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BLE Sensor Family – Gen2.5

PELICAN|TUNDRA

User Guide

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Document Revision

Revision	Issue Date	Status	Editor	Comments
0.1	May 4, 2021	Obsolete	Carter Mudryk	Initial draft based on full BLE Gen2 UG (including ATEX) T0006940_UG_v0.1
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2.1	December 8, 2023	Released	Carter Mudryk	• Updated photos to reflect actual enclosure. • Minor grammatical and formatting changes.

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List of Acronyms

BER ..... Bit Error Rate
BLE..... Bluetooth Low-Energy
CNR..... Cahiers des charges sur les Normes Radioélectriques (RSS)
DL ..... DownLink
EOS ..... End Of Service
EU ..... European Union
FCC..... Federal Communications Commission
FW ..... FirmWare
HW ..... HardWare
IoT ..... Internet of Things
IP ..... Ingress Protection
ISM ..... Industrial, Scientific, and Medical
LED ..... Light-Emitting Diode
LoRa ..... Long-Range
LoRaWAN..... Long-Range Wide-Area Network
LoS..... Line-of-Sight
LTC..... Lithium-Thionyl Chloride
MCU ..... MicroController Unit
NA ..... North America
NS ..... Network Server
OTA ..... Over The Air
PCB ..... Printed Circuit Board
PCBA..... Printed Circuit Board Assembly
Rev ..... Revision
RF ..... RadioFrequency
RSS..... Radio Standards Specifications (CNR)
RSSI ..... Received Signal Strength Indicator
Rx ..... Receive, receiver, etc.
SW..... SoftWare
TRM..... Technical Reference Manual
Tx..... Transmit, Transmitter, etc.
UG ..... User Guide
UL ..... UpLink
US ..... United States
v..... Version

1 Product Description

1.1 Overview

This document provides a user manual for the PELICAN and TUNDRA device variants in the *BLE Sensor Family Gen2.5* developed by TEKTELIC Communications Inc. This document includes descriptions of each variant and guides regarding the HW capabilities of each variant. For the functional operation and SW behaviour of each variant, please refer to the specific TRM document for that particular sensor.

Both PELICAN and TUNDRA variants are LoRaWAN-capable end-devices that support Tx/Rx in the following frequency bands as specified in the LoRaWAN Regional Parameters v1.0.2 [1]: AS923, AU915, EU868, IN865, KR920, RU864, US915. The PELICAN variants support BLE Tx/Rx in the 2.4 GHz band according to the BLE 5.3 specifications [2].

The Gen2.5 device family is the successor to the Gen2 device family. All sensors in the Gen2.5 family share a common internal printed circuit board (PCB), but have a variety of different transducers, functions, and use cases. The PELICAN and TUNDRA have different functions and use-cases, but share a mechanical enclosure.

- **PELICAN**:
  - Outdoor-rated, IP67, C-cell battery-operated sensor family variants with different mounting options.
  - Main function: to utilize periodic BLE scanning to collect data from nearby BLE peripherals to determine device location, or to act as a broadcasting BLE peripheral beacon.

- **TUNDRA:**
  - Outdoor-rated, IP67, C-cell battery-operated sensor family variants with different mounting options. Available with a thermistor probe, digital probe, or no probe.
  - Main function: to accurately measure ambient temperature and relative humidity, specifically temperatures as low as -40°C for cold storage applications.

Table 1-1 presents all PELICAN and TUNDRA variants and which HW/Mechanical/Transducer functions are supported by each in matrix format.

Table 1-1: HW, Transducer, and Mechanical Capabilities of the PELICAN and TUNDRA Variants

Feature / Transducer	Sensor Variant					
Grouping by PCBA T-Code	PELICAN **T0006984**		TUNDRA **T0006907**			
Module Product Names	PELICAN, Base	PELICAN, Wall-Mount	TUNDRA, Base	TUNDRA, Wall-Mount	TUNDRA, Probe	TUNDRA, Probe, Wall-Mount
Module Product Codes	T0007377	T0006906	T0006778	T0007334	T0007380	T0006779
Mounting	None	Wall	None	Wall	None	Wall
Supported Operating Environment	Outdoor (IP67)		Outdoor (IP67)		Indoor (IP67)	
External Probe					✓	
Battery	C-cell LTC		C-cell LTC			
Battery Gauge	✓		✓			
BLE Rx	✓					
BLE Tx	✓					
Magnetic Sensor	✓		✓			
Temperature + RH Transducer			✓			
Accelerometer	✓		✓			
Low-Intensity RF LEDs	✓		✓			

Table 1-2 shows all the different mechanical enclosure and mounting options with the corresponding product codes.

Table 1-2: All Mechanical Enclosure / Mounting Combinations of the Gen2 Sensor Variants

Variant Name	Variant Product Code	Enclosure and Mounting
PELICAN, Base	T0007377	
TUNDRA, Base	T0006778	
PELICAN, Wall-Mount	T0006906	
TUNDRA, Wall-Mount	T0007334	
TUNDRA, Probe	T0007380	
TUNDRA, Probe, Wall-Mount	T0006779	

1.2 External Appearance and Interfacing

The appearances and external interfacing layouts of all variants are shown in Figure 1-1.

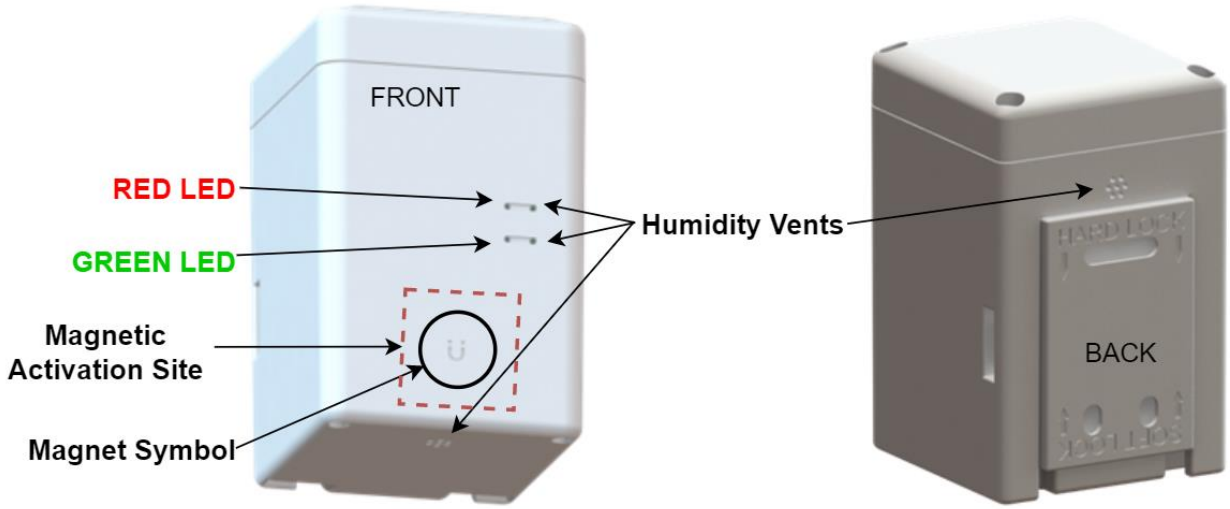

Figure 1-1: PELICAN and TUNDRA Enclosures and External Interfacing

1.3 Specifications and Sensing Functions

The Gen2.5 BLE Sensor Family specifications are listed in Table 1-3. The main sensing functions are described in the following subsections.

Table 1-3: BLE Asset Tracker Specifications.

Parameter	Specification
Environmental Rating	IP67
Enclosures and Mounting	Custom design by TEKTELIC
Operating Temperature	-40°C to 70°C
Storage Temperature for Optimal Battery Life	-25° to 55°C
Operating Relative Humidity	5% - 95% non-condensing
Storage Relative Humidity	10% - 100% non-condensing
Dimensions	65 mm x 45 mm x 41 mm (with bracket) 65 mm x 43 mm x 41 mm (without bracket)
Weight	63.5 g enclosure + 56.5 g battery = 120 g total (without bracket or probe)
Power Source	Battery-powered: 1x C-cell LTC (3.6 V)
Network technology/Frequency band	LoRaWAN in the following Global ISM bands [1]: AS923, AU915, EU868, IN865, KR920, RU864, US915
Air Interface	LoRa, BLE
Maximum Tx Power	15 dBm (PELICAN, all bands) 20 dBm (TUNDRA: AU915, IN865, US915)
Sensing Elements	BLE transceiver, accelerometer, thermometer, hygrometer, magnetic hall-effect transducer, battery gauge (not all sensing elements are available on all variants)

Parameter	Specification
Bluetooth Compatibility	BLE based on Bluetooth 5.3
LoRa RF Sensitivity	Up to -137 dBm (SF12, 125 kHz BW)
BLE Sensitivity (0.1% BER)	125 kbps: -103 dBm 500 kbps: -98 dBm 2 Mbps: -91 dBm
Accelerometer Sensitivity	Sample rate: 1, 10, 25, 50, 100, 200, 400 Hz Measurement range: ±2, ±4, ±8, ±16 *g* Precision: 16, 32, 64, 192 m*g*
LEDs	Green: Joining the network activity (all variants) Red: LoRa Tx or Rx activity (all variants)
Battery Gauge Features	Measures remaining capacity [%] and remaining lifetime [days]
Battery Lifetime	15+ years[1]

1.3.1 Bluetooth Low-Energy (BLE) Transceiver

BLE operation is the main function of the PELICAN. Each sensor can operate in 1 of 2 BLE *modes*:

- **Tracker Mode (default)**: The sensor conducts BLE Rx scanning to discover nearby BLE peripherals, determine their signal strengths, and relay this information via LoRaWAN UL to the NS. The primary use case is for indoor positioning/asset tracking.
- **Beacon Mode**: The sensor broadcasts BLE Tx advertisements so it is discoverable to nearby BLE scanning devices. The primary use case is for setting up a beacon network for indoor positioning/asset tracking.

The sensor supports BLE as specified by Bluetooth 5.0 and uses only the 3 default advertising channels: 37, 38, and 39 [3].

1.3.1.1 Tracker Mode

When in tracker mode, the BLE operates in Rx only; the tracker only scans and does not advertise, meaning it is not discoverable by other BLE-capable devices.

During each scan, other nearby advertising BLE devices can be discovered. Each discovered device has its data (MAC address and the RSSI of the advertisement packet) saved by the tracker to then be reported in a LoRaWAN data report UL. This UL is normally reported immediately after the scan concludes but may be delayed due to LoRaWAN duty cycle limitations[2] [4].

The tracker can be configured to conduct a BLE scan and report periodically. By default, a BLE scan and report is conducted every 60 min in tracker mode.

[1] With default settings operating at DR2. Applicable to NA region only.
[2] If a new BLE scan occurs before the results of the previous scan have been sent, the old scan results will be discarded.

The tracker can also be configured to conduct additional BLE scans and reports upon motion detected and motion cleared through the *Accelerometer Assist* feature, which is enabled by default.

A single BLE scan lasts for a configurable *scan duration*.

As illustrated in Figure 1-2, each scan duration is divided into regular *scan intervals*. The beginning of each scan interval marks the beginning of scanning on a different BLE channel frequency. The channels are cycled through in order; during the first scan interval the tracker receives on channel 37, the second on channel 38, the third on channel 39, the fourth on channel 37, and so on. The scan interval is configurable.

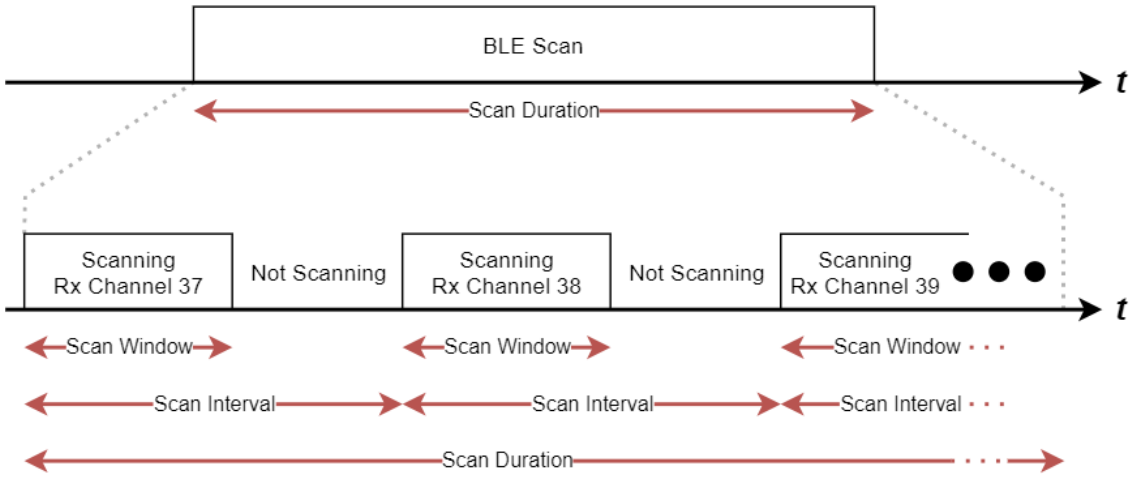

Figure 1-2: The BLE Scan Scheme

Also illustrated in Figure 1-2, the actual BLE scanning only occurs during the *scan window* portion of the scan interval. The scan window is configurable, which allows for the *scan duty cycle* to be implemented:

$$\boldsymbol{scan\ duty\ cycle} = \frac{\boldsymbol{scan\ window}}{\boldsymbol{scan\ interval}} \times \mathbf{100\%}$$

A scan window equal to the scan interval represents a scan duty cycle of 100% (a continuous scan) over each scan duration. This is the default behavior as it maximizes the chance of "discovering" nearby BLE advertisement packets for a given scan duration. Reducing the duty cycle below 100% has the advantage of decreasing power consumption at the expense of possibly missing some beacon signals.

The BLE scan can be disabled entirely and re-enabled at any time in tracker mode. BLE advertising never occurs during tracker mode.

The BLE scan is *passive*. This means the tracker listens to surrounding beacons but does not transmit to them to request additional information.

NOTE: The BLE and LoRa radio activity are mutually exclusive; they do not overlap. If any LoRaWAN reporting becomes due at the same time as a BLE scan, the reporting will be done after the BLE scan is complete.

At the end of each scan duration, up to *n* discovered BLE devices and RSSIs are reported over LoRaWAN. The value *n* is user configurable. If no devices are found, an empty list is uplinked. Over each scan duration, a BLE device beacon may be observed (discovered) more than once.

Up to 4 inclusion filter ranges can be set to filter discovered BLE devices by MAC address.

See the TRM for more details about tracker mode operation and configuration.

1.3.1.2 Beacon Mode

The SPARROW and PELICAN sensors support a *beacon mode* function as an alternative to tracker mode. The default mode of the sensor is tracker mode, so it must be switched into beacon mode.

When in beacon mode, the BLE operates in Tx only. It sends out periodic BLE *advertisements* which are small packets of data. These packets are discoverable by other SPARROWs and PELICANs operating in tracker mode, as well as any other device capable of BLE scanning.

When in beacon mode, the sensor is still LoRaWAN-backhauled. That is, it can still send sensor data in LoRaWAN ULs and be reconfigured through LoRaWAN DLs. Furthermore, all other transducer functions are accessible in either beacon or tracker mode.

After a beacon joins the LoRaWAN network, it begins broadcasting BLE advertisements. This continues throughout normal operation as a background process.

The *advertising interval* is the time between the beginnings of consecutive advertisement transmissions as shown in Figure 1-3. It is user-configurable in units of [ms].

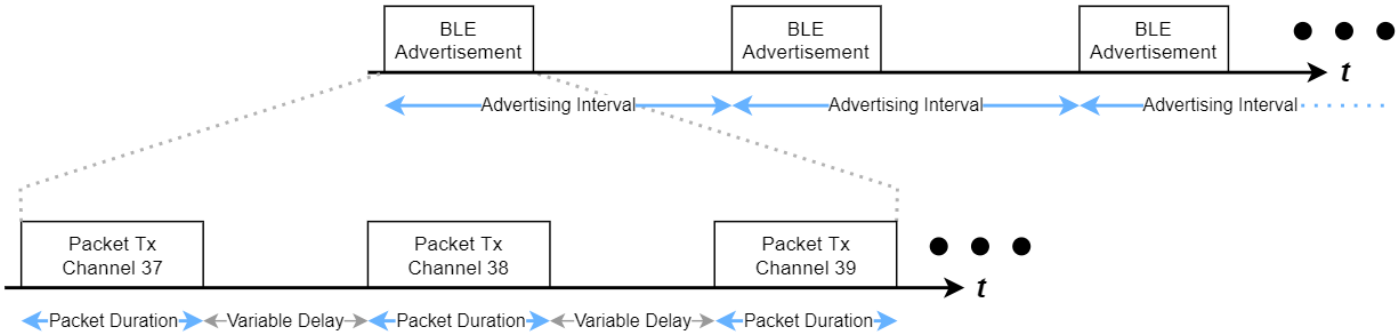

Figure 1-3: The BLE Advertisement Scheme

Figure 1-3 also shows that each single BLE advertisement comprises 3 individual packet transmissions, sent one after another on BLE channels 37, 38, and 39 [3]. This is to maximize the chances of a BLE device scanning on a single channel receiving 1 packet per advertising interval.

In addition to the advertising interval, the advertisement *Tx power* level is also a configurable operational parameter.

The BLE advertisement and LoRa radio transmission are mutually exclusive and never overlap. If any reporting becomes due, the BLE advertisements are paused while the LoRa activity is occurring.

The BLE advertising packet formatting supports 3 major BLE standards: iBeacon, Eddystone UID, and Eddystone TLM. By default, only iBeacon is enabled.

See the TRM for more details about beacon mode operation and configuration.

1.3.2 Magnetic Sensor

The PELICAN and TUNDRA variants are equipped with a magnetic hall-effect sensor[3]. Since the C-cell variants all have water-tight IP67 enclosures, there is no ability to have a battery pull-tab or reset button pinhole. The magnetic sensor therefore is included to address these purposes:

1. To wake the device from sleep (the sensors are shipped in a state of DEEP SLEEP).
2. To put the device to sleep.
3. To reset the device.
4. To force a LoRaWAN UL.

The position on the exterior of the enclosure on which the magnet must be placed to activate the reed switch is shown in Figure 1-1.

[3] A magnet is not included.

For more information on how to wake the device from sleep, refer to Section 2.4. For more information on how to use the magnetic sensor for the other purposes, refer to the corresponding TRM document.

1.3.3 Temperature and Relative Humidity Transducer

The TUNDRA variants contain a temperature and relative humidity (RH) transducer. Note that because the transducer element is located inside the sensor housing, sense response time will not be immediate. Vents in the front, bottom, and back of the enclosure are designed to allow ambient air to contact the transducer. Response time can be reduced by forcing air to move over the sensor in the region of the transducer opening.

Both PELICAN and TUNDRA can measure and report the MCU temperature. This is a less accurate temperature measurement using a transducer located in the device microprocessor.

The TUNDRA supports reporting temperature and RH values on a threshold basis; a window of "good operational range" can be user-defined. High and low alarm points can be set individually for ambient temperature, RH, and MCU temperature. The sample rate for checking the transducers is user configurable with different sample rates settable if the measured value is inside or outside the normal operating window.

1.3.4 Accelerometer Transducer

Both PELICAN and TUNDRA support motion sensing through an integrated 3-axis accelerometer which can optionally be disabled. The main role of the accelerometer in the is to detect motion that can indicate a change of the sensor's status from stillness to mobility, or vice versa.

The accelerometer generates an acceleration alarm when a motion event is detected that may or may not be reported OTA (user-configurable). An acceleration event report is based on exceeding a defined acceleration alarm threshold count in a defined alarm threshold period. These thresholds can be customized such that there will not be multiple reports for a single event, depending on the definition of an event in a particular use case. An alarm event can only be registered after a configurable grace period elapses since the last registered alarm event. Carefully setting the grace period is important and prevents from repeatedly registering an accelerometer event.

The accelerometer can also be polled periodically for its output acceleration vector for applications in which the sensor's orientation is of interest.

1.3.5 External Probe

TUNDRA Probe variants can be ordered with the choice of either a digital reed switch or an analog thermistor. The default input mode (digital or analog) depends on whether a digital or analog Sensor variant was ordered. The input mode is a configurable parameter, meaning that it can be toggled by the user at any time.

1.3.5.1 Digital Probe Operation

In the digital input mode, the external reed switch probe has only two values or states:

- Open (magnet absent) with a value of 0x 01.
- Closed (magnet present) with a value of 0x 00.

This mode of operation supports periodic and event-based (edge-triggered) reporting.

The input is edge-triggered and can be set to be triggered by the rising edge (Low/Closed to High/Open), falling edge (High/Open to Closed/Low), or both (default setting).

Application Examples for Digital Input Mode:

- Door Open/Close detection would use both rising and falling triggers to detect when the door was opened and when it was closed.
- Pulse counting from a water meter would use a single edge trigger, depending on the resting state of the connected device (positive pulse would use rising edge, negative pulse would use falling edge).

1.3.5.2 Analog Probe Operation

In the analog input mode, one probe pin is grounded, and the other pin is pulled up to VMCU (2.0 V) by a 68.1 kΩ resistor. The analog input has values in units of mV from 0 to VMCU (the precision is 1 mV[4]). The included probe is a custom 10 kΩ NTC thermistor.

The sensor FW can convert the measured probe voltage to temperature and report either the raw voltage or converted temperature. By default, the sensor reports probe temperature.

[4] The actual ADC output has a resolution of 0.61 mV.

2 Installation

2.1 Included Product and Installation Material

The following items are shipped with each sensor:

- 1x sensor inside an enclosure with 3.6 V C-cell LTC battery installed.
- 1x corresponding sensor Quick Start Guide.
- 1x mounting bracket (only for variants with mounting).

2.2 Safety Precautions

The following safety precautions should be observed for all Gen2 sensor variants:

- All installation practices must be in accordance with the local and national electrical codes.
- Replace only with approved batteries (see section 2.6).
- The following sensor variants are intended for indoor use only: T0006779, T0007380.
- The sensor contains a single LTC C-cell battery. When used correctly, lithium batteries provide a safe and dependable source of power. However, if they are misused or abused, leakage, venting, explosion, and/or fire can occur. The following are recommended safety precautions for battery usage [5].

  - **Keep batteries out of the reach of children.**
  - **Do not allow children to replace batteries without adult supervision.**
  - **Do not insert batteries in reverse.**
  - **Do not short-circuit batteries.**
  - **Do not charge batteries.**
  - **Do not force discharge batteries.**
  - **Do not mix batteries.**
  - **Do not leave discharged batteries in equipment.**
  - **Do not overheat batteries.**
  - **Do not weld or solder directly to batteries.**
  - **Do not open batteries.**
  - **Do not deform batteries.**
  - **Do not dispose of batteries in fire.**
  - **Do not expose contents to water.**
  - **Do not encapsulate and/or modify batteries.**
  - **Store unused batteries in their original packaging away from metal objects.**
  - **Do not mix or jumble batteries.**

2.3 Unpacking and Inspection

The following should be considered during the unpacking of a new sensor.

1. Inspect the shipping carton and report any significant damage to TEKTELIC.
2. Unpacking should be conducted in a clean and dry location.
3. 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

Each sensor has a set of commissioning information that must be entered into the network server for the sensor to be able to join the network and begin normal operation once activated. For instructions on how to do this please refer to the Network Server Quick Start Guide (available online in the *Knowledge Base*) [6].

The sensor is shipped in a secured enclosure with the battery preinstalled in a state of DEEP SLEEP. The magnetic activation/reset pattern is illustrated in Figure 2-1. A “magnet presence” is achieved by placing a sufficiently strong magnet against the enclosure at the magnetic activation site as shown in Figure 1-1. A “magnet absence” is achieved by taking the magnet away from the enclosure. Figure 2-1 shows that the pattern involves sustaining a “magnet presence” continuously for at least 3 s but less than 10 s.

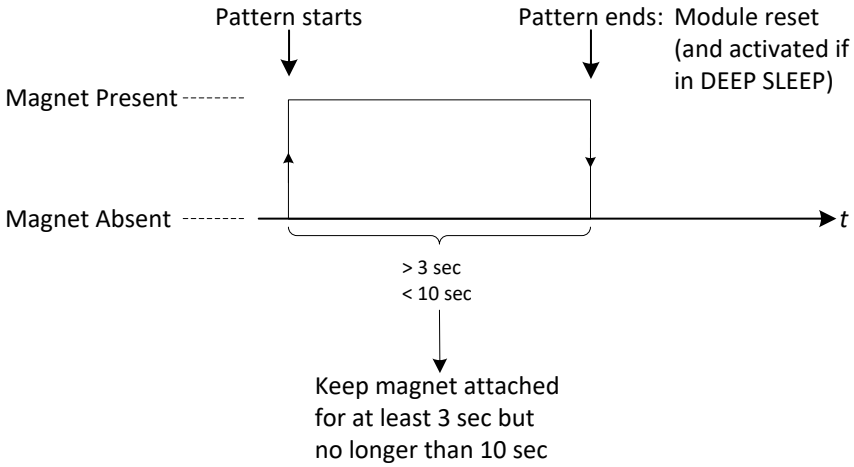

Figure 2-1: The Magnetic Activation/Reset Pattern.

When any sensor variant is activated it will display an LED indication (described in Section 3.3) to show that it is beginning to join the network. It may take up to 10 seconds between the time of activation and the beginning of the LED join attempt pattern.

Once activated, the sensor will automatically begin the join process. To turn the sensor off, the battery must be removed. To reset the device, the magnetic activation/reset pattern can be applied again.

2.5 Mounting Procedure

1. The mounting bracket needs to be secured to a wall or another solid surface by using an adhesive or mounting screws. The mounting bracket can be seen in the back view in Figure 1-1.

a. For use cases that require easily removable, less permanent mounting, ensure that the “SOFT LOCK” indication is installed with the arrows pointing up.

b. For use cases that require more securely fastened and permanent mounting, ensure that the “HARD LOCK” indication is installed with the arrow pointing up.

c. After the bracket has been secured, the sensor can be mounted by sliding the enclosure into the bracket ridges until a click is heard, indicating it is fully inserted.

2.6 Battery Replacement

The battery cover is marked with a battery symbol and uses Phillips Head H1 screws. This cover needs to be removed to replace the battery.

1. In a non-hazardous location, remove the battery cover by unscrewing the 4x phillips head screws using a size #1 phillips head screwdriver (see Figure 2-2).

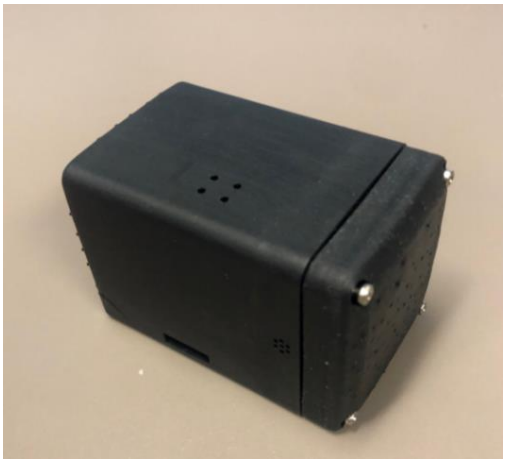

Figure 2-2: Removing the Battery Cover Screws

2. Remove and the used battery and replace it with a new 3.6V XENO XL-145F battery **ONLY**. When inserting the new battery, insert the negative terminal side first. The battery contact on the battery cover is the positive contact and is marked with a plus-sign (**+**) as shown in Figure 2-3.

Figure 2-3: Polarity Marker and Battery Insertion

3. Check that the gasket is undamaged and still properly seated with an adhesive on the battery cover.

4. Before reattaching the battery cover, ensure the proper orientation of the cover with respect to the front and back of the sensor chassis. The front of the sensor has rounder corners, and the back of the sensor has sharper corners, as seen in Figure 2-3.

5. Reassemble the cover to the chassis by using the 4x phillips head screws, using a #1 size screwdriver and up to 0.23 Nm of torque.

3 Operation, Alarms, and Management

3.1 Configuration

The PELICAN and TUNDRA variants support a full range of OTA configuration options. Specific technical details are available in the corresponding TRM documents. All configuration commands need to be sent OTA during the sensor's DL Rx windows.

3.2 Default Configuration

Table 3-1 lists the default reporting behaviour of the PELICAN and TUNDRA. Reporting behaviour can be changed from default through OTA DL commands.

Table 3-1: Default Reporting Periods

Reported Data	PELICAN	TUNDRA
Battery Data	24 hours	24 hours
Discovered BLE devices	1 hour	N/A
Ambient Temperature	N/A	1 hour
Relative Humidity	N/A	1 hour
Probe Data	N/A	1 hour (probe variants)
Acceleration Vector	Disabled	Disabled
MCU Temperature	Disabled	Disabled

3.3 RF LED Behaviour

The LED behaviour is not user configurable.

The LEDs are normally off. Their blinking patterns reflect different actions and states of the sensor. At a high level, the main patterns are summarized in Table 3-2. The detailed sequence and timings for each are described in the following subsections.

Table 3-2: Summary of LED Patterns

LED Pattern	Meaning
GREEN blinking rapidly and single RED flash every 10 s	JOIN mode; attempting to join the network
Single RED flash	UL sent
Single GREEN flash	DL received
3 quick RED flashes	Entering DEEP SLEEP

3.3.1 Power-On and Network Join Patterns

When the sensor is activated or reset:

1. Both GREEN and RED are OFF for approximately 0.5 s after any reset occurs.
2. Upon startup, the SW conducts its POST. Both GREEN and RED are turned on when the POST begins.
3. When the POST ends (about 2 s), both GREEN and RED are turned off. Immediately following, the sensor will do 1 of 2 things, depending on the POST result:
   a. If the POST passes, GREEN is toggled ON and OFF 3 times: every 100 ms for 0.6 s, as shown in Figure 3-1. In this case, the LED pattern proceeds to step 4.
   b. If the POST fails, RED is toggled ON and OFF 3 times: every 100 ms for 0.6 s, as shown in Figure 3-1. In this case, the device restarts and the LED pattern begins again at step 1 after approximately 4 s.

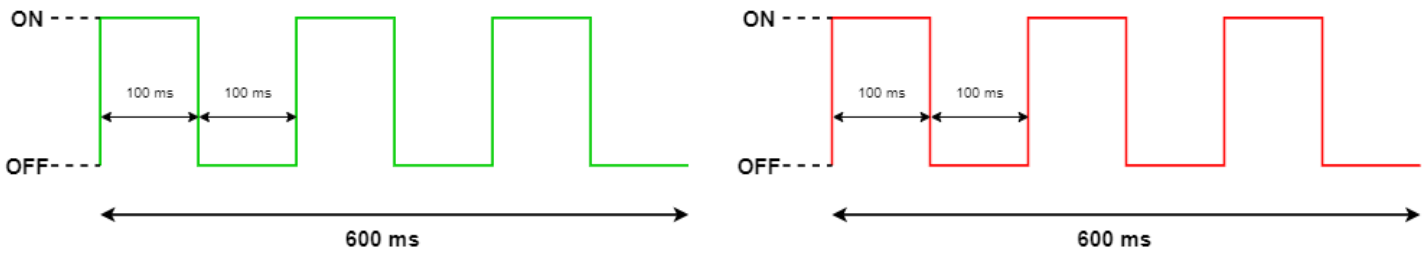

Figure 3-1: The GREEN POST Pass (left) and RED POST Failure (right) LED Patterns

4. After a successful POST, both **GREEN** and **RED** are turned off. Immediately following this, the sensor will enter JOIN mode and begin attempting to join the network. For the first hour[5]:

   a. **GREEN** is toggled ON and OFF every 50 ms for the first hour.

   b. **RED** flashes just once:

      i. with a pulse duration of 25 ms right after transmitting a JOIN REQUEST. This occurs at approximately 10 s intervals at the beginning of the join process, but at decreasing regularity the longer the join process continues due to battery saving measures and possible duty-cycle limitations in certain regions [4].

      ii. with a pulse duration of 100 ms right after receiving a JOIN ACCEPT. This will occur once, after which, the device will have joined the network and normal operation begins.

   If the sensor has been unsuccessfully trying to join for more than an hour, it enters *join back-off* to conserve power. While the sensor still attempts to join, **GREEN** stops flashing and **RED** flashes twice (ON time: 10 ms, OFF time: 10 ms) every 8 s. The JOIN LED pattern is shown in Figure 3-2

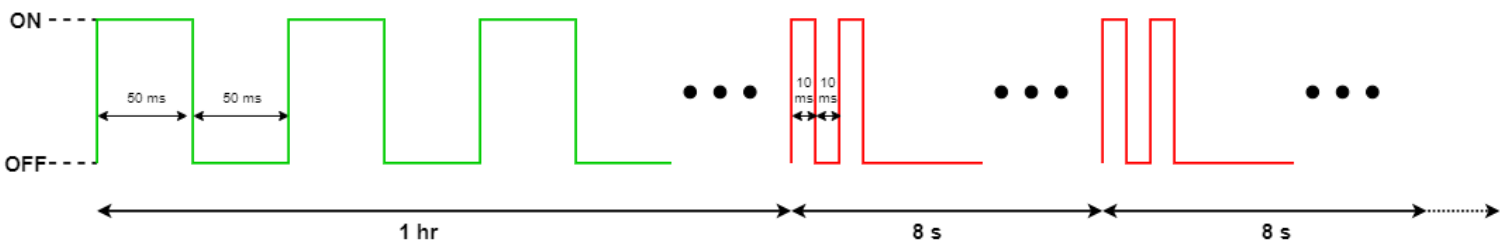

Figure 3-2: The LED Patterns During JOIN Mode

3.3.2 Normal Operation Patterns

After the Sensor has joined the network:

   a. **RED** flashes just once with a pulse duration of 25 ms right after transmitting an uplink.

[5] The very first time a sensor is activated out of the box or after a battery replacement, there might be some ramp-up time required due to battery passivation. See §**Error! Reference source not found.** for details.

b. **GREEN** flashes just once with a pulse duration of 100 ms right after receiving a downlink.

3.3.3 DEEP SLEEP and Magnetic Reset Patterns

The sensor displays an LED indication when it is brought out of DEEP SLEEP or reset by applying the magnetic pattern. The following LED pattern is displayed about 3 sec after the pattern is applied:

1. **GREEN** is turned ON for 75 ms, then turned OFF.
2. After a 100-500 ms pause while the device resets, the normal Power-On and Network Join LED patterns described in §3.3.1 occur.

There is another LED pattern for when the device is put back into DEEP SLEEP. The following LED pattern is displayed about 3 s after the pattern is applied:

1. After a 100-500 ms pause while the device resets, the Power-On POST LED patterns described in steps 1-3 in §3.3.1 occur.
2. Immediately, **RED** is toggled ON and OFF 3 times: every 100 ms for 0.6 sec as shown in Figure 3-3.

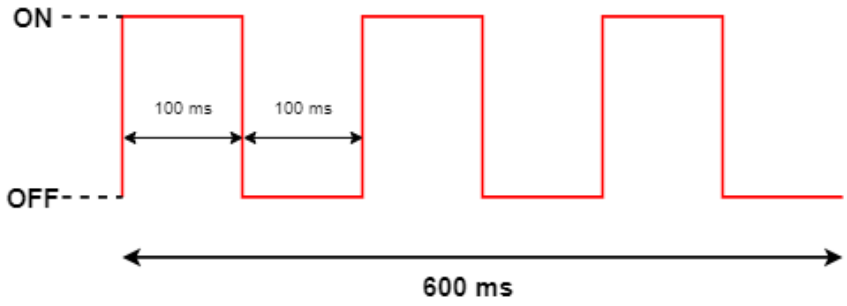

Figure 3-3: The RED LED Pattern Before Entering DEEP SLEEP

3.4 Reset Function

The PELICAN and TUNDRA are capable of a physically-triggered reset. This type of reset powers down the MCU and restarts it, causing the network join procedure to begin again. The reset is triggered by applying the magnetic pattern as shown in Figure 2-1. While this pattern causes the

sensor to wake from deep sleep before activation, during normal operation this pattern causes a reset.

NOTE: Shutting down or resetting the sensor will cause all unsaved user configurations to be lost. Save the desired configuration to the sensor flash before powering off or resetting.

4 Compliance Statements

Federal Communications Commission:

This device complies with Part 15 of the FCC Rules [7]. 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 an industrial 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) [8]. Operation is subject to the following two conditions:

i. This device may not cause interference, and

ii. 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 utilise 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 [9].

References

[1] LoRa Alliance, "LoRaWAN™ 1.0.2 Regional Parameters," February 2017. [Online]. Available: https://lora-alliance.org/wp-content/uploads/2020/11/lorawan_regional_parameters_v1.0.2_final_1944_1.pdf. [Accessed 12 April 2021].

[2] Bluetooth SIG, "Bluetooth Core Specifications v 5.0," 6 December 2016. [Online]. Available: https://www.mouser.it/pdfdocs/bluetooth-Core-v50.pdf. [Accessed 12 April 2021].

[3] Bluetooth SIG, "Core Specification 5.0," 6 Dec 2016. [Online]. Available: https://www.bluetooth.com/specifications/specs/core-specification-5/. [Accessed 15 November 2021].

[4] LoRa Alliance, "LoRaWAN Regional Parameters," v1.0.2, rev. B, Feb 2017.

[5] Tadiran Batteries GmbH, "Tadiran Lithium Batteries: Technical Brochure LTC-Batteries," Tadiran Batteries, Büdingen, Germany, 2020.

[6] TEKTELIC Communications Inc, "Network Server Quickstart Guide - Creating Your first network," 21 August 2019. [Online]. Available: https://support.tektelic.com/support/tektelic/ShowHomePage.do?articlestatus=published#Solutions/dv/27469600014617215/en/History. [Accessed 12 April 2021].

[7] Office of the Federal Register, "Electronic Code of Federal Regulations: Title 47; Part 15 - Radio Frequency Devices," e-CFR, 28 February 2020. [Online]. Available: https://www.ecfr.gov/cgi-bin/text-idx?SID=86ed79fc9447ceff183191690a733ec7&mc=true&node=pt47.1.15&rgn=div5#se47.1.15_11. [Accessed 3 March 2020].

[8] Innovation, Science and Economic Development Canada, "RSS-Gen: General Requirements for Compliance of Radio Apparatus; Issue 5; Amendment 1," March 2019. [Online]. Available: ic.gc.ca/eic/site/smt-gst.nsf/vwapj/RSS-Geni1amend12019-04EN.pdf/$FILE/RSS-Geni1amend12019-04EN.pdf. [Accessed 3 March 2020].

[9] OEHHA, "Proposition 65," California Office of Environmental Health Hazard Assessment, 2020. [Online]. Available: https://oehha.ca.gov/proposition-65. [Accessed 3 March 2020].

[10] Saft, Specialty Battery Group, "Primary lithium battery: LS 14500," Saft, September 2009. [Online]. Available: https://datasheet.octopart.com/LS14500-Saft-datasheet-15505441.pdf. [Accessed 3 March 2020].

[11] Tadiran Batteries, "Model TL-4903 Technical Data," January 2007. [Online]. Available: https://datasheet.octopart.com/TL-4903/S-Tadiran-datasheet-556727.pdf. [Accessed 3 March 2020].

[12] Tadiran Batteries GmbH, "LTC Batteries: SL-360," January 2012. [Online]. Available: https://datasheet.octopart.com/SL-360-S-Tadiran-datasheet-128477996.pdf. [Accessed 21 February 2020].

[13] Tadiran Battery Group, "Model TL-5903 Technical Data," November 2011. [Online]. Available: https://datasheet.octopart.com/TL-5903/S-Tadiran-datasheet-8817806.pdf. [Accessed 3 March 2020].

[14] Xeno Energy Co. Ltd., "XL-060F Specifications," 2010. [Online]. Available: http://www.xenoenergy.com/eng/file/Xeno%20Catalog%20XL-060F_E.pdf. [Accessed 3 March 2020].

[15] TEKTELIC Communications Inc., "BLE Asset Tracker: Technical Reference Manual T0005946_TRM_v0.4," TEKTELIC Communications Inc., Calgary, 2019.

[16] TEKTELIC Communications, Inc., *BLE ASSET Tracker Quick Start Guide T0005946_QSG_ver1.0,* Calgary, 2020.