EASY)

Proprietary algorithms within the module perform GPS ephemeris prediction locally from stored broadcast ephemeris data (received from tracked satellites). The algorithms predict orbital parameters for up to three days. The module must operate in Full Power mode for at least 5 minutes to collect ephemeris data from visible satellites, or 12 hours for the full constellation.

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

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

4.6.2. Server-Generated AGPS - Extended Prediction Orbit (EPO)

(MT3333-based modules only)

Server-generated ephemeris predictions are maintained on Telit AGPS servers. The predicted ephemeris file is obtained from the AGPS server and is transmitted to the module over a serial port. These predictions do not require local broadcast ephemeris collection and are valid for up to 14 days.

The MT3333-based modules support server-based AGPS as a standard feature.

Please refer to the next section regarding EPO support (Host EPO) on the SE878K7-Ax modules.

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

Please refer to the Telit EPO Application Note for details. Example source code is available under NDA.

Contact TELIT for support regarding this service.

See the next section regarding EPO support (Host EPO) on the MT3337-based modules.

4.6.3. Host EPO

The MT3337-based modules do not have flash memory. However, they can still make use of Assisted GPS. If the system design includes a host processor, it can access server-generated EPO data and send it to the module over the serial port. This data is valid for six hours.

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

Please refer to the MT333x Host EPO Application Note.

Contact Telit support for further details.

4.7. Elevation Mask Angle

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

4.8. Static Navigation

Static Navigation is an operating mode in which the receiver will freeze the position fix when the speed falls below a set threshold (indicating that the receiver is stationary).

The course and altitude are also frozen, and the speed is reported as "0".

The navigation solution is unfrozen when the speed increases above a threshold or when the computed position exceeds a set distance (10 m) from the frozen position (indicating that the receiver is again in motion). The speed threshold can be set via the PMTK386 command.

Set the threshold to zero to disable static navigation.

This feature is useful for applications in which very low dynamics are not expected, the classic example being an automotive application.

Static Navigation is disabled by default but can be enabled by command.

4.9. Jamming Rejection – Active Interference Cancellation (AIC)

The receiver module detects and removes narrow-band interfering signals (jamming signals) without the need for external components or tuning. It rejects up to 12 CW (Continuous Wave) type signals of up to –80 dBm (total power signal levels). This feature is useful both in the design stage and during the production stage for uncovering issues related to unexpected jamming. When enabled, Jamming Rejection will increase current drain by about 1 mA, and impact on GNSS performance is low at modest jamming levels. However, at high jamming levels (for example, –90 to –80 dBm), the RF signal sampling ADC starts to become saturated after which the GNSS signal levels start to diminish.

Jamming rejection is enabled by default but can be disabled with the PMTK286 command.
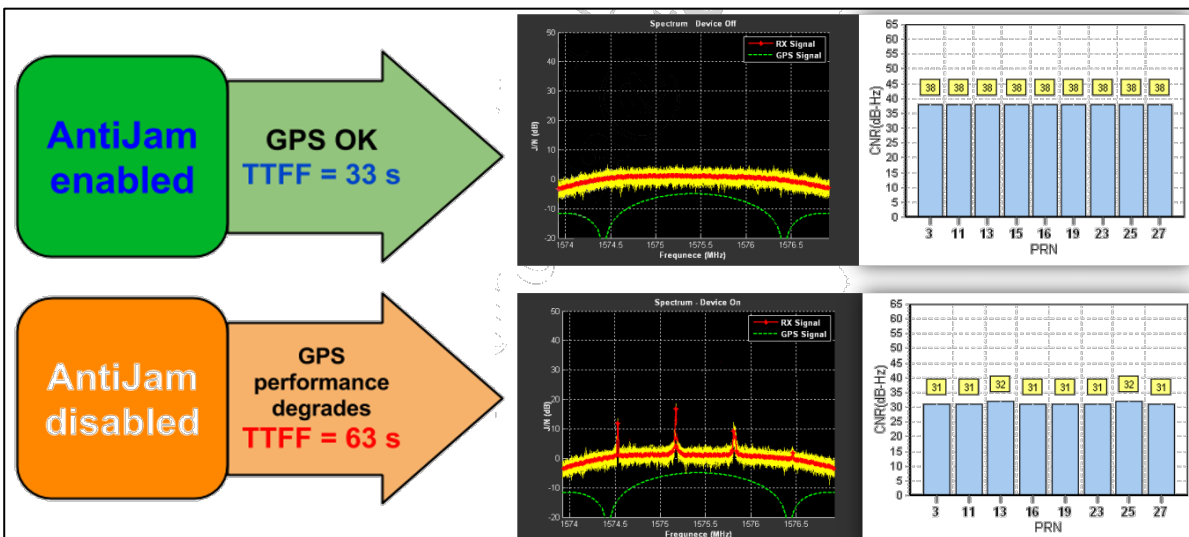
Figure 7: Jamming Rejection

4.10. Internal LNA

The modules include a built-in LNA and SAW filter to improve sensitivity when using the integrated patch antenna.

4.11.　　10 Hz Navigation

The default rate of 1 Hz can be changed by command PMTK500 to a maximum of 10 Hz.

MT3337-based receivers have a maximum of 5 Hz.

Enabling the SBAS feature limits the maximum fix rate to 5 Hz.

4.12.　　1PPS

1PPS is a one pulse per second signal.

Please refer to Section 9.4.5.1 1PPS for details.

4.13.　　Serial I/O Ports

Port 0:

All modules include a primary UART serial port.

Port 1:

The secondary port on MT3333-based modules is I^{2}C by default but can be changed to UART or SPI via command.

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

Please refer to section 9.5 I/O Ports for details.

4.14.　　Power Management Modes

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

The various power management modes can be enabled by sending the desired command:

Power Management - Command Summary		
$PMTK Cmd	Type	State
Full Power	To exit (wake) from a commanded low-power state	
225	0	Full
Perpetual Backup	To wake:Force_ON Signal (MT3333 only)	
225	4	Backup
Standby	To wake: Character to Rx	
161	0	Stop
161	1	Backup

Power Management - Command Summary		
Periodic (MT3333 only)		
223	-	Specify Extended Parameters
225	1	Backup
225	2	Standby
Always Locate (MT3333 only)		
223	-	Specify Extended Parameters
225	8	Standby
225	9	Backup
GLP (MT3333 only)		
262	0	Disable
262	3	Enable

Table 3: Power Management Command Summary

4.14.1. Full Power Continuous Mode

The receiver starts in full power continuous mode when powered up. This mode uses the acquisition engine to search for all possible satellites at full performance, resulting in the highest sensitivity and the shortest possible TTFF.

The receiver then switches to the tracking engine to lower the power consumption when:

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

To return to Full Power mode from a low power mode, send the NMEA command: $PMTK225,0*2B just after the module wakes up from its previous sleep cycle.

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

4.14.2. Backup Mode (Perpetual) (MT3333-based modules only)

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

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

Note: Only the MT3333-based modules have a Force_On pin.

This command will be rejected on MT3337-based modules.

To exit the Perpetual Backup mode, bring the Force_On signal high, then return to low. Please refer to Section 9.4.4.2 FORCE_ON for details.

4.14.3.   Standby Modes

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

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

SLEEP: ARM baseband and RF are powered down

Standby mode is entered by sending the following NMEA command:

$PMTK161,0*28   (STOP Mode)

$PMTK161,1*29   (SLEEP Mode)

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

4.14.4.   GLP Mode   (MT3333-based modules only)

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

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

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

A timeline is shown below:
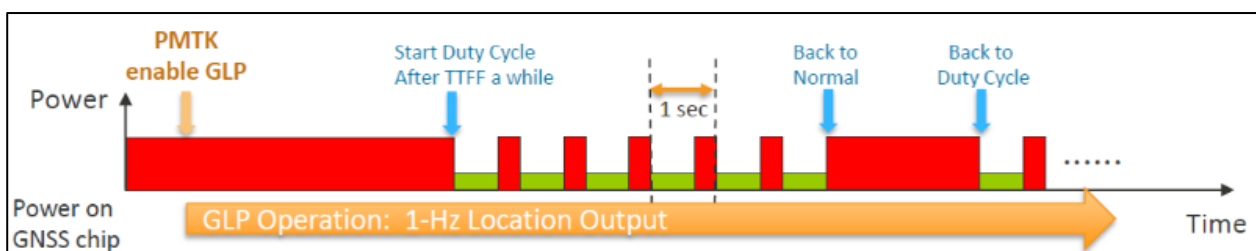
Figure 8: GNSS Low Power (GLP) Mode Diagram

To enter the GLP mode, send the command:

$PMTK262,3

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

$PMTK262,0

4.14.5. Periodic Modes (MT3333-based modules only)

These modes allow autonomous power on/off control with reduced fix rate to decrease average power consumption. The main power supply pin VCC_ON is still powered, but power distribution to internal circuits is controlled by the receiver firmware.

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

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

Figure 9: Periodic Modes Diagram

Figure 10: Periodic Mode - Example 1

Figure 11: Periodic Mode - Example 2

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

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

Where:

> SV = 1 to 4, default = 1

> SNR = 25 to 30, default = 28

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

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

This is the limit between successive DEE

$PMTK225,<Type>,<Run_time>,<Sleep_time>,<2^{nd}_run_time>,<2^{nd}_sleep_time>*<checkum>

Where:

> Type = 1 for Periodic (backup) mode or 2 for Periodic (standby) mode

> Run_time = Full Power period (ms)

> Sleep_time = Standby period (ms)

> 2^{nd}_run_time = Full Power period (ms) for extended acquisition if GNSS acquisition fails during Run_time

> 2^{nd}_sleep_time = Standby period (ms) for extended sleep if GNSS acquisition fails during Run_time

Example: $PMTK225,1,3000,12000,18000,72000*16

for periodic mode with 3 s navigation and 12 s sleep in backup state.

The acknowledgement response for the command is:

$PMTK001,225,3*35

To exit Periodic Sleep mode, send the NMEA command

$PMTK225,0*2B

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

4.14.6.   AlwaysLocate™ Mode   (MT3333-based modules only)

AlwaysLocate™ is an intelligent controller of the Periodic mode where the main supply pin VCC_IN is still powered, but power distribution is controlled internally. Depending on the environment and motion conditions, the module can autonomously and adaptively adjust the parameters of the Periodic mode (for example, RF on/off ratio and fix rate) to achieve a balance in positioning accuracy and power consumption. The average current drain will vary based on conditions.

To enter an AlwaysLocate mode, send the following NMEA command:

$PMTK225,<mode>*<checksum><CR><LF>

Where, mode = 8 for AlwaysLocate (standby) mode or 9 for AlwaysLocate (backup) mode

Example: $PMTK225,9*22

The acknowledgement response for the command is:

$PMTK001,225,3*35

To exit AlwaysLocate mode, send the NMEA command:

$PMTK225,0*2B

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

5. DATA RETENTION

(MT3333-based modules only)

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

If Vbatt is maintained, no data will be lost.

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

To erase EPO data, use the $PMTK127 command.

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

Table 4: Data Retention

6. PRODUCT PERFORMANCE

6.1. Horizontal Position Accuracy

Constellation	CEP (m)
GPS	1.3
GPS + Glonass	1.8
Test Conditions: 24-hr Static, Live signals, Full Power mode	
Note: MT3337-based modules support GPS only	

Table 5: SE878Kx-Ax Horizontal Position Accuracy

6.2. Time to First Fix

Constellations(s)	Start Type	Max TTFF (s)
GPS	Hot	2.4
	Warm AGPS	2.5
	Warm	26
	Cold	31
GPS + GLO	Hot	2.2
	Warm AGPS	3.1
	Warm	26
	Cold	33
Test Conditions: Static scenario, -130 dBm, Full Power mode		
Note: Mt337-based modules support GPS only.		

Table 6: SE878Kx-Ax Time to First Fix

6.3. Maximum RF Sensitivity

System	State	Minimum Signal Level (dBm)
GPS	Acquisition	-148
	Navigation	-163
	Tracking	-165
GPS + GLO	Acquisition	-148
	Navigation	-162
	Tracking	-165
Test conditions: Conducted signal. Static scenario. Full power mode.		
Note: MT3337-based modules support GPS only.		

Table 7: SE878Kx-Ax Max RF Sensitivity

6.4. Jamming Mitigation Performance Example
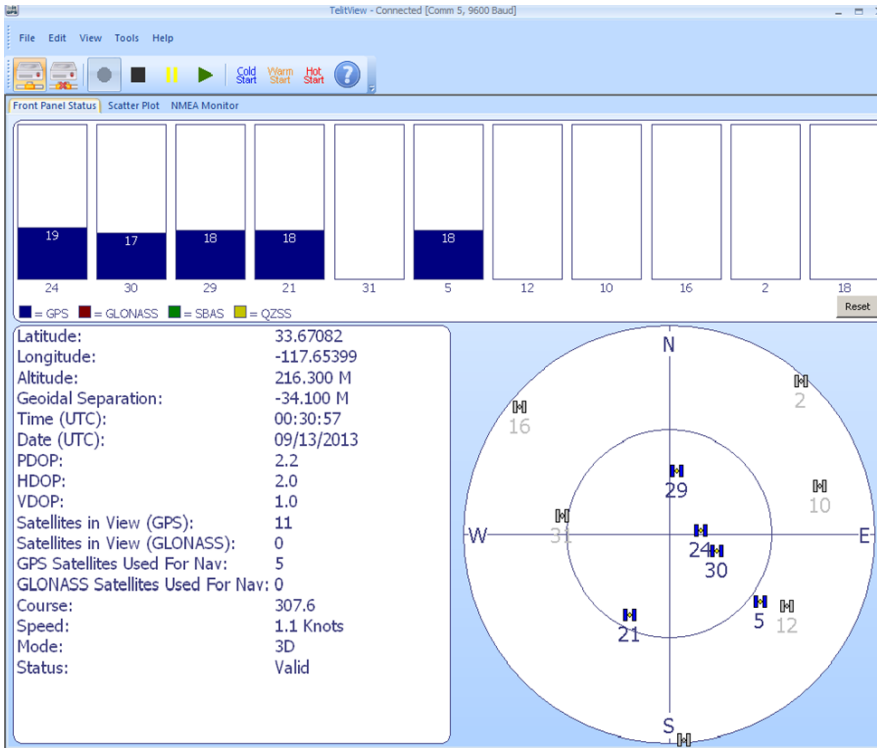
Figure 12: Jamming with AIC Disabled
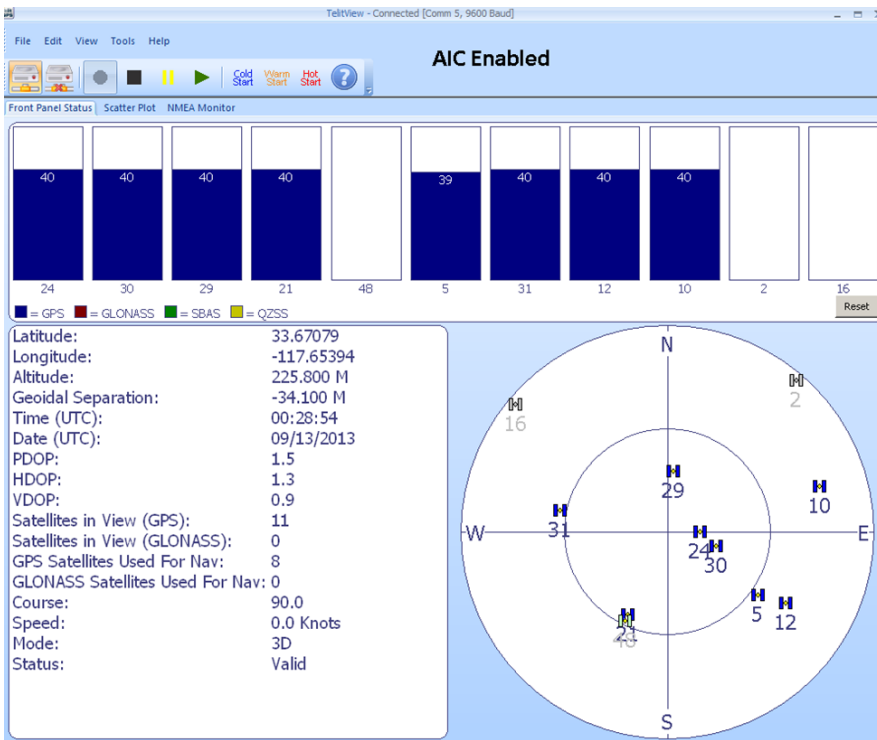
Figure 13: Jamming with AIC Enabled

7. MESSAGE INTERFACE

Data streams supported by the serial ports:

- NMEA messages (output) and commands (input)

- DGPS (RTCM SC-104) Version 2.3 protocol message types 1, 2, 3, and 9 (input)

- Server-based AGPS (Extended Prediction Orbit) I/O

For more information regarding the software interface, refer Telit MT Software User Guide.

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

7.1. NMEA Output Messages

Message protocol is NMEA-0183.

Default: GPS constellation is enabled.

GLONASS is also enabled for MT3333-based modules.

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

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

> **Note:** Some sentences may exceed the NMEA length limitation of 80 characters.

7.1.1. Standard Messages

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

Table 8: Default NMEA Output Messages

The following messages can be enabled by command:

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

Table 9: Available Messages

The following table shows the Talker IDs used:

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

Table 10: NMEA Talker IDs

7.1.2.   Proprietary Output Messages

The receivers support several proprietary NMEA output messages which contain additional receiver data and status information.

Message ID	Description
$PMTK010	System messages (for example, to report startup, and so on)

Table 11: Proprietary Output Messages

7.2.   NMEA Input Commands

The modules use NMEA proprietary messages for commands and command responses. This interface provides configuration and control over selected firmware features and operational properties of the module. Wait time is about 50 to 100 ms.

The format of a command is: $<command-ID>[,<parameters>]*<cr><lf>

Commands are NMEA proprietary format and begin with "$PMTKxxx".

Parameters, if present, are comma-delimited as specified in the NMEA protocol.

Unless otherwise noted in the Software User Guide, commands are echoed back to the user after the command is executed.

7.2.1.   NMEA Commands List

Below table provides the list of power management commands.

Command ID	Description
$PMTK000	Test. This command will be echoed back to the sender (for testing the communications link).

Command ID	Description
$PMTK101	Perform a HOT start
$PMTK102	Perform a WARM start
$PMTK103	Perform a COLD start. However, Time is preserved.
$PMTK104	Perform a FULL COLD start, erasing time and any stored almanac data
$PMTK120	Erase aiding data stored in flash memory
$PMTK127	Erase EPO data stored in flash memory
$PMTK251, Baudrate	Set NMEA Baud rate
$PMTK313,0	Disable SBAS feature
$PMTK313,1	Enable SBAS feature
$PMTK353,1,0,0,0,0	Enable GPS only
$PMTK353,0,1,0,0,0	Enable GLO only
$PMTK353,0,0,1,0,0	Enable GAL only
$PMTK353,0,0,0,0,1	Enable BDS only
$PMTK353,1,1,0,0,0	Enable GPS and GLO
$PMTK353,1,0,0,0,1	Enable GPS and BDS
$PMTK353,1,1,1,0,0	Enable GPS, GLO, and GAL
NOTE: Multi-constellation commands are not supported by the MT3337-baased modules	

Table 12: NMEA Input Commands List

8. FLASH UPGRADABILITY

(MT3333-based modules only)

Note: The MT3337-based modules use ROM memory and therefore are not upgradable.

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

The firmware stored in the internal Flash memory may be upgraded via the port 0 TX/RX pins.

In order to update the FW, the following steps should be performed to re-program the module.

1. Remove all power to the module.

2. Connect serial port USB cable to a PC.

3. Apply main power.

4. Clearing the entire flash memory is strongly recommended prior to programming.

5. Run the software utility to re-flash the module.

6. Upon successful completion of re-flashing, remove main power to the module for a minimum of 10 seconds.

7. Apply main power to the module.

8. Verify the module has returned to the normal operating state.

9. ELECTRICAL INTERFACE

9.1.   SE878Kx-Ax Family Pinout Diagram

Figure 14: SE878Kx-Ax Family Pinout Diagram
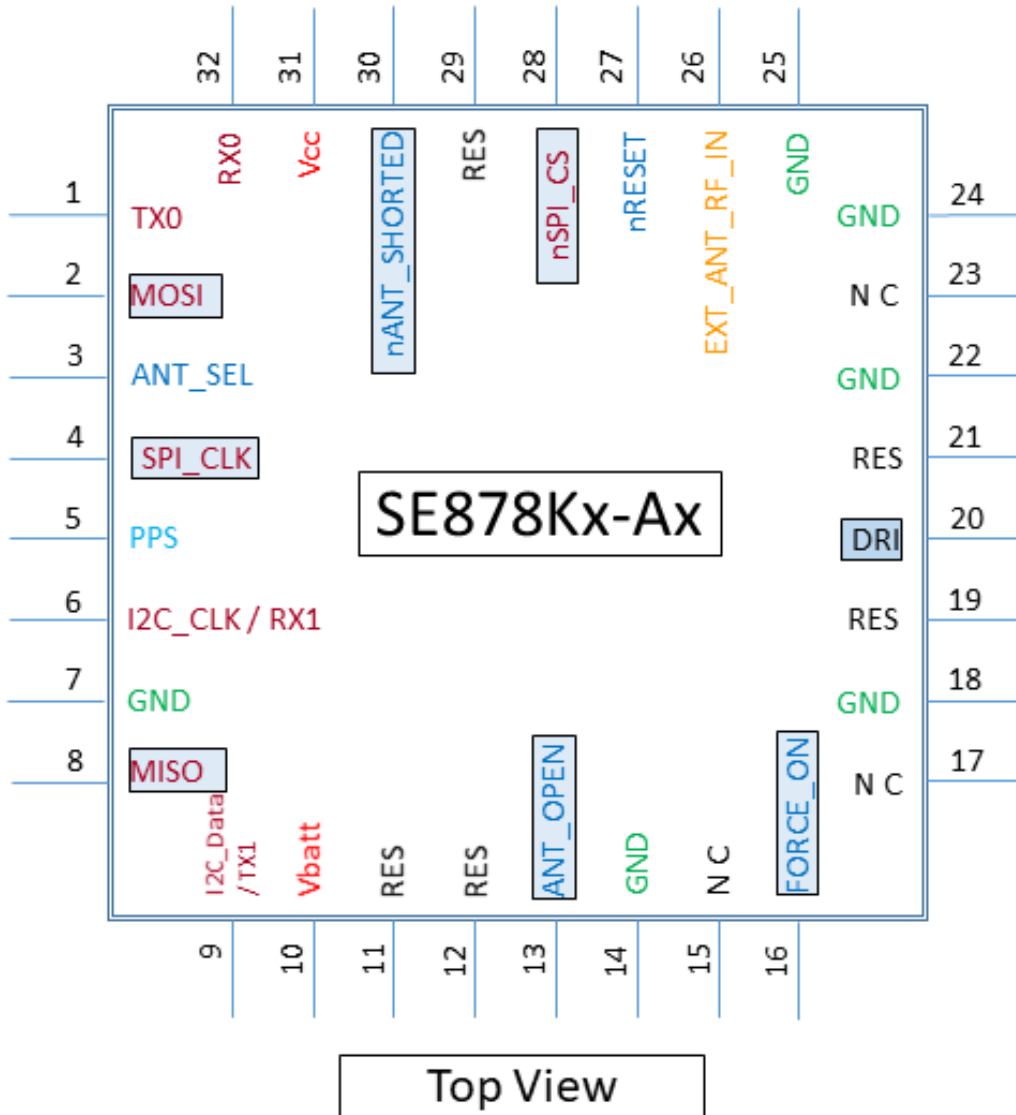
Note: ☐ These pins are not available on the SE878K7-Ax.

- FORCE_ON is available only on the SE878K3-Ax. It is not connected on the SE878K7-Ax.
- I2C and SPI are available only on the SE878K3-Ax. The SE878K7-Ax second port is UART.
- The SE878K3-Ax second port is switched between I2C (default) and UART or SPI via command.
- nANT_SHORTED and ANT_OPEN are not available on the SE878K7-Ax.

9.2. SE878Kx-Ax Module Pinout Tables

9.2.1. SE878K3-Ax Pinout Table

Pin	Name	Type	Description	Note
Power and Ground				
31	VCC	PWR	Main power supply	
10	VBATT	PWR	Backup Power supply	
7, 14, 18, 22, 24, 25	Ground	GND	Ground (all pins must be grounded)	
RF and Antenna				
26	EXT_ANT_RF_IN	RF	External Antenna RF Input	5
3	ANT_SEL	I	Antenna Select (High = Onboard)	
30	nANT_Shorted	I	Antenna Shorted (input) true low	1
13	ANT_Open	I	Antenna Open (input) true high	1
Control and Output				
27	nRESET	I	System Reset – Active Low	
16	FORCE_ON	I	Force full-power mode	2
5	PPS	O	Pulse Per Second	
I / O				
1	TX0	O	UART0 Serial Output (Transmit)	
32	RX0	I	UART0 Serial Input (Receive)	
9	I2C Data / TX1	I/O	I2C Data / UART1 Tx	3, 4
6	I2C Clock / RX1	I/O	I2C Clock / UART1 Rx	3, 4
8	SPI_MISO	I/O	SPI Data MISO	4
2	SPI_MOSI	I/O	SPI Data MOSI	4
4	SPI_CLK	I	SPI Clock	4
28	nSPI_CS	I	SPI_CS (active low)	4
20	DRI	O	Data Ready Indicator	4
Reserved & No Connection				
11, 12, 19, 21, 29	Reserved	Res	Do not connect	
15, 17, 23,	No Connection	NC	Not connected internally	

Pin	Name	Type	Description	Note
	1. nANT_SHORTED and ANT_OPEN are not connected on the SE878K7-Ax 2. FORCE_ON is available only on the SE878K3-Ax. It is not connected on the SE878K7-Ax 3. I2C and SPI are available only on the SE878K3-Ax. The SE878K7-Ax second port is UART. 4. The SE878K3-Ax second port is switched between I2C (default) and UART or SPI via command 5. The External Antenna RF Input is considered to be ESD sensitive.			

Table 13: SE878K3-Ax Pinout Tables

9.2.2.   SE878K7-Ax Pinout Table

Pin	Name	Type	Description	Note
Power and Ground				
31	VCC	PWR	Main power supply	
10	VBATT	PWR	Backup Power supply	
7, 14, 18, 22, 24, 25	Ground	GND	Ground (all pins to be grounded)	
RF and Antenna				
26	EXT_ANT_RF_IN	RF	External Antenna RF Input	5
3	ANT_SEL	I	Antenna Select (High = Onboard)	
Control and Output				
27	nRESET	I	System Reset – Active Low	
5	PPS	O	Pulse Per Second	
I / O				
1	TX0	O	UART0 Serial Output (Transmit)	
32	RX0	I	UART0 Serial Input (Receive)	
9	TX1	I/O	UART1 Tx	3
6	RX1	I/O	UART1 Rx	3
Reserved and No Connection				
2, 4, 8, 13, 16, 28, 30	Reserved	Res	See the SE878K3-Ax pinout for compatibility.	1, 2, 3
11,12, 19, 20, 21, 29	Reserved	Res	Do not connect	
15, 17, 23	No Connection	NC	Not connected internally	
	1. nANT_SHORTED and ANT_OPEN are not connected on the SE878K7-Ax 2. FORCE_ON is available only on the SE878K3-Ax. It is not connected on the SE878K7-Ax 3. I2C and SPI are available only on the SE878K3-Ax. The SE878K7-Ax second port is UART. 4. n/a 5. The External Antenna RF Input is ESD sensitive.			

Table 14: SE878K7-Ax Pinout Table

9.3.   DC Power Supply

The modules have two power supply pins V_{CC} and V_{BATT}.

Note: I/O voltage ranges are different from supply voltages Vcc and Vbatt.

9.3.1.   VCC

This is the main power input. The supply voltage must be in the range specified in Table 15: DC Supply Voltage

---

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

When power is first applied, the module will start up in full power continuous operation mode. During operation, the current drawn by the module can vary greatly, especially if enabling low-power operation modes. The supply must be able to handle the current fluctuation including any inrush surge current.

GPS/GNSS receiver modules require a clean and stable power supply. In designing such a supply, any resistance in the VCC line can negatively influence performance. Consider the following points: All supplies should be within the rated requirements. At the module input, use low ESR capacitors that can deliver the required current for switching from backup mode to normal operation. Keep the rail short and away from any noisy data lines or switching supplies, and so on. Wide power lines and power planes are preferred.

9.3.2.   VBATT

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

Vbatt supplies power to the following:

- Real-time clock (RTC)
- Battery backed RAM (BBRAM)
- EASY data

- Persistent data elements (not commanded option values)

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

9.3.3. DC Power Requirements

Main Supply Voltage & Backup Voltage					
Supply	Name	Min	Typ	Max	Units
Vcc and Vbatt	Vcc & Vbatt	2.8	3.3	4.3	V
✋ The drop from 2.7 V to 0 V must be > 1 ms. Also, keep the supply ripple as low as possible (< 50 mV)					

Table 15: DC Supply Voltage

9.3.4. DC Power Consumption: SE878K3-Ax

State & Constellation	Typ	Max	Units
Acquisition			
GPS Only	66	86	mW
GPS and Glonass	89	115	mW
Navigation/Tracking			
GPS Only	56	76	mW
GPS and Glonass	72	96	mW
Low Power Mode (GLP)			
GPS Only	50	79	mW
GPS and Glonass	52	105	mW
Vbatt	50	99	µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: 500 ms duty cycle SBAS: enabled 1PPS sync: enabled			

Table 16: SE878K3-Ax Power Consumption

9.3.5. DC Power Consumption: SE878K7-Ax

State (GPS only)	Typ	Max	Units
Acquisition	66	88	mW
Navigation/Tracking	52	86	mW
Vbatt	25	66	µW
Operating temperature: 25°C Supply voltages: 3.3 VDC nominal Low Power mode: 500 ms duty cycle SBAS: not supported 1PPS sync: disabled			

Table 17: SE878K7-Ax Power Consumption

9.4. Control and Status Signals

9.4.1. I/O Signal Levels

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

Note: Several different logic levels are utilized by the digital signal interfaces of the module.

9.4.2. Logic Levels – Inputs

RX0, RX1, nReset. Ant_Open, Ant-Short, Ant_Sel					
Signal	Symbol	Min	Typ	Max	Units
Input Voltage (L)	Vil	0		0.5	V
Input Voltage (H)	Vih	1.9		3.4	V
Note: These inputs have an internal pullup of 40 kΩ to 190 kΩ.					
Force_On					
Signal	Symbol	Min	Typ	Max	Units
Input Voltage (L)	Vil	0		0.275	V
Input Voltage (H)	Vih	0.825		3.4	V
Note: Force_On has no pullup or pulldown. For typical applications, use a pulldown of 10k Ω.					

Table 18: Input Logic Levels

9.4.3. Logic Levels – Outputs

TX0, TX1, DRI and 1PPS					
Signal	Symbol	Min	Typ	Max	Units
Output Voltage (L)	Vol			0.4	V
Output Voltage (H)	Voh	2.14		2.89	V
Normal Current (L)	Iol		-2		mA
Output Current (H)	Ioh		-2		mA

Table 19: Output Logic Levels

9.4.4. Control and Input Signals

9.4.4.1. nRESET

The nRESET input is an active low input to reset the receiver to the default starting state.

nRESET has an internal pullup.

This signal is not required for the module to operate properly, so this pin may be left unconnected. However, it is recommended to bring it out to a test point.

For logic levels, see Table 18: Input Logic Levels and Table 19: Output Logic Levels.

9.4.4.2. FORCE_ON   (MT3333-based modules only)

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

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

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

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

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

This signal is only available on the MT3333-based modules.

> **Note:** This pin has a maximum input voltage of 3.4 V.
>
> This is lower than the max for Vcc or Vbatt.

For logic levels, see Table 18: Input Logic Levels and Table 19: Output Logic Levels.

9.4.4.3. ANT_SEL

The Antenna Select pin selects the antenna to provide the RF signal to the module.

If HIGH, the onboard antenna will be used.

If LOW, the external antenna will be used.

The SE878K3-Ax can report the status of the antenna switch.

For logic levels, see Table 18: Input Logic Levels and Table 19: Output Logic Levels.

9.4.4.4. ANT_OPEN and nANT_SHORTED   (SE878K3-Ax only)

These inputs inform the module if the antenna current is too low (open) or too high (shorted).

The antenna status message will indicate the status to the user:

Antenna Status Message				
	Ant_Shorted Pin: Low (true)		Ant_Shorted Pin: High (false)	
Ant_Open Pin	High (true)	Low (false)	High (true)	Low (false)
Message	INVALID	SHORTED	OPEN	OK

Table 20: Antenna Status

9.4.5. Output Signals

9.4.5.1. 1PPS

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

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

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

Options for availability are:

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

NMEA output (timestamp) can be configured to have a fixed latency behind the 1PPS pulse of 460 to 485 ms via the $PMTK255 command. Default is variable latency.
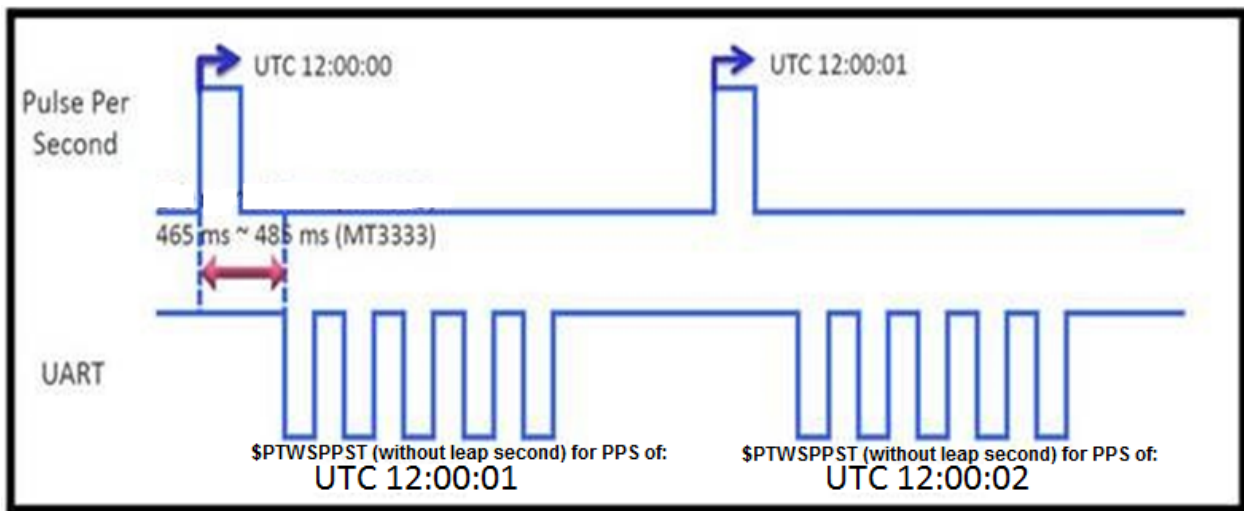
Figure 15: 1PPS NMEA Synchronization

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

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

Variation is ≈ 30 ns (1 σ).

9.5.   I/O Ports

Port 0:

All modules include a primary UART serial port (TX0 / RX0).

Port 1:

The secondary port on **MT3333-based** modules is I^2C by default but can be changed to UART (TX1/RX1) or SPI via command. The module will re-boot when the interface is changed.

The secondary **port on MT3337-based modules** is UART (TX1 / RX1) and cannot be changed.

9.5.1.   Port Usage

9.5.1.1. Primary (Port 0) Usage

TX0: NMEA message output

RX0: NMEA proprietary commands, RTCM SC-104 input and EPO data

TX0 / RX0 is also used to re-flash the module (MT3333-based modules only).

9.5.1.2. Secondary (Port 1) Usage

TX1: NMEA message output

RX1: DGPS input using the RTCM SC-104 protocol and NMEA commands.

I2C and SPI support the same data streams as UART.

> **Note:** The interface is selected via the $PMTK258 command.
>
> Note that the module will reset when the interface is changed.

9.5.2.   UART Port Operation

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

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

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

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

The idle state of UART interface lines is logic high.

UART TX logic levels are shown Table 18: Input Logic Levels and Table 19: Output Logic Levels.

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

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

9.5.3.   SPI Port Operation (MT3333-based modules only)

The MT3333-based modules support SPI interface on the 2nd port via command PMTK258.

- Data rate = 700 kbit/s
- Slave mode only.

Two methods are supported for the host to receive NMEA messages: Polling mode and Interrupt mode.

During a SPI transmission, data is transmitted (shifted out serially) and received (shifted in serially) simultaneously by the module. If no data is ready to be transmitted, the host (master) still needs to send padding bytes. It is suggested to set the value of the padding byte to "0xFF" since the module will ignore these padding bytes.

Data Ready Indicator is supported.

Further details and sample code are available under NDA from the MediaTek MT3339/MT3333 SPI Application Note.

9.5.4. I2C Port Operation (MT3333-based modules only)

MT3337-based modules do not support I2C interface.

MT3333-based modules 2nd serial port (port 1) is configured to use the I2C interface by default but can be changed to UART or SPI via command: $PMTK258

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

Features

- Slave mode only (hard-coded address = 0x10)

- Fast mode (up to 400 Kbps)

- 7-bit address

- 255-byte buffer

- The module operates in the polled mode (with the host as the master)

- Data Ready Indicator

Transmit

The host must be able to read several packets each report cycle. A minimum pause of 2 ms is required between reads to allow the module to fill the buffer. A longer delay is permissible. For example, if the report cycle is 1 second, set the polling sleep time to 500 ms for the next output interval to start.

The buffer will contain up to 254 data bytes plus an <LF> (x'0A") character.

Each NMEA sentence will be terminated by the (standard) <CR-LF> (x'0D, x'0A') characters, and a NMEA sentence can span buffers.

If necessary, the buffer is padded with x'0A' characters. x'0A' is also used for idle characters.

Receive

The maximum length for commands sent to the module.is 255 bytes.

A minimum of 10 ms is required between packets.

Note: The following features are fully supported via I2C:

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

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

- FW Flashing
- EPO
- Always locate

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

10. RF FRONT-END DESIGN

10.1.   RF Signal Requirements

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

The GPS signal is defined by the Interface Specification IS-GPS-200. This document states that the signal level received by a linearly polarized antenna having 3 dBi gain will be a minimum of -130 dBm when the antenna is in the worst-case orientation and the satellite is 5 degrees or more above the horizon.

In actual practice, the GPS satellites transmit slightly more power than specified by the IS, and the signal level typically increases if a satellite has higher elevation angles.

The GLONASS signal is defined by GLONASS ICD (currently 2008 Version 5.1). This document states that the power level of the received RF signal from a GLONASS satellite at the output of a 3dBi linearly polarized antenna is not less than -131dBm for L1 sub-band provided that the satellite is observed at an angle of 5 degrees or more above the horizon.

The receiver will display a reported C/No of 40 dB-Hz for a GPS signal level of -130 dBm at the RF input, assuming a system equivalent noise (SEN) 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.

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

- Satellite transmit power

- Satellite elevation angle

- Free space path loss

- Extraneous path loss (for example, 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, which is readily available online.

The GNSS signal is relatively immune to attenuation from rainfall. However, it is heavily influenced by attenuation due to foliage (such as tree canopies, and so on) as well as outright blockage caused by buildings, terrain or other objects near the line of sight to each specific GNSS satellite. This variable attenuation is highly dependent upon satellite location. If enough satellites are blocked, say at a lower elevation, or all in one general direction, the geometry of the remaining satellites will be worse (higher DOP) and will result in a lower position accuracy. The receiver reports this geometry effect in the form of PDOP, HDOP and VDOP numbers.

For example, in a vehicular application, the GNSS antenna may be placed on the dashboard or rear package tray of an automobile. The metal roof of the vehicle will cause significant blockage. Also, any thermal coating applied to the vehicle glass can attenuate the GNSS signal by as much as 15 dB. Again, both of these factors will affect the performance of the receiver.

Multipath interference results when the signal from a particular satellite is reflected from a surface (for example, a building or the roof of a car) and is received by the GNSS antenna either in addition to or in place of the line of sight signal. The reflected signal has a path length that is longer than the line of sight path, so it can either attenuate the original signal, or if received in place of the original signal, can add error in determining a solution because the distance to the particular satellite is actually shorter than measured. It is this phenomenon (as well as the partial sky obscuration) that makes GNSS navigation in urban canyons (narrow roads surrounded by high-rise buildings) so challenging. In general, the reflection of a GNSS signal causes its polarization to reverse. The implications of this are covered in the next section.

10.2. External GNSS Antenna

An external antenna may be connected to the EXT_ANT_RF_IN pin.

Warning: The EXT_ANT_RF_IN pin is ESD sensitive.

The external antenna is selected by the ANT_SEL antenna select pin.

This should be an active antenna (with its own SAW filter and LNA). Power should be supplied via an external Bias-T.

10.3. Onboard GNSS Antenna (included in the module)

Note that these modules include an RF input switch which allows an external antenna to be connected and provide the GNSS signal instead of the onboard antenna.

The SE878Kx-Ax modules include an Amotech 17mm x 17 mm ceramic patch antenna shown in the following table:

Antenna	Module	GNSS Constellations supported
Amotech 17mm x 17 mm ceramic patch antenna	SE878K3-Ax	GPS, Galileo, GLONASS, BeiDou
	SE878K7-Ax	GPS

Table 21: Patch Antenna

Warning: In order to optimize antenna performance, it is strongly recommended to design a 25 mm by 25 mm ground plane under the module on the application PCB.

If the ground plane size is smaller than 25 mm by 25 mm, center frequency detuning may occur.

Please refer to the next section for Ground Plane information.

10.4. Ground Plane

It is recommended to include at least a 25mm by 25mm (square) ground plane around the module in the PCB design as shown below in order to optimize antenna performance.

The ground plane should be on the top layer of the PCB (directly under the module) with the module centered on it.
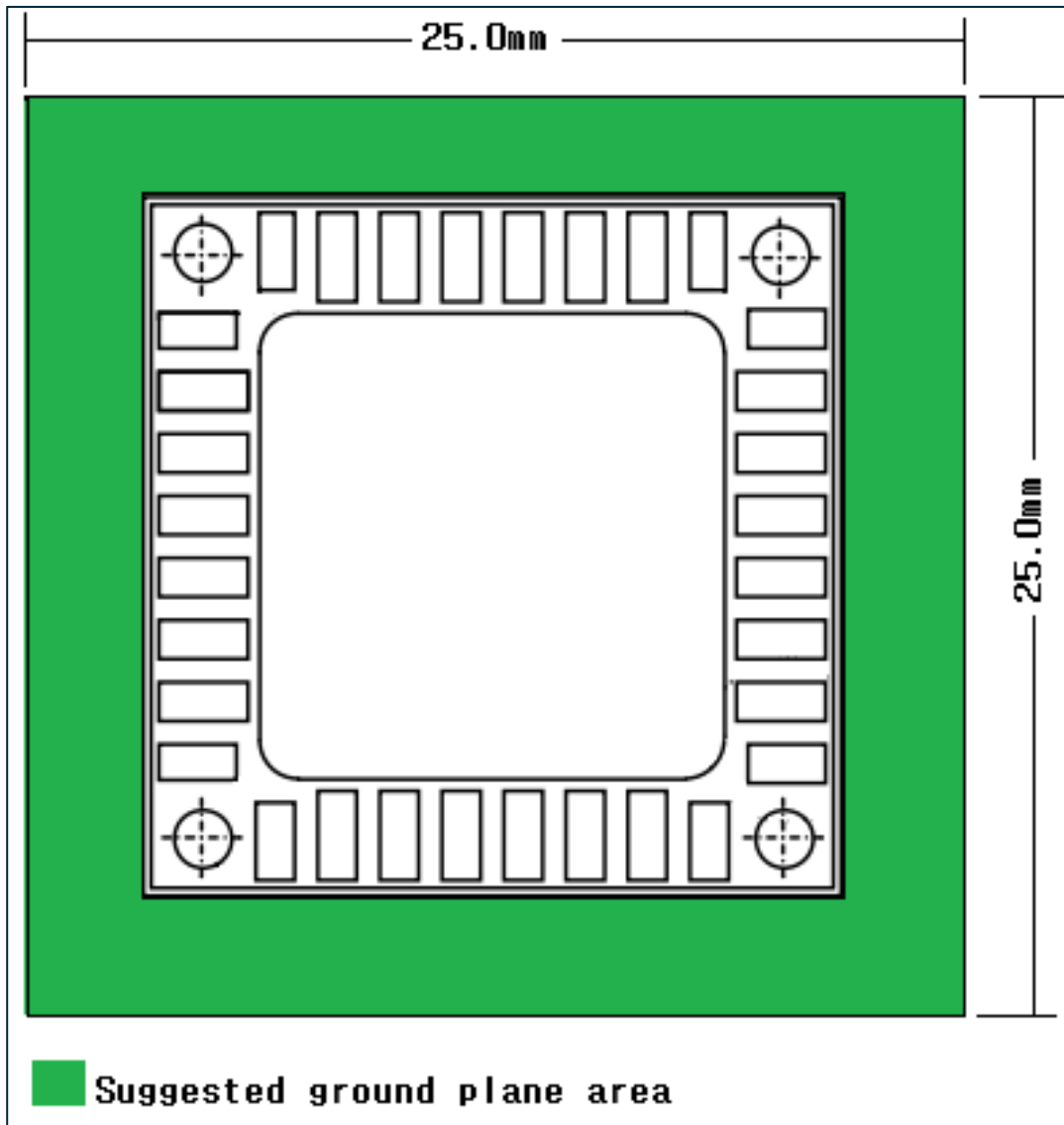
Figure 16: SE878Kx-Ax Ground Plane

Note: "The ground plane should be continuous. There is no "keepout" area under the module."

10.5.   System Noise Floor

The receiver will display a reported C/No of 40 dB-Hz for an input signal level of -130 dBm. The C/No number means the carrier (or signal) is 40 dB greater than the noise floor measured in a one Hz bandwidth. This is a standard method of measuring GNSS receiver performance.

The simplified formula is:

C/No = GNSS Signal level – Thermal Noise – System NF

Equation 1:Carrier to Noise Ratio

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

We can estimate a typical system noise figure of 4 dB for the module, consisting of the pre-select SAW filter loss, the LNA noise figure, and implementation losses within the digital signal processing unit. The DSP noise is typically 1.0 to 1.5 dB.

However, if a good quality external LNA is used, the noise figure of that LNA (typically better than 1dB) could reduce the overall system noise figure from 4 dB to approximately 2 dB.

10.6.   RF 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 is capable of rejecting CW jamming signals in each band (GPS/Galileo, GLONASS, and BeiDou), but would still be affected by non-CW signals.

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

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

10.7.   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.
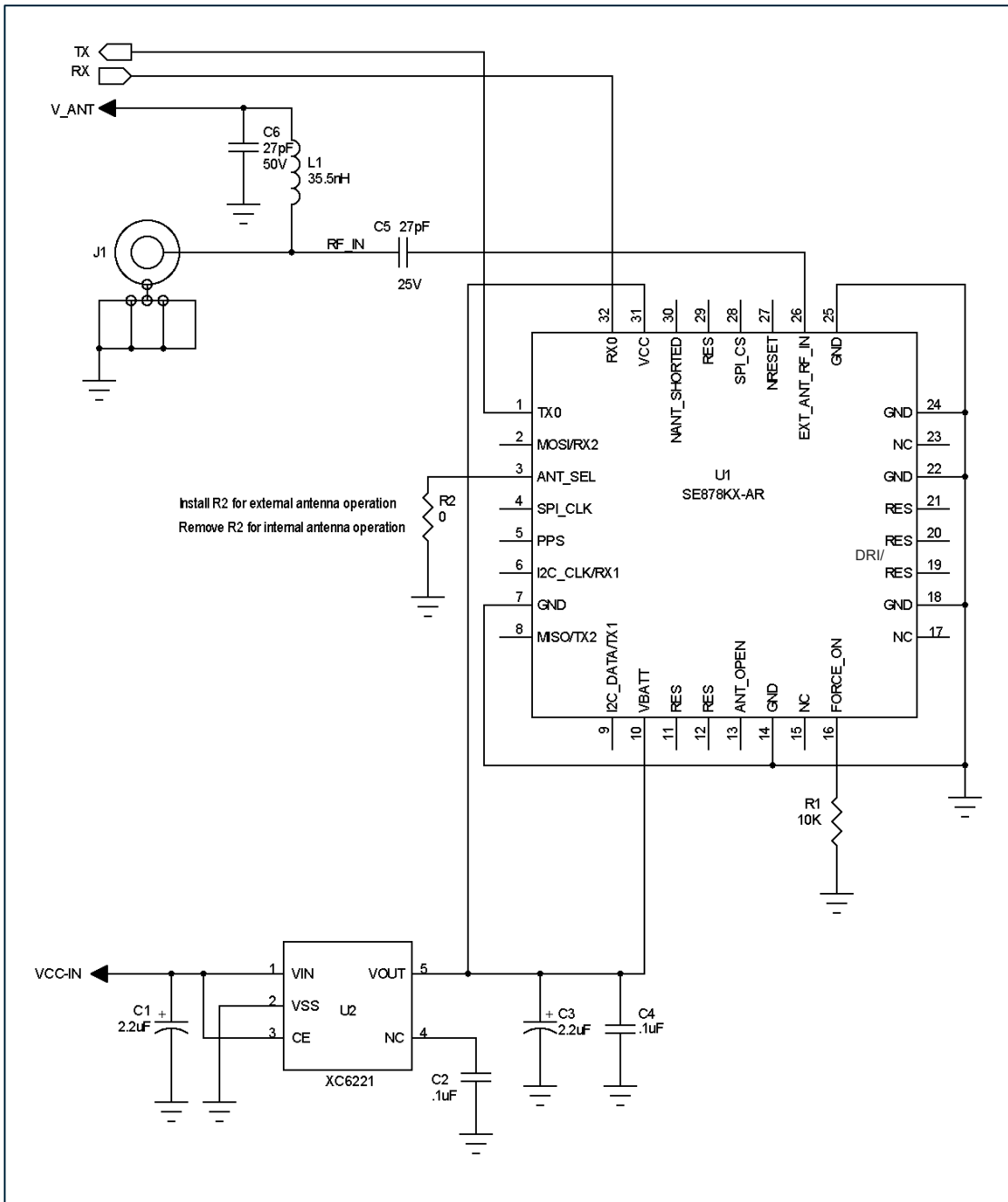
11. REFERENCE DESIGN

Figure 17: SE878Kx-Ax Reference Design

Along with power and grounds, the minimum signals required to operate the receiver properly are the RF input signal and two digital I/O signals (TX and RX).

TX and RX are UART lines with a default of 9600-8-N-1. They are used for message output and command input. Be careful not to drive the RX line if the module is turned off.

> **Note:** See chapter 9 Electrical Interface for important details.
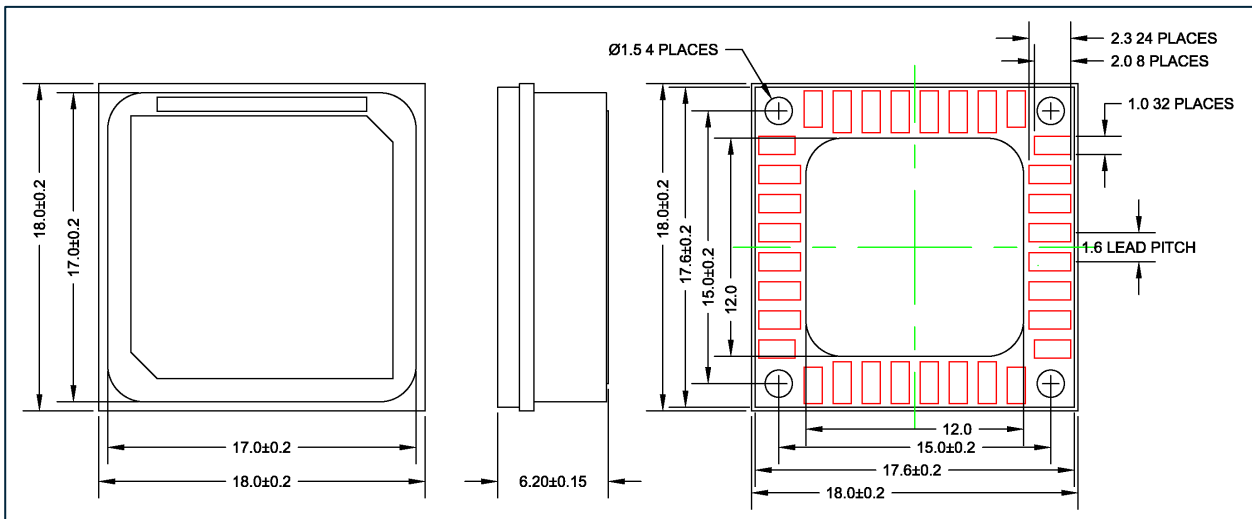
12. MECHANICAL DRAWING

Figure 18: SE878Kx-A Mechanical Drawing
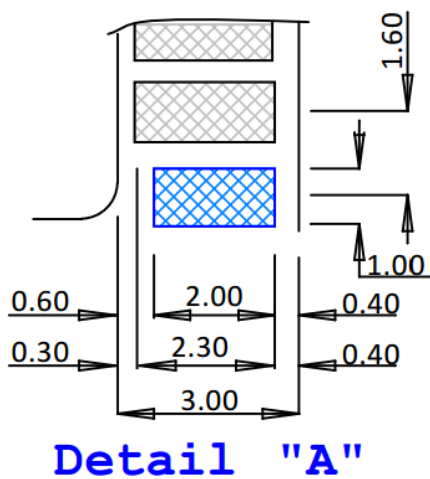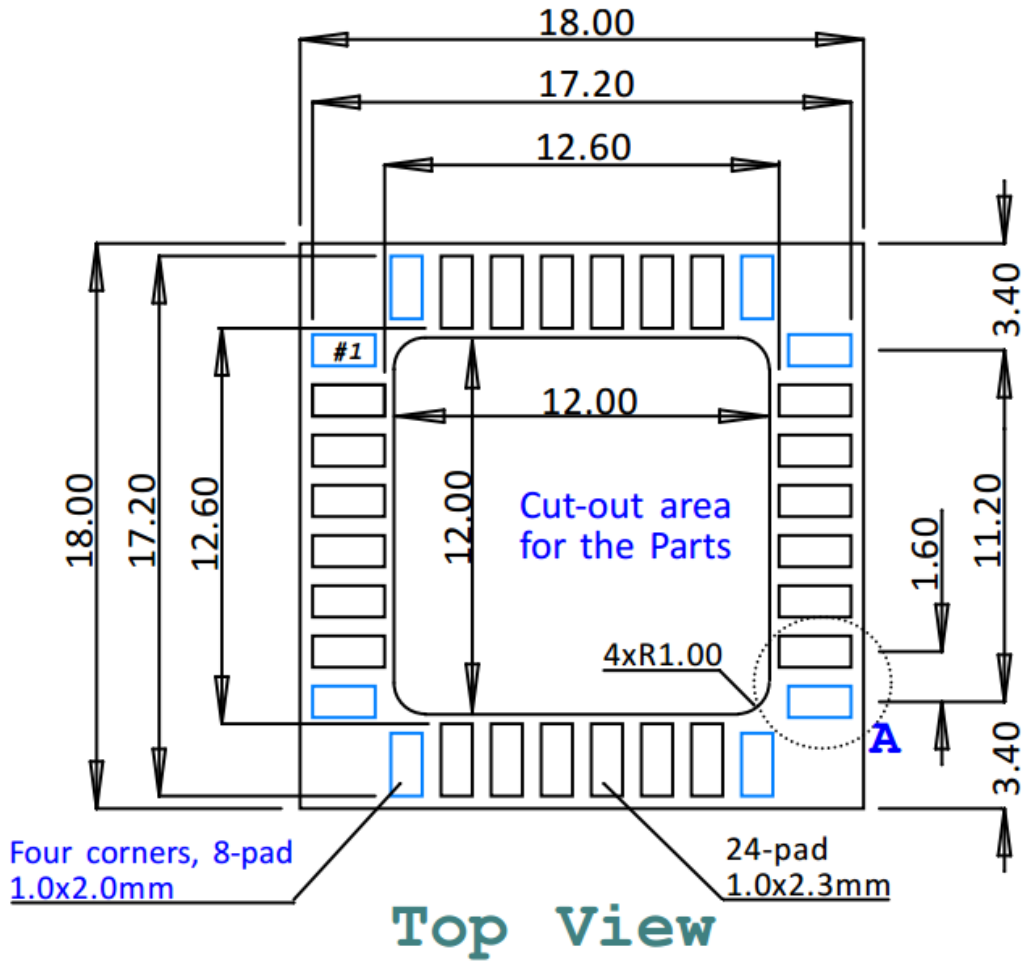
13. PCB FOOTPRINT

Figure 19: SE878Kx-Ax PCB Footprint

14. PACKAGING AND HANDLING

14.1. Product Marking and Serialization

The SE878Kx-Ax module label has a 2D Barcode identifying the module and its serial number.

Contact a Telit representative for information on specific module serial numbers.
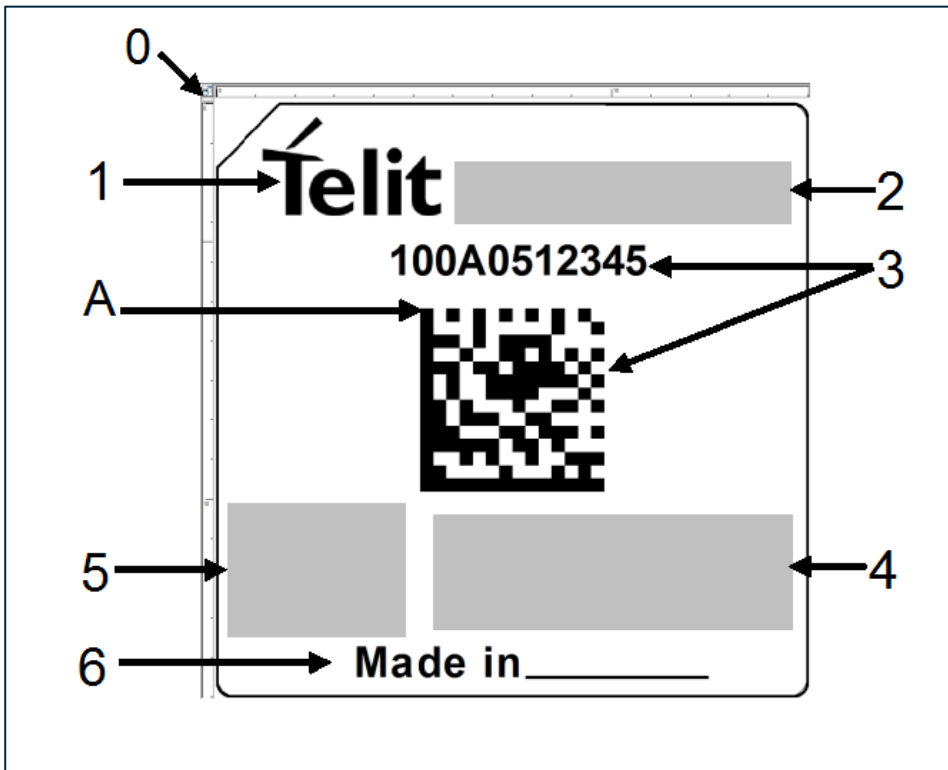
Figure 20: Product Label

Key	Description
1	Telit logo
2	Product Name
3	Telit Serial Number barcode (type 2D data matrix) 11 digit (base 36 – 0 to 9 followed by A to Z)
4	Special identification or blank
5	CE mark
6	Country of origin

Table 22: Product Label Description

14.2. Product Packaging

SE878Kx-Ax modules are shipped in Tape and Reel form. The reeled modules are shipped in 24mm mini reels with 300 units per reel. Each reel is 'dry' packaged and vacuum sealed in a Moisture Barrier Bag (MBB) with two silica gel packs and placed in a carton.

The minimum order quantity for shipping is 300 units.
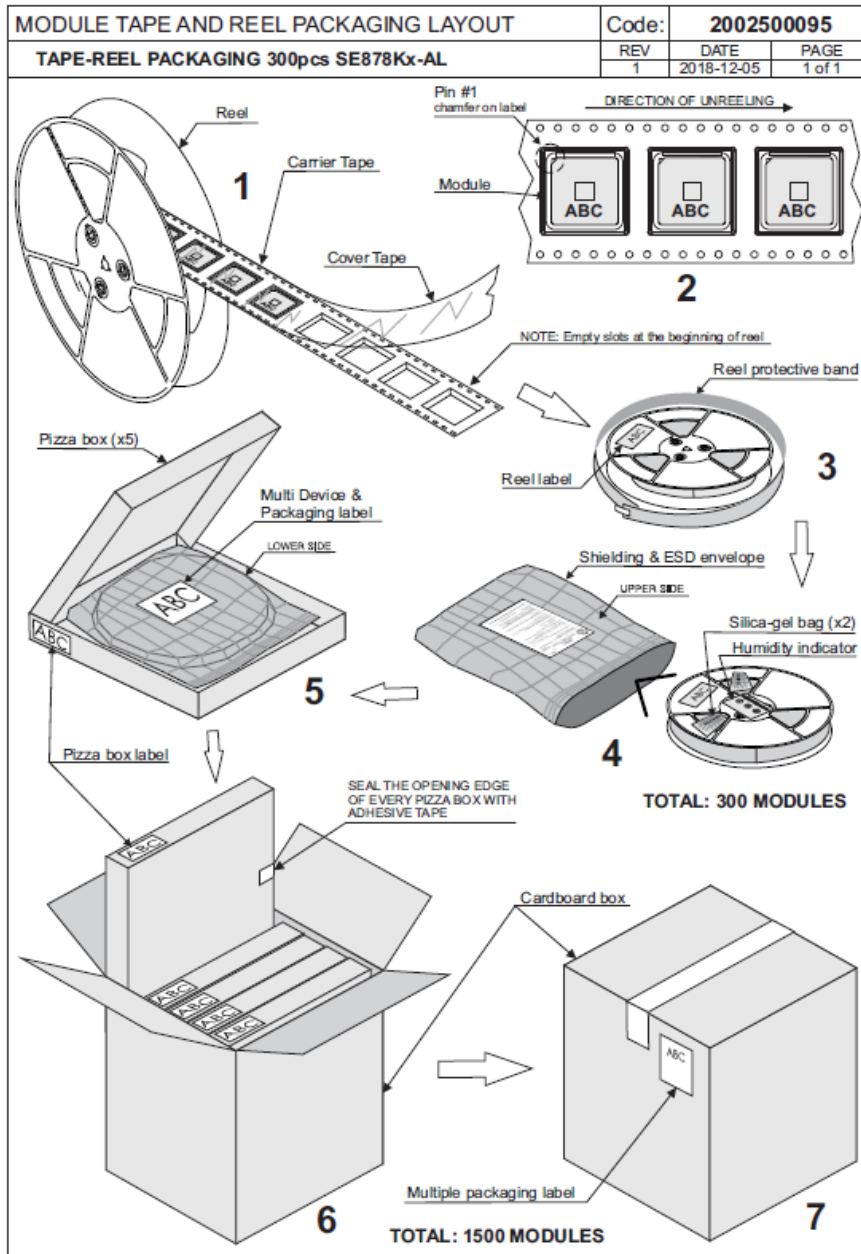
All packaging is ESD protective lined.

Figure 21: SE878Kx-Ax Tape & Reel Packaging

The receivers are Moisture Sensitive Devices (MSD). Please follow the MSD and ESD handling instructions on the labels of the MBB and exterior carton.

14.3. 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.

Note: 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.

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

The modules are supplied in a hermetically sealed bag with desiccant and humidity indicator cards. The 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°C ± 5°C for 48 hours.

Warning: However, the packaging materials (tape and reel or trays) can <u>NOT</u> 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 *https://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 °C and < 90% relative humidity (RH)
2. Peak package body temperature: _____ °C

   If Blank, see adjacent bar code label
3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must

   a) Mounted within: _____ 168 _____ hours of factory

   If Blank, see adjacent bar code label

   conditions ≤ 30 °C/60%

   b) stored at <10% RH

4. Devices require bake, before mounting, if:

   a) Humidity Indicator Card is > 10% when read at 23 ± 5 °C

   b) 3a or 3b not met.

5. If baking is required, devices may be baked for 48 hours at 125 ± 5 °C

   Note: If device containers cannot be subjected to high temperature or shorter bake times are desired,

   reference IPC/JEDEC J-STD-033 for bake procedure

Bag Seal Date: _____

If Blank, see adjacent bar code label

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

Figure 22: Moisture Sensitive Device Label

14.4.   ESD Sensitivity

Note: 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.

Warning: The RF-IN pin is ESD sensitive.

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

14.5.   Assembly Considerations

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

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

14.6.   Washing Considerations

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

14.7.   Reflow

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

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

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

Note: JEDEC standards are available free from the JEDEC website *https://www.jedec.org*.

The recommended reflow profile is shown in the following figure:
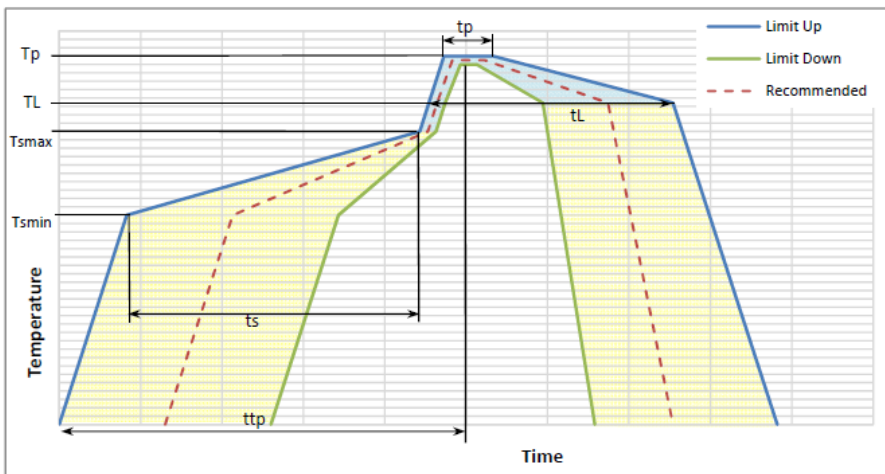
Profile Feature	Pb-Free Assembly
Average ramp-up rate (TL to Tp)	3°C/seccond max
Preheat	
- Temperature Min (Tsmin)	150°C
- Temperature Max (Tsmax)	200°C
- Time (Tsmin to Tsmax) ts	60-180 seconds
Tsmax to TL	
- Ramp-up rate	3°C/seccond max
Time maintained above:	
- Temperature (TL)	217°C
- Time (tL)	60-150 seconds
Peak Temperature (Tp)	245°C +0/-5 °C
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds
Ramp-down Rate	6°C/second max
Time 25°C to Peak Temperature Tp (ttp)	8 minutes max

Figure 23: Recommended Reflow Profile

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

14.8. Safety

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

Please refer to section 17.3 Safety Recommendations for further safety recommendations.

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

Operating 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	600 m/sec (acquisition and navigation) 2G acceleration

Table 23: SE878Kx-Ax Operating Environmental Limits

15.2. Storage Environmental Limits

Storage 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	18 G peak, 5 millisecond duration
Shock (in shipping container)	10 drops from 75 cm onto concrete floor

Table 24: SE878Kx-Ax Storage Environmental Limits

16. COMPLIANCES

The SE878Kx-Ax modules comply with the following:

- Directive 2011/65/EU art. 16 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)

- Manufactured in an ISO 9001: 2008 accredited facility

- Manufactured to TS 16949:2009 requirements

- Directive 2014/53/EU Radio Equipment Directive (RED)

16.1.   CE Declarations of Conformity

DocuSign Envelope ID: B8CFF44C-9317-47EB-91EA-3B5C16F7EAD9

EU DECLARATION OF CONFORMITY [20553DOC00132A]

1 **SE878K3-A** (product name)

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

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

4 GNSS L1 receiver Wireless Module
   SW Version(s) Ver3.8.13_3333_0100800

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

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

6 The conformity with the essential requirements set out in Art.3 of the 2014/53/EU has been demonstrated against the following harmonized standards:
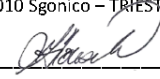
Harmonized Standard reference	Article of Directive 2014/53/EU
EN 60950-1:2006+A11:2009+A1:2010+A12:2011+A2:2013	3.1 (a): Health and Safety of the User
Draft ETSI 301 489-1 v2.2.0 & 301 489-19 v2.1.0	3.1 (b): Electromagnetic Compatibility
ETSI 303 413 v1.1.1	3.2: Effective use of spectrum allocated

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

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

   Thus,   CE   is placed on the product.

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

9 The Technical Documentation (TD) relevant to the product described above and which supports this Declaration of Conformity, is held at: Telit Communications S.p.A., Via Stazione di Prosecco, 5/b - 34010 Sgonico – TRIESTE – ITALY

   Trieste,   **2018-04-18**   _____   _____

                          Group CFO, Corporate   **VP R&D GNSS**
                            Eran Edri   Georgia Frousiakis

   EU-Type Examination Certificate No. 20180413085347   Technical Documentation: 30553TCF00122A
                                   www.Telit.com/RED

Telit Communications S.p.A.	Cap. Soc. € 3.000.000	Società soggetta all'attività	Società con socio unico
Via Stazione di Prosecco n. 5/B	Partita IVA 03711600266	di direzione e coordinamento	(Telit Communications PLC)
34010 Sgonico (TS) - ITALY	Cod.Fisc. 03711600266	da parte di Telit Communications PLC	
Phone +39 040 4192 111	Nr. R.E.A. TS-120027	con sede in Londra (art.2497 bis C.C.)	
Fax +39 040 4192 333			

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

Figure 24: SE878K3-A CE Declaration of Conformity

EU DECLARATION OF CONFORMITY [20553DOC00133A]

1 **SE878K7-A** (product name)

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

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

4 GPS L1 receiver Wireless Module
   SW Version(s) Ver2.3.2_3337__15010801

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

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

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

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

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

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

   Thus,   CE   is placed on the product.

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

9 The Technical Documentation (TD) relevant to the product described above and which supports this Declaration of Conformity, is held at: Telit Communications S.p.A., Via Stazione di Prosecco, 5/b - 34010 Sgonico – TRIESTE – ITALY

   Trieste,   **2018-04-18**   _____   _____

                                Group CFO, Corporate   **VP R&D GNSS**
                                Eran Edri   Georgia Frousiakis

   EU-Type Examination Certificate No. 20180413085646   Technical Documentation: 30553TCF00123A

                                www.Telit.com/RED

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Via Stazione di Prosecco n. 5/B   Partita IVA 03711600266   di direzione e coordinamento   (Telit Communications PLC)
34010 Sgonico (TS) - ITALY   Cod.Fisc. 03711600266   da parte di Telit Communications PLC
Phone +39 040 4192 111   Nr. R.E.A. TS-120027   con sede in Londra (art.2497 bis C.C.)
Fax   +39 040 4192 333

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Figure 25: SE878K7-A CE Declaration of Conformity

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17.3.   Safety Recommendations

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

- it can interfere with other electronic devices, particularly in environments such as hospitals, airports, aircrafts, etc.

- there is a risk of explosion such as gasoline stations, oil refineries, etc. It is the responsibility of the user to enforce the country regulation and the specific environment regulation.

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

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

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

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

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

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

18. GLOSSARY 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 can 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, autonomously 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 can reliably continue navigation after the satellite signals have been acquired.
NMEA	National Marine Electronics Association
QZSS	Quasi-Zenith Satellite System The Japanese regional system.

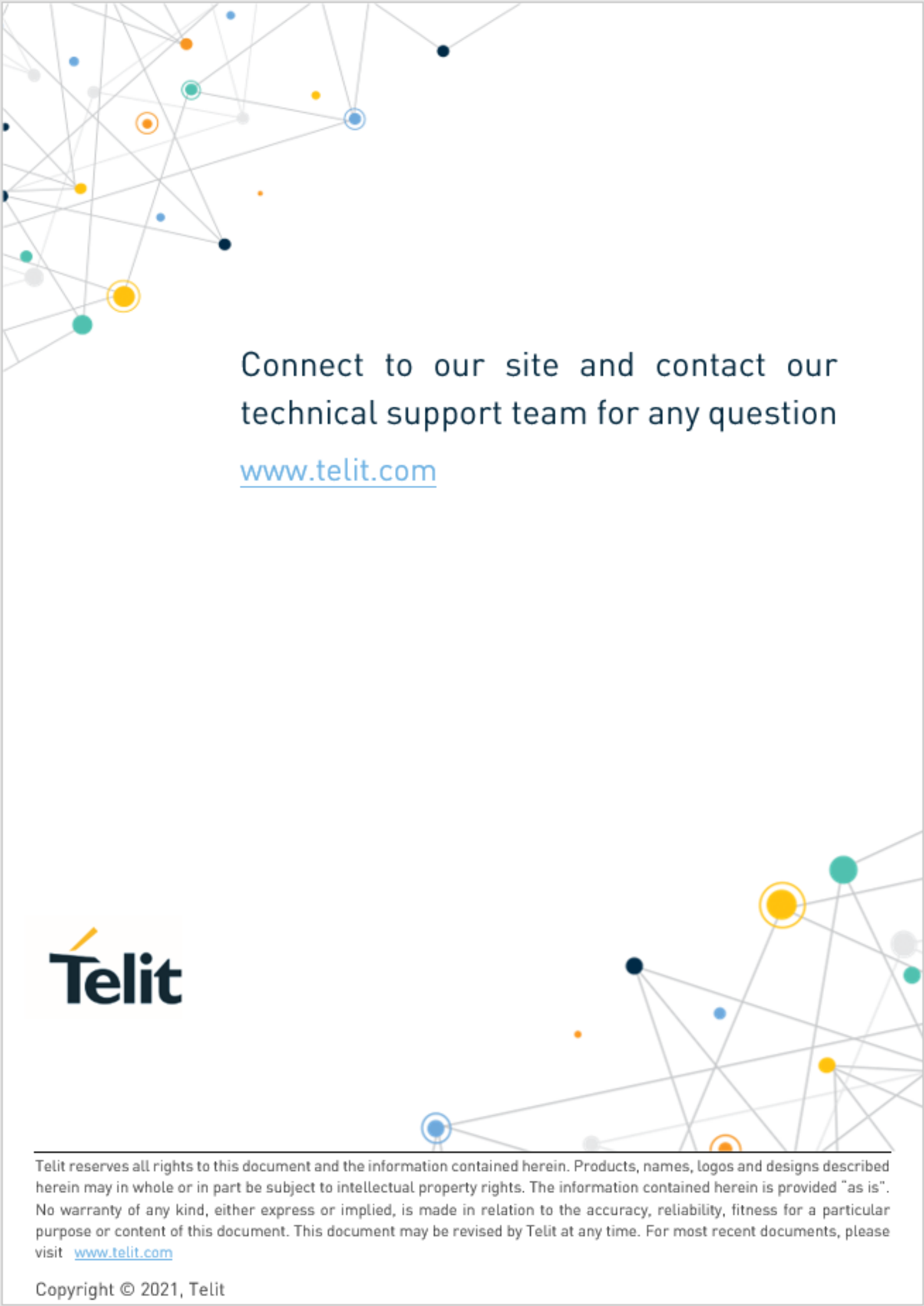|	
Reacquisition	receiver, while in normal operation, losing the RF signal (perhaps due to the antenna cable being disconnected or a vehicle entering a tunnel), and re-establishing a valid fix after the signal is restored. Contrast with Reset and Restart.
Restart	A receiver beginning operation after 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 can maintain tracking of a satellite signal after acquisition is complete. The receiver may stop navigating since it cannot decode the navigation message at this signal level.
TTFF	Time to First Fix The elapsed time required by a receiver to achieve a valid position solution from a specified starting condition. This value will vary with the operating state of the receiver, the length of time since the last position fix, the location of the last fix, and the specific receiver design. A standard reference level of -130 dBm is used for testing.

UART	Universal Asynchronous Receiver/Transmitter An integrated circuit (or part thereof) which provides a serial communication port for a computer or peripheral device.
WAAS	Wide Area Augmentation System The North American SBAS system developed by the US Federal Aviation Administration (FAA).
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.

19.   DOCUMENT HISTORY

Revision	Date	Changes
9	2021-08-23	Added note on Ground plane on section 10.4
8	2021-07-21	Corrected Figure numbers Minor editorial changes
7	2021-07-15	Modified section 9.5.4 to document features supported via I2C port. Updated document to new Telit standard template
6	2020-04-13	Removed the following sections: • 9.2.3 Signal Levels • 9.2.4 Logic Levels – Inputs • 9.2.5 Logic Levels – Outputs Minor editorial changes
5	2019-08-27	Minor text revisions
4	2018-08-07	Removed prohibition against driving nRESET high. Changed allowance of one reflow to two reflows. Minor reformatting.
3	2018-07-09	SBAS ranging is not supported Added reference to SE868Kx-Ax (smaller module) Added Pin 20 - Data Ready Indicator Removed restriction against fast-discharge LDO I/O second port description updated Minor text and formatting changes
2	2018-05-18	Added that enabling BDS disables GLONASS and Galileo Corrected descriptions of serial ports Changed pin name from SPI_CS to nSPI_CS Removed restriction prohibiting use of an LDO with fast discharge Added RED Documents of Conformity Updated module photos Minor text changes
1	2018-03-16	Changed "3337" to "3333" in 4.14.2 Force-on note Corrected the pinout diagram & tables and reference schematic Made I/O port names consistent
0	2018-03-12	First edition (with revised pin numbers & QZSS default)

From Mod.0809 rev.3

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