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# SEAL Wearable GPS Tracker

## User Guide

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## Acronyms and Glossary

<b>BeiDou</b> .....	BeiDou Navigation Satellite System (BDS), a Chinese satellite navigation system
<b>BER</b> .....	bit error rate
<b>BLE</b> .....	Bluetooth Low Energy
<b>bps</b> .....	bits per second
<b>DL</b> .....	downlink
<b>EIRP</b> ....	equivalent isotropically radiated power
<b>FCC</b> .....	Federal Communications Commission
<b>GLONASS</b> .....	GLObal NAVigation Satellite System
<b>GNSS</b> ...	Global Navigation Satellite System
<b>GPS</b> .....	Global Positioning System
<b>IoT</b> .....	Internet of Things
<b>IP</b> .....	Ingress Protection
<b>LED</b> .....	light emitting diode
<b>LID</b> .....	lithium-iron disulfide
<b>LoRa</b> ...	a patented “long-range” IoT technology acquired by Semtech
<b>LoRaWAN</b> .....	LoRa wide area network (a network protocol based on LoRa)
<b>MCU</b> ...	microcontroller unit
<b>NS</b> .....	network server
<b>OTA</b> ....	over the air
<b>PCBA</b> ..	printed circuit board assembly
<b>QZSS</b> ...	Quasi-Zenith Satellite System
<b>RF</b> .....	radio frequency
<b>RSS</b> .....	Radio Standards Specifications
<b>RSSI</b> ....	received signal strength indicator
<b>Rx</b> .....	receiver, receive
<b>SBAS</b> ...	Satellite-Based Augmentation System
<b>Tracker</b> .....	any variant of the SEAL Wearable GPS Tracker
<b>TTF</b> ...	time to first fix
<b>TRM</b> ...	technical reference manual
<b>Tx</b> .....	transmitter, transmit
<b>UG</b> .....	user guide (this document)
<b>UTC</b> ....	Coordinated Universal Time
<b>UV</b> .....	ultraviolet
<b>ver.</b> .....	version

# 1 Product Description

## 1.1 Overview

This document is the User Guide for the *SEAL Wearable GPS Tracker* designed and developed by TEKTELIC Communications, henceforth referred to as *SEAL* or *SEAL Tracker*.

SEAL is a light, small factor, long battery lifetime, low-cost LoRaWAN sensor used as a wearable device for tracking people based on GNSS and BLE technologies. SEAL is also available in ATEX/IECEx certified versions (SEAL Ex) for use in explosive atmospheres. Please refer to the SEAL Ex User Guide T0008740 for information specific to the SEAL Ex versions.

SEAL uses a Semtech modem for LoRaWAN communication, and a low-power, IoT targeted MCU, with built-in BLE module. Other hardware features include a high-sensitivity GNSS receiver, a low power 3-axis MEMS accelerometer, and a digital barometric air pressure sensor. There is also a push button used as an emergency/SOS/panic button, a buzzer to locally indicate the emergency button (EB) press or harness disconnection, a mute button (MB) to manually mute (disable) or unmute (enable) the buzzer, and two sets of LEDs, one at the top one at the front, to indicate emergency status, low battery, and the system going into or out of DEEP SLEEP, are among other features.

**Table 1-1: SEAL Wearable GPS Tracker Model**

Model	Description	RF Region	Tx Band (MHz)	Rx Band (MHz)
T0008768	SEAL Wearable GPS Tracker	US915	923-928	902-915
T0008769	SEAL Wearable GPS Tracker with Harness Clip	EU868	863-870	863-870

SEAL comes in two versions, with and without a harness clip. The harness clip detects if the unit is clipped in place or not and triggers a local alarm.

The supported features of the different SEAL variants are tabulated below

**Table 1-2: Functional features of SEAL variants**

Feature	SEAL Functional Variants	
	SEAL with harness clip	SEAL without harness clip
Battery Lifetime info (Percentage and days remaining)	X	X
GNSS Fix Position and time stamp	X	X
GNSS Danger zone	X	X
GNSS datalogging	X	X

Groundspeed	X	X
Discovered BLE devices	X	X
BLE Danger zone	X	X
Emergency button	X	X
Fall detection	X	X
Safety Harness detection	X	
Elevation detection	X	X
Atmospheric Pressure	X	X
Acceleration Vector Report	X	X
Temperature	X	X
GNSS Diagnostics info	X	X

Figure 1-1 and Figure 1-2 below illustrates the clip and the non-clip variants of SEAL.

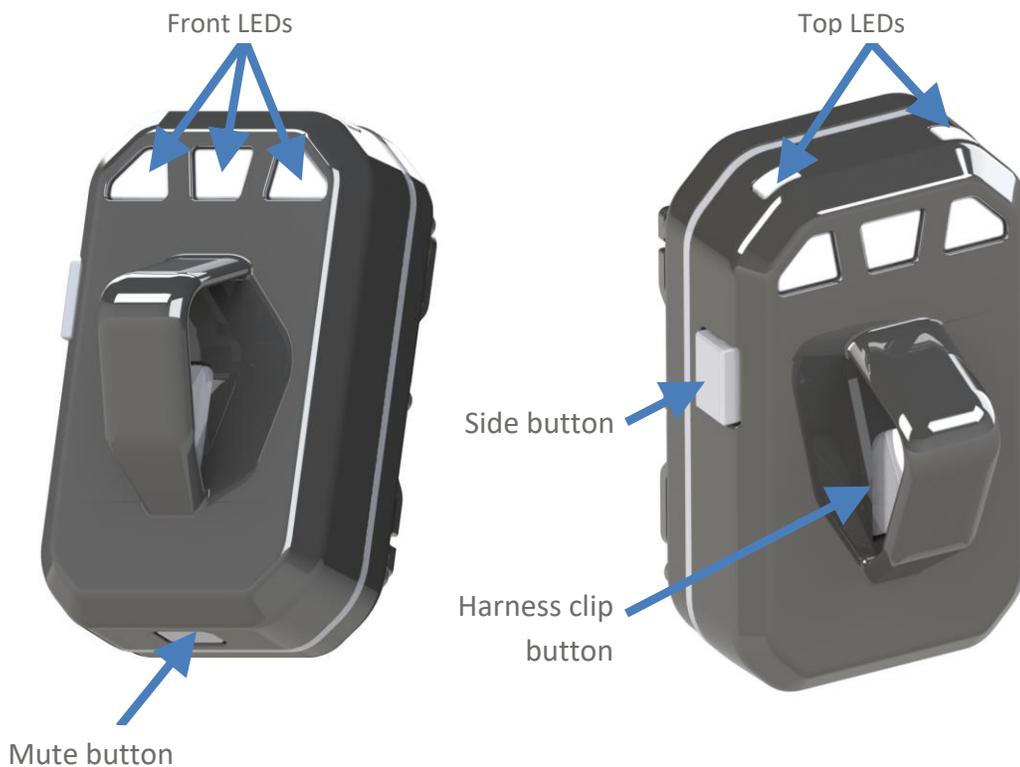


**Figure 1-1: The SEAL Wearable GPS Tracker – Clip Variant.**



Figure 1-2: The SEAL Wearable GPS Tracker – Non-Clip Variant.

Figure 1-3: SEAL Wearable GPS Tracker – LEDs and buttons



## 1.2 Specifications

The specifications for SEAL are listed in Table 1-.

**Table 1-2: SEAL Wearable GPS Tracker Specifications**

Parameter	Specification
Use Environment	Indoor and outdoor locations
Form Factor	Wearable
Environmental Rating	IP67
Humidity Control	EPTFE vent
Operating Temperature	-20°C–60°C
Storage Temperature for Optimal Battery Life	-25°C–55°C
Size	Clip variant: 104 mm x 70 mm x 57.8 mm non-clip variant: 104 mm x 70 mm x 33.8 mm
Weight	100 g without batteries; add 15 g per battery.
Power Source	Battery powered: 3x AA-cell LID
Network technology/Frequency band	LoRaWAN EU868/US915/AS923/AU915/IN865/KR920/RU864
Air Interface	LoRa
Maximum Tx Power	15 dBm
Sensing Functions	GNSS, Accelerometer, BLE, Temperature, Pressure, Battery Gauge
GNSS Features	Support of GPS/QZSS, GLONASS, Galileo, BeiDou Support of up to 4 concurrent GNSSs Data logging up to 3,000 entries Geofencing up to 4 circular geofences 2.5 m position accuracy (CEP 50%) TTFF: <ul style="list-style-type: none"> <li>• 60 sec cold start</li> <li>• 5 sec hot start</li> </ul> Sensitivity: <ul style="list-style-type: none"> <li>• -160 dBm tracking and navigation</li> <li>• -148 dBm cold start</li> <li>• -157 dBm hot start</li> </ul>
Accelerometer Sensitivity	Sample rate: 1 Hz, 10 Hz, 25 Hz, 50 Hz, 100 Hz, 200 Hz, 400 Hz Measurement range: $\pm 2 g$ , $\pm 4 g$ , $\pm 8 g$ , $\pm 16 g$ Precision: 16 mg, 32 mg, 64 mg, 192 mg
Bluetooth Compatibility	BLE base on Bluetooth 5
BLE horizontal accuracy	$\leq 5$ m
BLE Sensitivity (0.1% BER)	125 kbps: -103 dBm 500 kbps: -98 dBm 2 Mbps: -91 dBm
BLE Danger Zones	Supports geofencing of up to 4 BLE mac address ranges
Temperature Measurement Accuracy	Accuracy: $< \pm 0.5$ °C
Barometric Pressure	Range: 300 to 1200 hPa Precision: $< \pm 0.002 hPa$ (or $\pm 0.02m$ ) Relative accuracy: $< \pm 0.06 hPa$ (or $\pm 0.5m$ ) Absolute accuracy: $< \pm 1 hPa$ ( $\pm 8m$ )

Parameter	Specification
Battery Lifetime	1.5 years

### 1.3 Transducer Details

SEAL is equipped with a number of different transducers. A general overview of the transducers is given below.

1. GNSS: SEAL uses a GNSS receiver module for GNSS localization and other GNSS-related features such as GNSS danger zone and GNSS datalogging. The GNSS receiver is a low power, high precision module that supports concurrent receptions of up to four GNSS constellations (GPS, GLONASS, Galileo, and BeiDou). The high number of visible satellites enables the receiver to select the best signals. This maximizes the position availability, in particular under challenging conditions such as in deep urban canyons. The typical and maximum accuracies of the GNSS position fixes for SEAL is listed below
  - a. Position accuracy (50% CEP): 2.5m<sup>1</sup>
  - b. Time to first fix: Cold start: 1-minute, Hot start: 5s
2. BLE: SEAL’s MCU is an ultra-low power IoT targeted module with in-built support for Bluetooth low energy SIG 5.2 technology. SEAL ONLY supports the use of this technology as a TRACKER. This means that SEAL can track and discover BLE devices nearby, but it can’t be discovered by other BLE Trackers. By default, the BLE scanning functionality of SEAL is disabled. However, this can easily be changed by sending a simple OTA command to enable the BLE mode. SEAL can track and report up to 128 devices per scan.
3. Accelerometer: SEAL has a 3-axis MEMS digital accelerometer for motion detection to wake the device up from inactivity sleep, and free-fall detection. The accelerometer is an ultra-low-power high performance three-axis linear accelerometer. The device features ultra-low-power operational modes that allow advanced power saving and smart embedded functions. The accelerometer has dynamically user-selectable full scales of  $\pm 2g/\pm 4g/\pm 8g/\pm 16g$  and is capable of measuring accelerations with output data rates from 1 Hz to 5.3 kHz.
4. Barometer: SEAL has a barometer for accurately measuring barometric pressure and temperature. The typical and maximum accuracies specified across the operating relative humidity and temperature range of the sensor are listed below:
  - a. Operation range: Pressure: 300 –1200 hPa, temperature: -40 – 85 °C
  - b. Pressure sensor precision:  $\pm 0.002$  hPa (or  $\pm 0.02$  m) (high precision mode).
  - c. Relative accuracy:  $\pm 0.06$  hPa (or  $\pm 0.5$  m)

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<sup>1</sup> Calculated from 6 hours of continuous multi-constellation fixes in static open and clear sky.

- d. Absolute accuracy:  $\pm 1$  hPa (or  $\pm 8$  m)
  - e. Temperature accuracy:  $\pm 0.5^{\circ}\text{C}$ .
5. Battery current: SEAL continuously monitors the battery current usage and uses this information to compute remaining battery life.

## 2 Installation

### 2.1 Included Product and Installation Material

The following items are included with each package:

- One SEAL Wearable GPS Tracker module
- A full compliment of Lithium Iron Disulfide AA batteries (already installed in the sensor)
- A Quick Start Guide

### 2.2 Safety Precautions

The following safety precautions should be observed:

**USE ONLY ENERGIZER L91 ULTIMATE LITHIUM AA SIZE 1.5 V LITHIUM IRON DISULFIDE BATTERIES.  
ALWAYS REPLACE ALL BATTERIES TOGETHER AS A SET WITH FRESH NEW BATTERIES.**

### 2.3 Unpacking and Inspection

The following should be considered during the unpacking of a new SEAL product:

- Inspect the shipping carton and report any significant damage to TEKTELIC.
- Unpacking should be conducted in a clean and dry location.
- Do not discard the shipping box or inserts as they will be required if a unit is returned for repair or re-configuration.

### 2.4 Commissioning and Activation

SEAL is shipped in closed enclosure with the batteries installed and engaged. However, SEAL is in a state of DEEP SLEEP where it draws infinitesimal current, until it is woken up (activated) by a button pattern.

The SEAL module does not need to be opened for activation. Assuming the module has been commissioned on the NS using the commissioning info provided with the unit, use the button pattern to wake up the Tracker as detailed below. A button press is achieved by pressing the mute button and feeling a click. A mute button release is achieved by releasing the mute button.

The following the button pattern is required to activate the unit:

1. Press the mute button for 1s, then release the mute button.
2. Press the mute button for at least 3 sec but less than 10 sec, then release the mute button.

As soon as the specified mute button press is applied, the module will wake from a DEEP-SLEEP state and try to join the network. See Section 4.3 for the expected LED behaviour of the Tracker during the

join process. It may take about 5 sec from completion of the wake-up button sequence to the LED activity showing join attempts.

Note that the specified button press pattern always triggers a module reset, even during normal operation. The mute button is located on the base of all the SEAL variants as shown below.



**Figure 2-1: SEAL with clip showing the mute button.**

The SEAL can be put into DEEP SLEEP at anytime by applying the pattern described above while the device is trying to join the network (this is indicated by rapid flashing of the top LEDs). If put into DEEP SLEEP, the SEAL module can be woken up (re-activated) again using the same procedure explained above. Removing and reinserting the batteries can also reset the SEAL module.

**Note:** Removing and replacing the batteries of the SEAL Tracker does not cause it to go into DEEP SLEEP. As soon as new batteries are inserted, the SEAL Tracker boots up and tries to join the network.

## 2.5 Mounting

On the battery side of the enclosure, there are four clip holes that can be used to clip the SEAL Tracker to a belt or harness clip as shown in see Figure 2-2 below. The recommended clipping screw type is M3 5mm stainless steel screws. Separate mounting screws are not provided with the SEAL Tracker.



Figure 2-2: The Tracker clipped to a belt clip (Left) and harness clip (Right).

## 2.6 Battery Replacement

The module battery cover is secured by six hex socket head screws identified in Figure 2-2. **Error! Reference source not found.** Remove all six screws using a 1.5 mm internal hex screwdriver. Be careful not to misplace the back-cover or any of the screws and washers.

The SEAL module accepts three Energizer L91 AA size Lithium Iron Disulfide “Ultimate Lithium” batteries. Always replace all batteries together as a set. Observe the battery polarity markings when inserting the batteries.

Once the new batteries are inserted, replace the battery cover and inspect the silicone gasket along the outer mating edge of the battery cover for proper alignment and sealing to the case.

Once the cover and gasket are properly in place, secure the battery cover using the same six hex socket head screws. Tighten the six cover screws to 2.5 lbf-in (30 N-cm).

Once the batteries make contact with the terminals, the SEAL Tracker is powered ON and tries to join the network, with its LEDs behaving as described in Section 4.34.3.

## **3 Power up, Commissioning, and Monitoring**

### **3.1 Required Equipment**

No special equipment is required to power on the SEAL Tracker.

### **3.2 Power Up/Down Procedure**

Once the sensor information has been added to the Network Server, press the mute button pattern explained in Section 2.4. The batteries must be removed to turn off the device, but the described mute button press pattern can be used to reset the device.

## 4 Operation, Alarms, and Management

### 4.1 Configuration

The SEAL Tracker supports a full range of OTA configuration options. Specific technical details are available in the SEAL TRM [1]. All configuration commands need to be sent OTA during SEAL's receive windows.

### 4.2 Default Configuration

The default configuration on the SEAL tracker is:

- Report the remaining battery capacity in percentage once every day.
- Report GNSS position fix coordinates, time stamp and groundspeed once every 15 mins in NORMAL mode and once every minute in EMERGENCY mode
- Report the Safety status once every 5 minutes in NORMAL mode and once every minute in EMERGENCY mode

### 4.3 LED Behaviour

See Figure 1-3 for the location and identification of the SEAL LEDs.

During the boot and join process:

- All LEDs are turned OFF when power is first applied.
- All three front LEDs are turned on when the device health self-check begins
  - If the front LED flashes rapidly after they were turned off, then the self checks have failed. Consider replacing the batteries, or moving the SEAL Tracker to an environment within the temperature range.
  - If the top LED flashes rapidly after the front LEDs are turned off, then the self checks have passed. The SEAL Tracker moves to the net step below.
- After a small delay (< 10 seconds) the top LEDs start blinking rapidly indicating the SEAL Tracker is trying to join the network. During this time the SEAL Tracker sends join request uplinks at least once every 10s, with the front LED blinking every time a join request is sent. If the SEAL Tracker is not successful in joining the network after one hour, it backs off the joining process by reducing the rate at which it sends the join request to a significantly lower rate to conserve battery. The flash rate of the LEDs is also reduced to once every 10s.
- During normal operation, the front LED blinks whenever LoRa uplink activity occurs on the Tracker (transmitting packets).

## 4.4 Push Buttons

SEAL has two common push buttons: one on the side called the emergency/panic button used for activating and deactivating the emergency mode, and another on the base called the mute button used for muting and unmuting the buzzer, and resetting and putting the Tracker into and out of deep sleep (check Section 2.4 for more information)

The SEAL variants with harness clip have a third button at the front of the device, used for detecting a harness connection. See Figure 1-3 for an illustration of where all the buttons are positioned.

## 4.5 Activation, Putting to DEEP SLEEP, Resetting, and Shutting Down

Table 4-1 shows how to activate, put to DEEP SLEEP, reset, or completely turn off the SEAL Tracker.

**Table 4-1: How to Activate, Put to DEEP SLEEP, Reset, or Shut Down SEAL**

Desired Action	What to Do
Activate out of DEEP SLEEP	<ul style="list-style-type: none"><li>Apply the specified mute button pattern described in Section 2.4 to a SEAL Tracker in deep sleep (this step does not require opening the SEAL module)</li></ul>
Put to DEEP SLEEP	<ul style="list-style-type: none"><li>Apply the specified mute button pattern described in Section 2.4 while the SEAL Tracker is trying to join the network</li></ul>
Reset	Apply the specified mute button pattern described in Section 2.4 to the SEAL Tracker in operation (this step does not require opening the SEAL module) OR: <ul style="list-style-type: none"><li>Remove and reinsert the batteries</li></ul>
Completely power off	<ul style="list-style-type: none"><li>Remove the batteries</li></ul>

**NOTE:** Shutting down or resetting the SEAL Tracker will cause all unsaved user configurations to be lost. Save your desired configuration to the flash before powering off, putting to DEEP SLEEP, or resetting the SEAL Tracker.

## 5 Compliance Statements

### **Federal Communications Commission:**

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

To comply with FCC exposure limits for general population / uncontrolled exposure, this device should be installed at a distance of 20 cm from all persons and must not be co-located or operating in conjunction with any other transmitter.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

### ***Innovation, Science and Economic Development Canada (Industry Canada):***

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

- (1) This device may not cause interference, and
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

This device should be installed and operated with minimum distance 0.2 m from human body.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

- (1) L'appareil ne doit pas produire de brouillage.
- (2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet appareil doit être installé et utilisé à une distance minimale de 0.2 m du corps humain.

***California Proposition 65:***

 **WARNING:** This product can expose you to chemicals including lead, nickel, and carbon black, which are known to the State of California to cause cancer, birth defects or other reproductive harm. For more information, go to [www.P65Warnings.ca.gov](http://www.P65Warnings.ca.gov).

## References

- [1] Tektelic Communications, T0007705\_TRM\_v1.0.
- [2] LoRa Alliance, "LoRaWAN Specification," ver. 1.0.2, July 2016.
- [3] LoRa Alliance, "LoRaWAN 1.0.2 Regional Parameters," rev. B, Feb 2017.