



Micro Tracker Firmware V1.9

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1 INTRODUCTION

1.1 Document purpose

This document describes in detail the usage of Asset tracker MCU applicative Firmware that runs on Micro Tracker. Chapters 2 to 4 are related to the main functionalities of the device, chapter 5 discusses the geolocation strategies and Chapter 6 explains the BLE communication function. The next chapters 7 and 8 give more details for Uplink and Downlink messages. Finally, chapter 9 to 10 provide some device configuration examples to support specific applications.

This document is reserved to support team, distributors and integrator teams to give a deeper knowledge of all the possible settings. We do reserve the right to modify the contents in future releases.

1.2 Product description

The Abeeway Micro Tracker is a multi-mode tracker combining GPS/Low power GPS, WIFI, LoRaWAN™ and BLE radios with embedded sensors to support accurate outdoor and indoor geolocation. A button, a buzzer and 2 LEDs are available to interface with the user. The Micro Tracker, with its small size and long battery lifetime, is the ideal product for many tracking applications.

1.3 Applications

- Workforce optimization and safety: lone workers monitoring, tracking, SOS panic button alerts on construction sites, mines, oil & gas platforms, factories and other industrial indoor and outdoor facilities
- Tracking and monitoring of assets, vehicles, machines and equipment
- Antitheft applications, notification and location trigger when device is moving, at fixed frequency updates or on demand
- Personal tracking with help button: employees, elderly, children
- Personal assets protection: cars, motorbikes, bikes, keychains, luggage, handbags or pets.

2 FEATURES

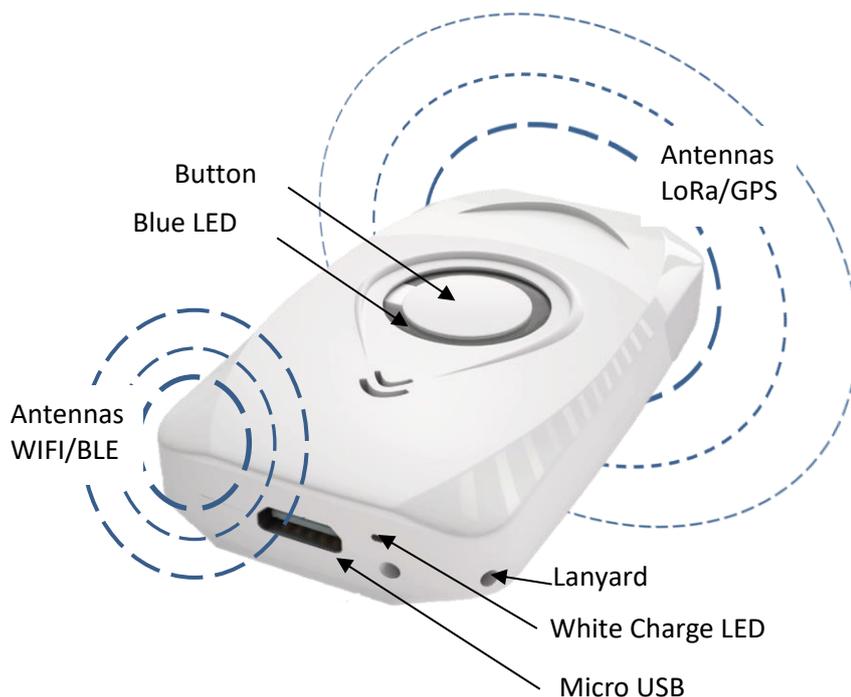
- **Multiple operating modes**
 - ✓ **Standby:** LoRaWAN™ heartbeat only
 - ✓ **Motion tracking:** Get the tracker position at a given cycle when motion is detected.
 - ✓ **Permanent tracking:** Get permanently a position of the tracker.
 - ✓ **Start/End motion tracking:** Get position messages during motion start and end events.
 - ✓ **Activity tracking:** Monitor activity rate with embedded sensors.
 - ✓ **OFF:** device stopped
- **Position on demand:** Receive the tracker position only when requested (very low power operating mode).
- Low frequency periodic position (I.e. once per hour to once a day)
- **Configurable motion detection**
- **SOS support**
- **Shock detection**
- **Supported geolocation technologies**
 - ✓ **GPS:** Precise outdoor position.
 - ✓ **Low power GPS = LPGPS:** Get quick position outdoors and daylight indoor conditions.
 - ✓ **WIFI:** Indoors positioning and urban area.
 - ✓ **BLE:** Indoors positioning
- **Buzzer and LEDs**
- **Temperature monitoring**
- **Battery monitoring**
- **Embedded antennas**
- **LoRaWAN™ Class A radio**
- **Water-spray resistant enclosure (IP64)**

The asset tracker V1.9 brings the following new features

- Temperature monitoring
- New downlink to update the operational mode
- Long WIFI payload support
- Additional LoRaWAN™ transmission strategy
- Additional event messages
- BLE Bond deletion via a button sequence

The Release note is available on the documentation portal

3 MICRO TRACKER DEVICE



3.1 Getting started

- Charge your device using a micro USB cable. While charging the white LED is ON. When the battery is fully charged the white LED goes OFF.
- A long press is needed to turn ON the device (starting in motion tracking mode in standard configuration).
- Your LoRaWAN™ network provider can use two activation modes¹:
 - ✓ OTAA (Over The Air Activation) that requires the following keys to join the network: DEVEUI, APPEUI and APPKEY for each device. (the most used)
 - ✓ ABP (Activation by personalization) that requires the following keys to connect to the network: DEVEUI, DEVADDR, NWKKEY and APPKEY for each device
- Depending on your operator, some actions need to be done to activate the transfer of the data through Abeeway servers. Please refer to your vendor for more information.

Note

The provided trackers are in OTA configuration only. It can't be modified by configuration. If you need trackers working in ABP please refer to your vendor.

3.2 Tracker best placement

The device can be attached with the provided lanyard or placed in a bag, or inside an asset. It is recommended to place the tracker in a way that LoRaWAN/GPS antenna is pointing towards the sky for best LoRaWAN/GPS coverage.

Note

The close environment and orientation of the tracker can influence the radio performance. For optimum results keep the zone around the antenna area clear from any conducting material or magnetic fields.

4 FUNCTIONING

4.1 Main operating modes

4.1.1 Overview

The tracker supports up to six different operational modes: Off, Standby, Motion tracking, Permanent tracking, Start/End tracking, Activity tracking.

The mode is configurable using configurations parameters

For more details, please refer to the following chapter: [Parameters for operational modes](#)

Alongside the main operating mode, the tracker can perform extra operations known as side operations.

Notes

- 1- The LoRaWAN™ transmission periods may not be respected due to the duty cycle network constraint.
- 2- Event messages can also be sent depending on the configuration of bits 6, 8 and 9 of the *config_flags* parameter. (see table in section [event message](#))

4.1.2 OFF mode

The tracker is in deep low power mode. No LoRaWAN™ uplinks are sent.

A long button press is required to wake up the device. There are three different ways to enter this mode:

- User action (long button press, if the device is allowed for, and if the tracker is not in SOS mode)).
- Low battery level.
- LoRaWAN™ downlink request.

In each case, a shutdown message is sent via LoRaWAN™ uplink, with the cause. See section [Shutdown message](#) for more details.

4.1.3 Standby mode

The tracker sends periodically short LoRaWAN™ messages, called heartbeat, at the configured frequency (*lora_period*). The device positions can be obtained in this mode by using the side operations features (see the [side operations](#) section).

4.1.4 Motion tracking mode

The tracker provides positions at the *ul_period* frequency only when the device is moving. The positions are given by the geolocation strategy defined by *geoloc_sensor parameter*.

When the device is not moving, the position message is replaced by the heartbeat message transmitted at the *lora_period* frequency.

The end of motion is detected when the device has not moved during a *motion_duration* delay.

4.1.5 Permanent tracking mode

The device reports its positions at the *ul_period* frequency regardless of the motion. It uses the *geoloc_sensor* parameter for the geolocation technology.

Heartbeat messages are sent if there are no uplink messages during *lora_period* seconds.

Note

Regular positions can also be obtained using standby mode + side operation **periodic position**.

See section [Example](#) to have an example of such configuration.

4.1.6 Motion Start/End tracking mode

This mode is used when only the beginning and the end of a motion is the point of the interest. The tracker provides its position when it starts and stops moving. The technology used is defined by the *geoloc_sensor* parameter. In this mode, (*motion_nb_pos+1*) positions messages (due to a start or an end) are reported and are spaced in time by the parameter *ul_period*.

If either **geoloc_start** or the **motion_start** message is selected, the first LoRaWAN™ position message will be sent once the position has been acquired. For more details, please refer to the section [Position message scheduling](#).

The end of the motion is detected when there is no movement during *motion_duration* seconds. Heartbeat messages are sent if there are no uplink message during *lora_period* seconds.

4.1.7 Activity mode

This mode sends an activity reports instead of positions by counting the amount of motions with the accelerometer. Each motion detection increases a counter (if 3 motion events are detected during a 2 seconds period interval) and the counter value is reported at the *ul_period* frequency.

Heartbeat messages are sent if there are no other uplink messages during *lora_period* seconds.

Notes

- 1- The counter is reset when
 - Any downlink message is received
 - The tracker is turned on
- 2- The number of transmissions of activity payload is given by the *transmit_strat* parameter (and *transmit_strat_custom* parameter if configured), with the following behavior:
 - *Double transmission case*:
 - Activity messages are sent twice spaced by the *ul_period*.
 - If the counter is incremented during the *ul_period*, the new value is sent otherwise the previous one is reported.
 - If the tracker is moving while the payload is created, the uplink applies the double transmission
 - *Single transmission case*:
 - Activity messages are sent three times spaced by the *ul_period*.
 - If the counter is incremented during this period, the counter value is updated else it is sent with the same value

4.2 Side operations

Whatever the operating mode (except OFF mode), the tracker supports **side operations**, which can be:

- Periodic positions reporting
- Positions on Demand
- Alert positions or SOS mode
- Periodic activity reporting

Notes

- 1- All side operations can be accrued.
- 2- **SOS mode** and **alert positions** are mutually exclusive. A dedicated bit in the *config_flags* parameter dictates the tracker behavior.

4.2.1 Periodic position message reporting

The device sends additional positions at the *periodic_pos_period* frequency. This feature is disabled when its associated configuration parameter is set to 0.

This periodic position reporting uses the *geoloc_method* geolocation strategy.

4.2.2 Position on Demand

The tracker position can be requested via LoRaWAN™ downlink message.

In this case, the *geoloc_method* strategy is used.

Note

This action has precedence over the main operational mode. So, if a position acquisition is already in progress, the operation is stopped, and the demand is serviced.

4.2.3 Alert position

After double clicking the button, the tracker starts automatically a position acquisition using the *geoloc_method* strategy. As previously stated, If the position acquisition is in progress, the operation is stopped, and the demand is serviced.

The LoRaWAN™ position messages are tagged with the **alert flag** and the **position on demand** flag.

4.2.4 Periodic activity reporting

The tracker can report periodically its activity (motion detection). The reporting frequency is controlled by the parameter *periodic_activity_period*. When this parameter is set to 0, this feature is disabled.

The associated LoRaWAN™ uplink message will contain the history of the activity split in six-time windows equals to 1/6 of the configured period (*periodic_activity_period*).

4.3 SOS mode

This capability forces the device in a specific tracking mode tagged as SOS, for instance when the tracker's carrier needs help.

Once this feature is activated, the behavior is the following:

- The tracker sends continuously its position at a fixed period of 120 seconds.
- The tracker uses the geolocation strategy: *geoloc_sensor*, with a GPS timeout fixed to 120 seconds.
- The LoRaWAN™ position messages are tagged with an alert flag. (see [uplink description](#) for more detail)
- The tracker's blue led is blinking

The tracker can enter this mode by either double clicking the button or receiving a **SOS start** LoRaWAN™ downlink. This mode is disabled by either another double click, a **SOS stop** LoRaWAN™ downlink or a mode change request. When it is deactivated, it stops blinking and a [melody](#) is played.

Refer the [timing diagram chapter](#) for more details on the position messages scheduling.

Note

While the tracker is in SOS mode:

- The operating mode reported in the payloads is the one before entering the SOS mode.
- The alert bit is set.

Refer to [Common message header](#) section for more information about it.

4.4 Motion detection

4.4.1 Overview

The tracker embeds a three axis accelerometer, which detects accelerations and triggers a motion event. It is configurable with two parameters:

- *motion_sensitivity*: Allows a fine tuning of the acceleration intensity to trigger a motion event.
- *motion_duration*: Defines the delay needed without any motion detection to generate a **motion end** event.

The accelerometer is always active except in OFF mode

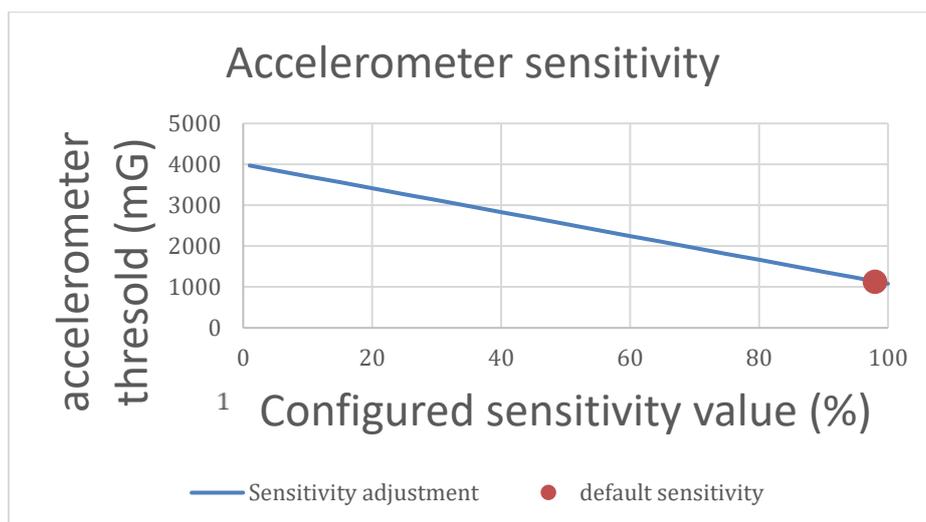
4.4.2 Motion sensitivity

The accelerometer sensitivity can be fine-tuned by configuration via the parameter *motion_sensitivity* as follows:

- The zero value is used for the default sensitivity:
- The range [1 .. 100] gives the sensitivity (in percentage).

Notes

- 1- High percentage values should be used when a high sensitivity is expected (a light motion triggers an event).
- 2- Low percentage values should be used when a low sensitivity is expected (a strong motion trigger an event).
- 3- The default sensitivity value is 0 (low resolution, very low consumption).
- 4- The following picture shows the conversion between mG (milli Gravity unit) and percentage



Examples

- 1- High sensitivity: *motion_sensitivity* = 100
- 2- Low sensitivity: *motion_sensitivity* = 1

4.4.3 Motion duration

The end of a motion is triggered by the absence of movement using a configuration parameter called *motion_duration*.

This parameter is expressed in seconds and ranges from [60 .. 3600]. The factory default value is 120 seconds.

4.4.4 Device orientation

The acceleration values from the three axes are available with the **motion end** event messages or by sending a specific downlink (see section [Request device configuration](#) for more details). This allows the application to determine the tracker orientation. For more details regarding the associated LoRaWAN™ messages, see [here](#).

4.5 Event Messages

These messages are notifications sent by the tracker informing the server about specific events

Based on the configuration, events can be:

- Geolocation start: Sent when the tracker begins a geolocation
- Motion start: Sent when the trackers begins a motion
- Motion end: Sent when the end of a motion is detected. (after *motion_duration* delay)
- BLE connected: Sent when a tracker is bonded and BLE connected to a mobile or a tablet
- BLE disconnected: Sent when a tracker is bonded and BLE disconnected to a mobile or a tablet
- Temperature information: Sent if the measured temperature is below or above the configured thresholds
- BLE Bond deleted: Sent when the bond is deleted on the tracker

See section [Event message](#) for the format of the uplinks.

The sending of Geolocation start, Motion start, and Motion end event messages depend on the operational mode as well as of the *config_flags* (bits 6, 8 and 9). See subsections below for more data

4.5.1 In Standby operating mode

config flag bits	Bit6 geolocation start	Bit 8 Motion start	Bit 9 Motion end	Message
Beginning of motion	Don't care	1	Don't care	Motion Start event
End of motion	Don't care	Don't care	1	Motion End event

4.5.2 In Motion tracking operating mode

config flag bits	Bit6 geolocation start	Bit 8 Motion start	Bit 9 Motion end	Message
Beginning of motion	0	0	Don't care	Geoloc Start event
	Don't care	1	Don't care	Motion Start event
	1	0	Don't care	WIFI position
End of motion	Don't care	Don't care	1	Motion End event

4.5.3 In permanent tracking operating mode

config flag bits	Bit6 geolocation start	Bit 8 Motion start	Bit 9 Motion end	Message
Entering of the mode	0	Don't care	Don't care	Geoloc Start event
	1	0	Don't care	WIFI position
Beginning of motion	Don't care	1	Don't care	Motion Start event
End of motion	Don't care	Don't care	1	Motion End event

4.5.4 In activity tracking operating mode

config flag bits	Bit6 geolocation start	Bit 8 Motion start	Bit 9 Motion end	Message
Beginning of motion	Don't care	1	x	Motion Start event
End of motion	Don't care	Don't care	Don't care	Motion End event

4.5.5 In start / end tracking operating mode

config flag bits	Bit6 geolocation start	Bit 8 Motion start	Bit 9 Motion end	Message
Beginning of motion	0	0	Don't care	Geoloc Start event
	Don't care	1	Don't care	Motion Start event
	1	0	Don't care	WIFI position
End of motion	0	Don't care	0	Geoloc Start event
	Don't care	Don't care	1	Motion End event
	1	Don't care	0	WIFI position

4.5.6 BLE connection status (all operating modes)

BLE Connection status	Message
New BLE connection (if the tracker is also bonded)	BLE connected
End of BLE connection (if the tracker is also bonded)	BLE disconnected
BLE bond is deleted on the tracker	BLE bond deleted

4.5.7 Temperature event (all operating modes)

	temperature_high 0x1D	temperature_low 0x1E	Message
Temperature > temperature_high	Configured	Don't care	High temperature event (byte 5= 0x01)
After a high temperature event : Temperature < temperature_high -5°C	Configured	Don't care	Normal Temperature event (byte 5=0x00)
Temperature > temperature_high	Not configured (=255=0xFF)	Don't care	No event message
Temperature < temperature_low	NA	Configured	Low temperature event (byte 5=0x02)
After a low temperature event : Temperature < temperature_low -5°C	Configured	NA	Normal Temperature event (byte 5=0x00)
Temperature < temperature_low	Don't care	Not configured (=255=0xFF)	No event message

See section [temperature monitoring](#) for more details

Notes:

- 1- Configured means not set to 255 (0xFF) but to a temperature value
- 2- Not configured: value= 255(0xff)

4.6 Shock detection

4.6.1 Overview

This feature enables the reporting of the shocks detected by the tracker. The configuration is flexible enough to detect a shock either globally or belonging to a given direction.

4.6.2 Configuration

The configuration of the shock detection is based on a single parameter called *shock_detection*. This parameter gives the accelerometer sensitivity used to trigger the shock events. The threshold can range from 0 to 100%. Value 0 means no detection.

Notes

- 1- The *motion_sensitivity* parameter must be configured (nonzero value)
- 2- The *shock_detection* parameter must be lower than the *motion_sensitivity*, otherwise all motions events are considered as shocks

4.6.3 Shock detection message

Upon the detection of a shock event, the tracker triggers a LoRaWAN™ message as follows: The first message is sent immediately with the actual acceleration values. The next ones are delayed by two minutes. In this case the reported value will be the highest shock that occurred during this fixed period. If no shock is detected during the two minutes period, no more payload is sent.

4.7 Temperature monitoring

This feature is designed to report temperature events when the temperature measured by the device is above or below the configured thresholds, *temperature_high* and *temperature_low* parameters.

Each threshold is used independently.

The value 255 is used to **disable** the threshold.

A specific action can be taken if the temperature exceeds one of the configured thresholds. Example: The geolocation can be deactivated.

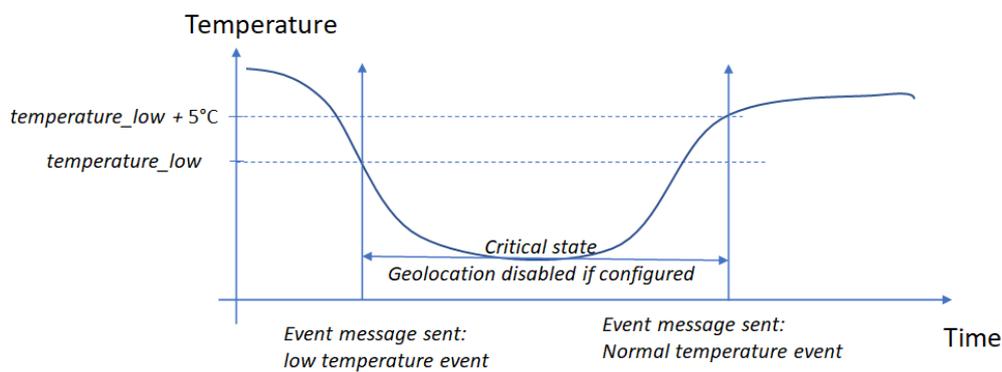
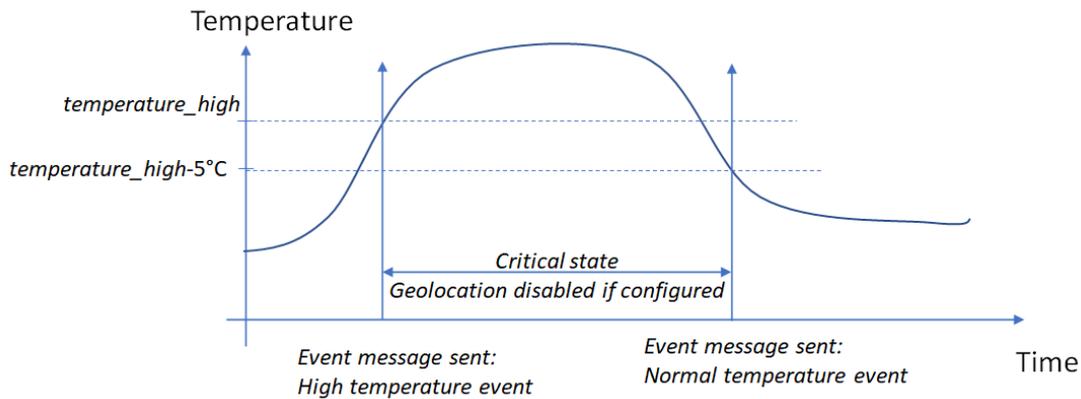
This action is configured via the parameter *temperature_action*.

The temperature monitoring is enabled if one of the two thresholds is not set to the **disable** value.

The temperature measurement is done periodically. If one of the configured thresholds is reached, a matching event is sent and a critical state is entered until the temperature comes back to an acceptable value (refer to the [table](#) for more data).

Notes

- 1- The temperature measurement periodicity is 10 minutes if the tracker is in the critical state and 2 minutes otherwise. See the definition of critical state below.
- 2- To come back in a normal state, the temperature should be either above the *temperature_low* + 5°Celsius or below the *temperature_high* – 5°Celsius.
- 3- Disabling the geolocation during the critical state (configured via the parameter *temperature_action*) could be useful to preserve the battery.
- 4- Temperature event payloads are sent only on state changes unless the geolocation has been disabled. In this case, geolocation uplinks are replaced by temperature event messages.



Temperature Monitoring data is reported with an Event payload described [here](#).

4.8 Low battery management

The battery level monitoring is done as follows:

- Every 5 minutes
- On a button press (short or long)

When the battery level goes below 3,2V, the device sends a shutdown message with the reason **low battery** then moves to the **OFF** mode (no more LoRaWAN™ payloads are sent).

The tracker remains in this state until the battery is recharged and restarted with a button press.

Before moving to the OFF state, a low battery melody is played.

On restarted the tracker goes back to its previous operational mode.

Notes

- 1- If the battery level is below 2.8V, it will take much longer than the regular two hours to fully recharge the tracker.
- 2- See the application note [battery percentage](#) for more details

4.9 User interfaces

4.9.1 Button management

The interface from the user to the tracker is performed via a button.

Sequence	Action	Output
Two short presses	Trigger an alert position or start/ end the SOS mode	Other LED pattern (see next section)
Three short presses	Indicates with a melody if the tracker is bonded or not	Buzzer melody: <ul style="list-style-type: none"> • BLE bond failure melody • BLE bond success melody
Any press when battery low (short or long press) ⁽¹⁾	Go to OFF mode, except if mode disabled	Buzzer melody fast LED blinking
One long press when device OFF and good battery	Wake up	LED pattern (See next section)
One very long press (5 s) when device ON.	Go to the OFF mode, except if mode disabled or if the tracker is in SOS mode	Buzzer melody
Button down when device is ON		Blue LED ON
1 long press, 6 short press, and 1 long press	Delete BLE bond	The bond is deleted, BLE bond on going melody is heard

Note

(1) See section [Low battery management](#) for more details.

4.9.2 LED interface

One of the two interfaces from the tracker to the user is done via the LED interface. Several patterns have been defined for different outputs.

LED blinking patterns

Three fast blinks	Go to the OFF mode (Low battery or user operation)
Three slow blinks	Device starting for the first time
Long fast blink of blue LED	LoRaWAN™ join operation in progress
2 short blinks+ 1 long blink repeated three times	GPS fix done ⁽¹⁾
Fast blink of blue LED after two button clicks	Device acknowledges the alert position
Slow blink of blue LED after two button clicks	SOS mode. Blinking remains until the mode is left

Note

(1) If configured on *config_flags* parameter.

4.9.3 Buzzer melodies

The second interface from the tracker to the user is done via a buzzer.

Up to nine different melodies have been defined:

Melody	Purpose
Device reset	Device is resetting/ going to bootloader
Major rising scale	Device is starting
Major falling scale	Device is going to OFF mode
Low battery	Low battery detected
SOS stop	Device has left SOS mode
BLE bond in progress	Tracker in not bonded. Waiting for a bond
BLE bond failure	Bond process unsuccessful
BLE bond success	Bond process successful
BLE alert	Alert activated from connected device using BLE

A zip file containing the different sounds can be found in the same folder as this document.

5 GEOLOCATION STRATEGY MODES

5.1 Main operating modes and SOS mode

The following geolocation technology settings (*geoloc_sensor* parameter) are used by the main operating modes: motion-tracking, permanent-tracking, start/end tracking and SOS. Note that in standby mode, only side operations can report positions.

- **WIFI only** → Only WIFI scans are used for position determination.
- **GPS only** → Only the GPS is used for position determination.
- **LPGPS only** → GPS and low power-GPS are used for position determination.
- **BLE beacon scan only** → Provide data formatted as a list of “MAC address/RSSI” couple that can be used to compute a position
- **Multi-technologies modes**
 - **WIFI-GPS only** → WIFI then GPS if WIFI fails in one geolocation cycle.
 - **WIFI-LPGPS only** → WIFI then Low power-GPS if WIFI fails in one geolocation cycle.
 - **BLE-GPS only** → BLE then GPS if BLE fails in one geolocation cycle.
 - **WIFI-LPGPS/ WIFI-GPS** → WIFI-low power GPS first, then WIFI-GPS if WIFI-low power GPS fails until timeout, then back to WIFI-low power GPS.

5.2 Side operations

The following geolocation technology setting (*geoloc_method* parameter) are used for periodic-reporting, on-demand or alert operations.

- **WIFI only** → Only WIFI scans are used for position determination.
- **GPS only** → Only the GPS is used for position determination.
- **LPGPS only** → GPS and low power-GPS are used for position determination.
- **BLE beacon scan only** → Provide data formatted as a list of “MAC address/RSSI” couple that can be used to compute a position
- **Multi-technologies modes**
 - **WIFI-GPS only** → WIFI then GPS if WIFI fails in one geolocation cycle.
 - **WIFI-LPGPS only** → WIFI then Low power-GPS if WIFI fails in one geolocation cycle.
 - **BLE-GPS only** → BLE then GPS if BLE fails in one geolocation cycle.

5.3 Geolocation technology description

5.3.1 Position message scheduling

The position message reporting frequency is based on the *ul_period* parameter. However, the first message can be postponed due to the position acquisition delay.

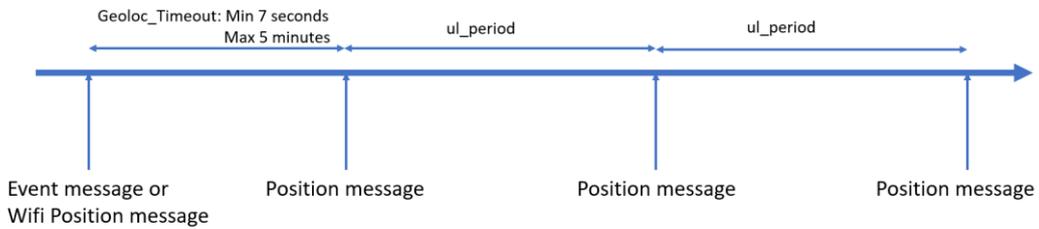
This delay depends on the geolocation strategy used.

Nonetheless, the tracker triggers an uplink message each time a new geolocation cycle starts. This message depends on the operating mode used and the *config_flags* configuration

After the transmission of this initial message, a first position is transmitted with the following delay:

- GPS, WIFI-GPS or BLE-GPS: the *gps_timeout* parameter is used. See GPS section to have details about the timeout used)
- LPGPS, or WIFI-LPGPS: the *agps_timeout* parameter is used.
- WIFI only: the timeout is fixed to 10 seconds.
- BLE only: the timeout is given by the *ble_beacon_timeout* parameter increased by 2 seconds

Geoloc generic processing:



After the first position is obtained, the geolocation timing uplinks are scheduled using the *ul_period* parameter (or 120 seconds fixed in SOS mode).

Important note:

Depending on *the config_flags*, the event message can be:

- A geoloc_start event message
- A motion start event message
- A motion end event message

Refer to the section [Event Messages](#) for more details

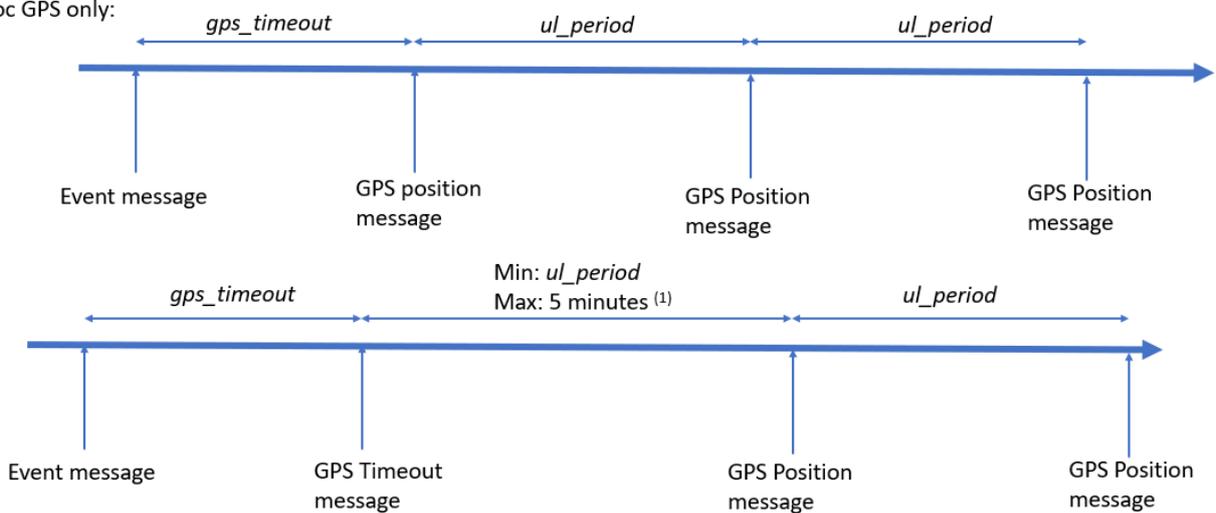
5.3.2 GPS

When doing a cold start, the tracker sends its first position using the *gps_timeout* value or using 5 minutes delay (if an event message is set instead of WIFI first position payload). After this first message, the tracker uses systematically a timeout of 5 minutes instead of the configured one (except in SOS mode), until it succeeds in having a position.

ote

The fixed timeout of 5 minutes is not used for the side operating mode **periodic position**.

Geoloc GPS only:



Timings used in the figure above:

- *gps_timeout*=120 seconds
- *ul_period*=180 seconds

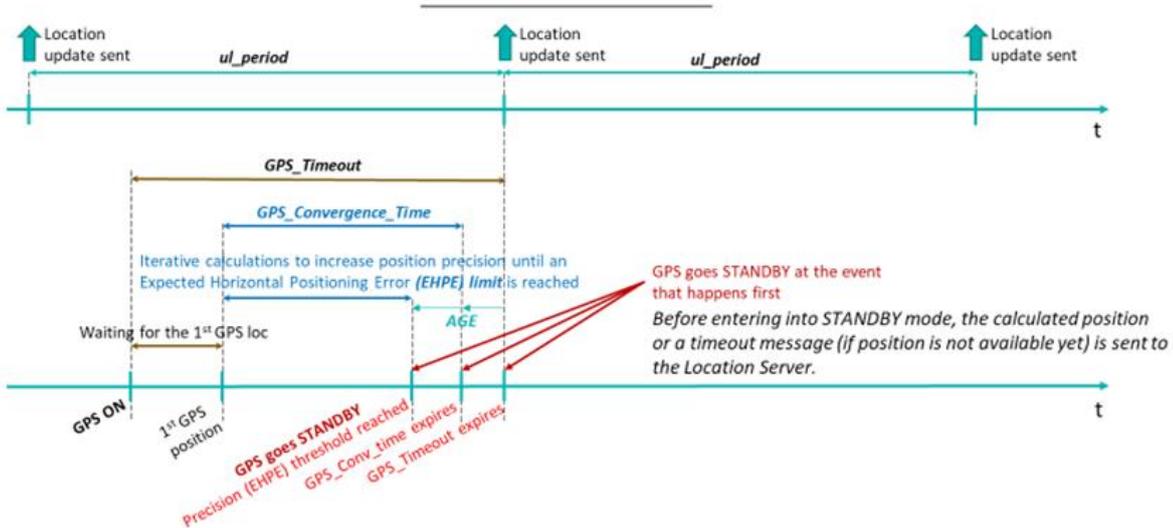
Note

(1) If *ul_period* > 5 minutes, The uplink is sent after *ul_period* time)

To complete a position, the GPS module expects one of the two following conditions to be achieved.

- The *gps_convergence* timeout in seconds (time let to the GPS module to compute a more precise position) expires.
- The *gps_ehpe* value is below the configured value. EHPE (Estimated Horizontal Position Error) is provided by the GPS component and is expressed in meters.

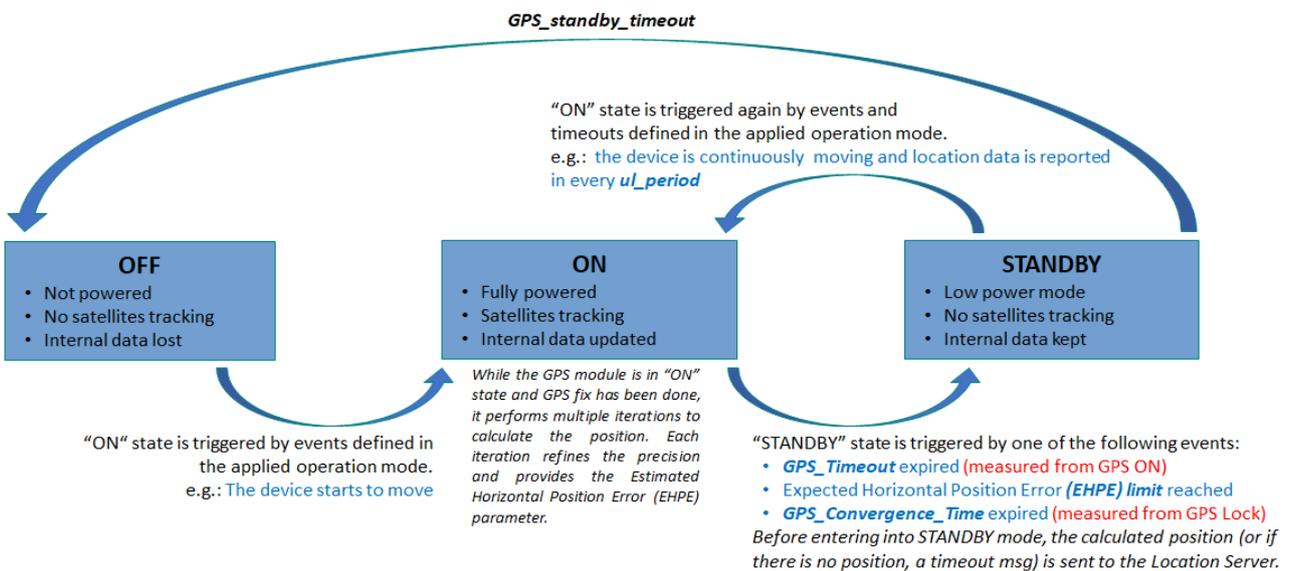
GPS Module Activity Time Line – GPS Geoloc Strategy



Once completed the position is reported via LoRaWAN™ and the GPS component switches to the standby state. Once the *gps_standby_timeout* delay expires, the GPS component is powered off. This leads to a loss of all data and ephemeris.

In the case where the GPS module didn't succeed, a GPS timeout message is sent instead of a GPS position message.

GPS state diagram



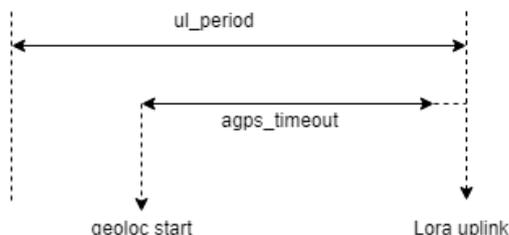
Note

In the case where the *gps_timeout* value is greater than the *ul_period*, the actual GPS timeout will be *ul_period*.

5.3.3 Low power GPS

With this technology, the device sends the data given by the GPS module before the *agps_timeout* delay expiry and the position calculation are done by the ABEEWAY server.

If the GPS component didn't succeed in having enough data to provide to the server, a LPGPS timeout message is sent instead of a LPGPS data message.



Notes

- 1- In the case where the *agps_timeout* value is greater than the *ul_period*, the actual GPS timeout will be *ul_period*.
- 2- The GPS position obtained in this mode does not pay attention to the parameters described in the precedent section (*gps_convergence*, *gps_ehpe* and *gps_timeout*).

5.3.4 WIFI

Since a WIFI scan is always done within three seconds, there is no timeout parameter.

Once the scan is done, the BSSIDs along with associated RSSI are sent via LoRaWAN™ the position calculation is done by the ThingPark X Location Engine in the geolocation backend..

In a multi technology geolocation, a WIFI scan results are only sent in the uplink if with the number of BSSIDs are greater than or equals to 3. .

If there are less than 3 BSSIDs found, then this triggers a technology switch (move to GPS or LPGPS).

5.3.5 BLE SCAN

This technology scans the BLE beacons and reports them via LoRaWAN™.

The configuration is based on three parameters:

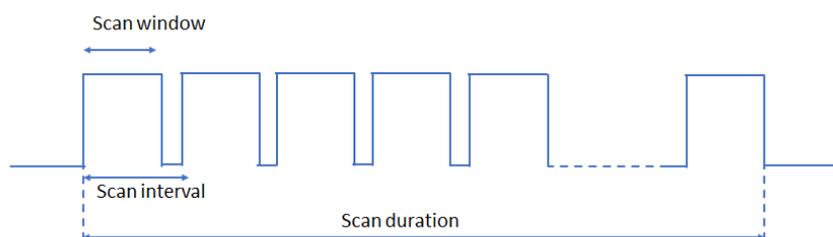
- *ble_beacon_timeout*: BLE scan duration.
- *ble_beacon_cnt*: Maximum number of beacons to be reported in the position message.
- *ble_rssi_filter*: BLE RSSI condition to trigger a geolocation switch. Applicable only with BLE-GPS geolocation mode. The switch to the GPS technology occurs if there is no beacon with a RSSI greater than the configured value.

The figure below describes the timing of a scan

Scan duration=minimum (*ul_period*, *ble_beacon_timeout*)

Scan window=120 milliseconds

Scan interval=130 milliseconds



Notes

- 1- In a multi-technology geolocation, the tracker switches to another geolocation technology if no beacons are detected or if there is no beacon with a RSSI greater than the *ble_rssi_filter* value
- 2- In the case where the technology used is **BLE only** and the BLE component fails to detect BLE beacons, the device reports a **BLE failure message**.
- 3- BLE communication interface should not be activated with BLE scan geolocation modes

Configuration example

ble_beacon_cnt = 0x04: The maximum number of beacons sent in LoRaWAN™ position messages is 4

Notes

- 1- BLE Beacons must be at least compliant with:
 - iBeacon (Apple)
 - Eddystone (Google)
- 2- The geolocation backend (ThingPark X Location Engine) does not support the position calculation based on BLE beacons. However, it can push the BLE beacons received in uplink to the application server. After that, it is up to the application to process them.

5.3.6 Multi-technologies

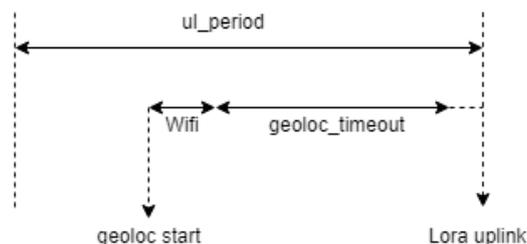
These technologies use two different components in a same geolocation cycle:

- WIFI-GPS: Start with a WIFI scan, then switch to the GPS in case of WIFI failure.
- WIFI-LPGPS: Start with a WIFI scan, then switch on the LPGPS in case of failure.
- BLE-GPS: Start with a BLE scan, then switch on the GPS in case of failure.

WIFI- GPS and WIFI-LPGPS

A WIFI scan result is considered as successful if at least three BSSID are present in the scan. In this case a WIFI position message is sent via LoRaWAN™. Otherwise, the tracker tries immediately the next geolocation technology (GPS or LPGPS), in the same geolocation cycle.

The picture below shows the timing diagram.



The actual geolocation timeout can be determined using the formula:

$Geoloc_timeout = gps_timeout$ or $agps_timeout$ depending on the used technology

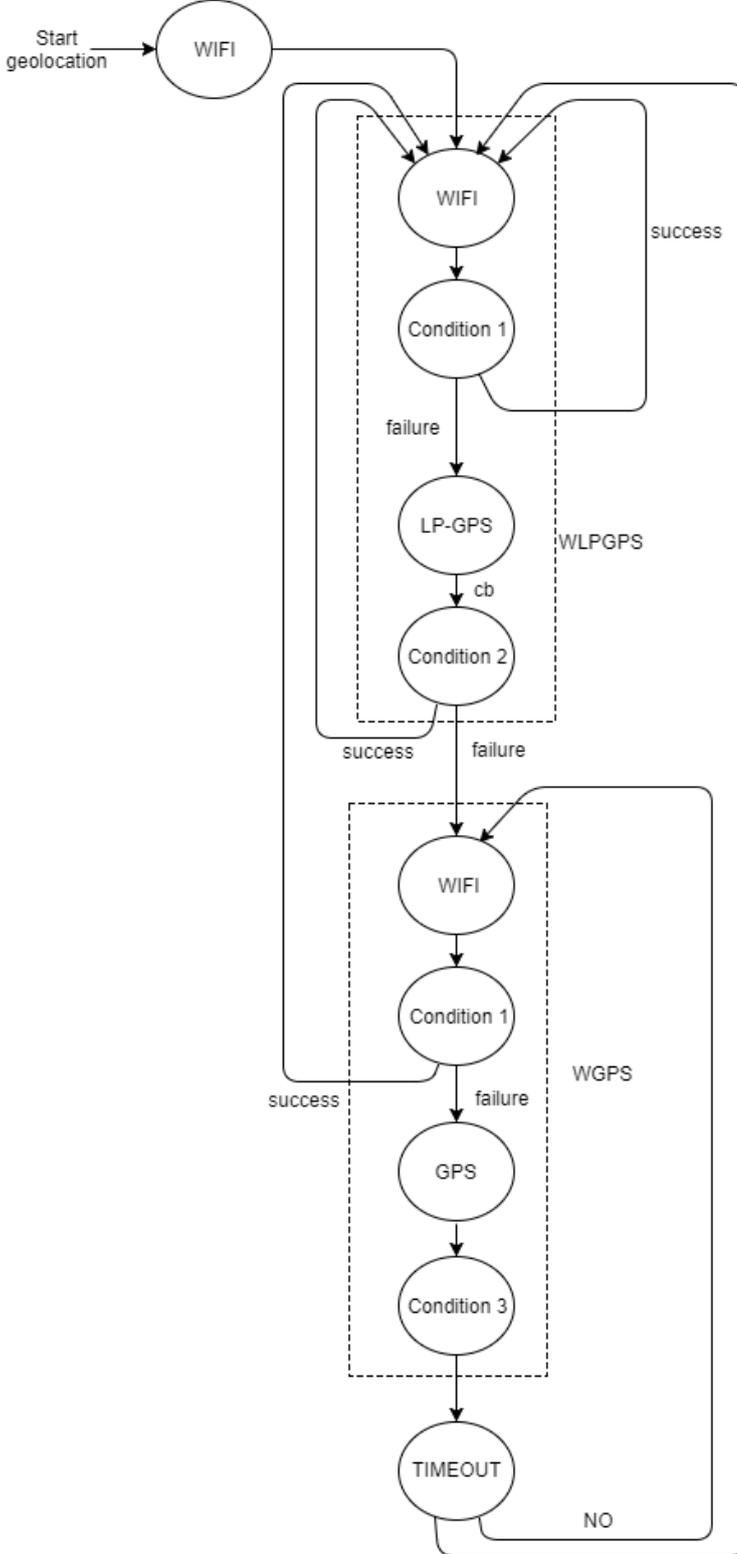
If $geoloc_timeout + WIFI_time$ (5 seconds) +switching techno time (3 seconds) is higher than *ul_period*, *geoloc_timeout* is adjusted and reduced to fit the *ul_period*.

BLE- GPS

A BLE scan result is considered as successful if at least one beacon is detected during the scan, with a measured RSSI value greater than *ble_rssi_filter* value. In this case BLE position message is sent via LoRaWAN™. Otherwise, the tracker tries immediately the next geolocation technology (GPS), in the same geolocation cycle.

5.3.7 Multi technology switching state diagrams

The multi-technology state diagram is shown below:



Dotted rectangles represent 1 cycle of geolocation (ul_period time)

Condition 1: success if at least 3 WIFI BSSIDs are seen

Condition 2: success if at least 5 satellites with $C/N \geq 15$ a GPS position are found by the GPS module within $agps_timeout$ period

Condition 3: success if a GPS position is obtained within $agps_timeout$ period

TIMEOUT= Maximum(10 minutes; ($3 * ul_period + 10$ seconds))

6 BLE COMMUNICATION INTERFACE

6.1 Overview

The MCU applicative firmware version 1.9 uses the Bluetooth Low Energy (BLE) capabilities of the micro trackers to interface with BT devices, such as Smart-phones, for the following use cases

- Controlling the micro tracker via a mobile application
- Updating the firmwares (BLE and main application)

The connectivity can be enabled or disabled via the bit 5 of the *config_flags* parameter.

Smartphones or graphical tablets run the **Client application** and are called **Central devices** in this section.

Note

BLE communication interface should not be activated with BLE scan geolocation modes. Refer to the section [Limitation](#).

6.2 Connection and pairing

6.2.1 Advertisement and connection

When the tracker is powered on, it tries to establish a connection with a **central device**.

Notes

- 1- If the device is not connected within 1-minute delay the BLE module is switched off.
- 2- WIFI scans cannot be performed while it's advertising and not bonded, to not interfere with bonding process.

6.2.2 Bonding procedure

When the tracker is turned on, if it is not bonded, it sends advertisements for 1minute. During this period, the buzzer beeps periodically.

Once the connection has been established, the **Client application** should send a bond request within a fixed delay of 1 minute. If no bond request is received during this period, the BLE module is switched off.

If the bonding fails, the device must be switched off then on to restart the bonding procedure.

6.2.3 Secured connection

A secured connection is established when a known **Central device** initiates a connection request and bounded information are present.

Security keys are stored in both the tracker and **Central device**. The connection is encrypted.

As soon as the BLE secure connection is established (with the bond information), the tracker enters in a special mode where the following applies:

- Accelerometer and battery monitoring tasks are maintained.
- All LoRaWAN™ communications are stopped. (except shutdown message in case the tracker is turned off)
- No geolocation is performed.

Notes

- 1- Once connected, the tracker does not accept any other BLE connections.
- 2- If the tracker has bonding information, only the paired **central device** can connect to it.
- 3- When the tracker is actively bonded and connected to the central device, the geolocation is done by **central device**.

6.2.3.1 Disconnection with a bonded device

The usual BLE keepalive mechanism between the **central device** and the tracker is done at the frequency of one message per second (*Maximum connection interval*).

The BLE connection is said lost if no messages are received for 6 seconds (*Supervision timeout*).

30 seconds after a secured connection is lost, the last configured operational mode of the tracker is restored.

6.2.3.2 Clear bond event

The bond information can be cleared by:

- A LoRaWAN™ Downlink (see [BLE parameters](#) sections for more details)
- A specific BLE command
- A specific button sequence: 1 long press, 6 short press, and 1 long press

Once cleared the tracker is disconnected from the **central device** and switches to its configured operational mode. The bonding procedure restarts.

6.2.3.3 Asymmetric BLE pairing

The asymmetric BLE pairing feature is configurable in the *config_flags* (bit11) and controls if the device (micro-tracker) can renew the bound in case the central device has lost its bonding:

- If set, the tracker cannot renew the bonding and it won't be able to reconnect with another **central device** (this configuration enhances the security, however, the device's bond can be reset by sending [BLE bond reset downlink message](#))
- If clear, the tracker allows you to renew bonding.

6.3 FW update over the air via BLE

It is possible to use the BLE connection to perform the firmware update of the tracker

- BLE firmware
- MCU Applicative firmware

6.4 Client application

For **client applications** implementations, a dedicated [application note](#) is available on the website.

6.5 Limitation

The BLE communication interface cannot be used with BLE scan geolocation modes.

In the case of an incorrect configuration or setting via LoRaWAN™, the BLE geolocation modes have precedence over the BLE communication interface.

This means that if bit 5 of *config_flags* (Activate BLE communication interface) is activated and the geolocation sensor or method are BLE based, then the BLE communication interface will be disabled.

7 UPLINK MESSAGES

This section describes the payload messages supported by the tracker.

Unless otherwise specified, all values are transmitted in network byte order (MSB first).

Each message is composed of two parts:

- A common header
- A specific data part

The tracker supports different types of uplink messages, that are described in the following sections:

Message type		Content
Frame pending	0x00	This uplink message is sent to trigger the sending. (and speed up the configuration of the tracker) if downlink messages are available on gateway and no other uplink message is on the queue
Position	0x03	GPS, low power GPS, WIFI or BLE position data
Energy status	0x04	Used by the server to estimate the battery level. Contains information related to the power consumption
Heartbeat	0x05	Notify the server that the tracker is operational and under LoRaWAN™ coverage
Activity Status ⁽¹⁾	0x07	Reports the activity counter. Used only by the activity tracking operating mode
Configuration ⁽¹⁾	0x07	Reports the partial or whole configuration of the trackers,
Shock detection ⁽¹⁾	0x07	Reports the accelerometer vector (X, Y, Z) of the detected shock
Shutdown	0x09	Sent when the tracker is set off
Event ⁽²⁾	0x0A	Sent event information about tracker.
Debug	0x0F	Internal use only

Notes

- (1) Activity status message, configuration message and shock detection message share the same identifier. They are differentiated by the value of the byte 5 of the payload.
- (2) Configurable via the *config_flags* parameter

7.1 LoRaWAN™ uplink transmission

7.1.1 Basic Transmission strategy used

The tracker follows the LoRaWAN™ requirements regarding the transmission (like duty cycle). Each transmission is managed according to the *transmit_strat* parameter:

Strategy	ID	Static device	Motion device ⁽³⁾
Single fixed	0x00	Single transmission using network ADR ⁽²⁾ .	Single transmission using a fixed data rate ⁽¹⁾ .
Single random	0x01		Single transmission using a random data rate within [DR0-DR5].
Dual random	0x02		Double transmissions: <ul style="list-style-type: none"> • First transmission using a random data rate within [DR4-DR5]. • Second transmission using a random data rate within [DR0-DR3].
Dual fixed	0x03		Double transmissions: <ul style="list-style-type: none"> • First transmission using a random data rate within [DR4-DR5]. • Second transmission using a fixed data rate ⁽¹⁾.
Network ADR	0x04		Single transmission using network ADR ⁽²⁾ .
Custom strategy	0x05	Based on <i>transmit_strat_custom</i> parameter	

Notes

- (1) Value provisioned in the device in the factory
- (2) Number of retransmission and rate managed by the network (with the same sequence number)
- (3) Tracker is considered in motion until the *motion_duration* timer expires.

Refer to the section [LoRaWAN™ parameters](#) for more details.

7.1.2 Custom Transmission strategy (experimented user only)

It is activated only if *transmit_strat* parameter is set to 0x05 (custom strategy). The strategy is then defined with *transmit_strat_custom* parameter

Refer to the dedicated application note [LoRa Transmission strategy](#) for more data.

7.1.3 Confirmed uplink

The device can be configured to request LoRaWAN™ confirmations for a collection of uplink message types. The parameter *confirmed_ul_bitmap* is used to select the message types that requires a confirmation. Only message types in the range 0x00 to 0x0F can be selected.

Example: Confirmed uplink of message types 0x0 and 0x3: $\text{bitmap} = 2^0 + 2^3 = 1 + 8 = 9$.

The parameter *confirmed_ul_retry* gives the number of retransmissions that the tracker should do in the case where the LoRaWAN™ confirmation is not received.

A value 0 means that the uplink will request the LoRaWAN™ confirmation but will not retry in case of a failure.

7.2 Encoded form

Some parameters are encoded with the following algorithm:

```
static float _step_size (float lo, float hi, unsigned nbits, unsigned nresv)
{ return 1.0/((((1 << nbits) -1) -nresv)/(hi -lo)); }
```

```
float mt_value_decode(uint32_t value, float lo, float hi, unsigned nbits, unsigned nresv)
{ return ((value -nresv /2) * _step_size(lo, hi, nbits , nresv) + lo);}
```

Where:

- ✓ **nbits:** Number of bits used to encode.
- ✓ **lo:** Min value that can be encoded
- ✓ **hi:** Max value that can be encoded
- ✓ **nresv:** Number of reserved values, not used for the encoding.

Notes

- 1- Values calculated using this formula provide a truncated value rounding within a range of step_size. Decoded value < Real value < decoded value + step_size
- 2- **if real value < step size, then a value of 0 is decoded**

7.3 Common message header

Common header					Data
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Variable
Type	Status	Battery	Temperature	ACK/Opt	Information

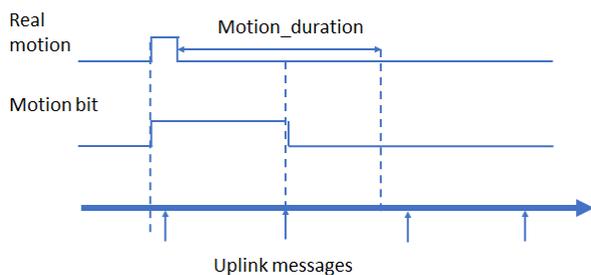
Type: refer to [Message types](#)

Status:

Bit7-5	Operating mode: <ul style="list-style-type: none"> ➤ 0- Standby ➤ 1- Motion tracking ➤ 2- Permanent tracking ➤ 3- Motion start/end tracking ➤ 4- Activity tracking ➤ 5- OFF⁽²⁾
Bit 4	Set if the user alert/SOS has been entered
Bit 3	Reserved bit
Bit 2	Set if the tracker is in motion state since the last payload is sent ⁽¹⁾
Bit 1	Set for a periodic position message
Bit 0	Set for a position on demand message

Notes

- (1) The motion bit setting can be pictured as follow:



- (2) In shutdown payload, the operating mode is always OFF

Battery:

- 0x00: the battery is charging
- 0x01 to 0xFE: Battery voltage expressed in volt. [Encoded form](#) using **lo**= 2.8, **hi**= 4.2, **nbits**= 8, **nresv**= 2. It is given with a step of 5,5mV.
- 0xFF: Error in measurement

Temperature: Temperature measured in the device, expressed in degree Celsius. [Encoded form](#) using **lo**= -44, **hi**= 85, **nbits**= 8, **nresv**= 0. It is given with a step of 0.5°C

ACK/opt:

Bit 7-4	ACK	Acknowledge token. Refer the section Acknowledge token for more details
Bit 3-0	Opt	Optional data (depending on message type. Currently used only for position messages)

Information: Variable part depending on the message type.

7.4 Heartbeat messages

Common header	Data		
Byte 0-4	Byte 5	Byte 6-8	Byte 9-11
Header with Type=0x05	Cause	FW version	BLE FW version

Cause: Last MCU reset cause

- 0x00- Default value, no reset was done on the tracker
- 0x01- Power-On Reset
- 0x02- Brown-Out Unregulated Domain Reset
- 0x04- Brown-Out Regulated Domain Reset
- 0x08- External Pin Reset
- 0x10- Watchdog Reset
- 0x20- Lockup Reset
- 0x40- System Request (application) Reset

FW version: MCU applicative Firmware version on the device,

- Byte 6: Firmware major version
- Byte 7: Firmware minor revision
- Byte 8: Firmware iteration

BLE FW version: BLE Firmware version on the device,

- Byte 9: Firmware major version
- Byte 10: Firmware minor revision
- Byte 11: Firmware iteration

Note

The fields Major, Minor and Revision form the firmware version as follow: Major.Minor-Iteration

Example: 1.8-0 is coded as 0x010800

7.5 Position messages

Common header				Data
Byte 0	Byte 1-3	Byte 4		(1)
Type=0x03	Status/Batt/ Temp.	ACK	Opt	Position Information

Note

(1) The size of data part depends on the type of position message

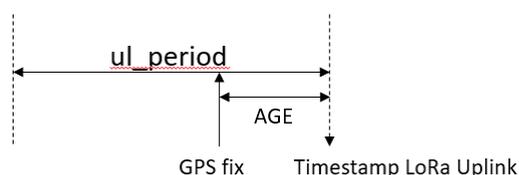
Opt: type of position message

- 0 – GPS fix
- 1 – GPS timeout
- 2 – Encrypted WIFI BSSIDs (No more used but still supported).
- 3 – WIFI timeout
- 4 – WIFI failure
- 5, 6 – LPGPS data (encrypted, not described in this document)
- 7 – BLE beacon scan
- 8 – BLE beacon failure
- 9 – WIFI BSSIDs

7.5.1 GPS fix payload

Common header	Position information data				
Byte 0-4	Byte 5	Byte 6-8	Byte 9-11	Byte 12	Byte 13-15
Header with Opt=0	Age	Latitude	Longitude	EHPE	Encrypted

Age: Time difference between the fix and the LoRaWAN™ transmission. [Encoded form](#) using **lo= 0, hi= 2040, nbits= 8, resv= 0**. Expressed in seconds. The step is 8 seconds.



Latitude: Latitude of the position (expressed in degree) calculated as follow:

Latitude = Latitude << 8

If Latitude > 0x7FFFFFFF then Latitude = Latitude – 0x100000000

Latitude = Latitude / 10⁷

Longitude: Longitude of the position (expressed in degree) calculated as follow:

Longitude = Longitude << 8

If Longitude > 0x7FFFFFFF then Longitude = Longitude – 0x100000000

Longitude = Longitude / 10⁷

EHPE: Estimated Horizontal Position Error, expressed in meters. [Encoded form](#) using **lo= 0, hi= 1000, nbits= 8, nresv= 0**. The step is 3.9 meters.

7.5.2 GPS timeout payload

Common header	Position information data				
Byte 0-4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Header with Opt=1	Cause	C/N 0	C/N 1	C/N 2	C/N 3

Cause: Timeout cause

- 0 – User timeout cause

C/N 0: Carrier over noise (dBm) for the first satellite seen.

C/N 1: Carrier over noise (dBm) for the second satellite seen.

C/N 2: Carrier over noise (dBm) for the third satellite seen.

C/N 3: Carrier over noise (dBm) for the fourth satellite seen.

Notes

- 1- The satellites are ordered based on their C/N. The best is sent in C/N 0.
- 2- **C/N** encoding uses: **lo**= 0, **hi**=50, **nbits**=8, **nresv**= 0. It is expressed in dBm with a step of 0,2dBm
- 3- Encoded form is detailed in the [Encoded form](#) section.

7.5.3 WIFI timeout payload

Common header	Position information data					
Byte 0-4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10
Header with Opt=3	v_bat1	v_bat2	v_bat3	v_bat4	v_bat5	v_bat6

V_bat1: Encoded voltage at the start time (T0) of the WIFI scan.

V_bat2: Encoded voltage at T0 + 0.5 second.

V_bat3: Encoded voltage at T0 + 1 second.

V_bat4: Encoded voltage at T0 + 1.5 second.

V_bat5: Encoded voltage at T0 + 2 seconds.

V_bat6: Encoded voltage at T0 + 2.5 seconds.

Notes

- 1- Most of time a WIFI timeout occurs due to low battery.
- 2- See [here](#) for more information about the voltage decoding

7.5.4 WIFI failure payload

Common header	Position information data						
Byte 0-4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11
Header with Opt=4	v_bat1	v_bat2	v_bat3	v_bat4	v_bat5	v_bat6	Error

V_bat1: Encoded voltage at the start time (T0) of the WIFI scan.

V_bat2: Encoded voltage at T0 + 0.5 second.

V_bat3: Encoded voltage at T0 + 1 second.

V_bat4: Encoded voltage at T0 + 1.5 second.

V_bat5: Encoded voltage at T0 + 2 seconds.

V_bat6: Encoded voltage at T0 + 2.5 seconds.

Error:

- 0 – WIFI connection failure
- 1 – Scan failure
- 2 – Antenna unavailable
- 3 – WIFI not supported on this device

Notes

- 1- Most of time a WIFI timeout occurs due to a low battery condition.
- 2- See [here](#) for more information about the voltage decoding

7.5.5 WIFI BSSID payload

Common header	Position information data								
Byte 0-4	Byte5	B 6-11	Byte12	B 13-18	Byte19	B 20-25	Byte26	B 27-32	Byte33
Header with Opt=9	Age	BSSID0	RSSI0	BSSID1	RSSI1	BSSID2	RSSI2	BSSID3	RSSI3

Age: [Encoded form](#) of scan age with **lo=0**, **hi=2040**, **nbits=8**, **nres=0**. Expressed in seconds. The step is 8 seconds.

BSSID x: BSSID of the WIFI station x.

RSSIx: Receive Signal Strength Indication of the WIFI station x. Non encoded form (**negative value**, refer to the section [Two's complement Encoding](#) for information for the encoding). It is expressed in dBm.

When long WIFI payload is activated in *config_flags* parameter and transmit strategy is not well chosen, too long payload could not be transmitted. In this case, after 5 discarded uplinks, the tracker sends the following error message:

Common header				Data
Byte 0	Byte 1-3	Byte 4		Byte 5-6
Type=0x0f	Status/Batt/ Temp.	ACK	0x02	Length Error counter

Length Error counter: Number of payloads discarded due to uplink length error

Notes

- 1- The payload contains the listened WIFI stations (up to 12 if bit 12 of *config_flags* parameter is set).
- 2- If less than 4 stations are listened, the payload will be reduced.
- 3- BSSID address is provided in big endian format. So, the byte 6 of the payload contains the MSB of the BSSID0, while the byte 11 contains its LSB.
- 4- The datarate and the transmit strategy must be adapted to the payload size, or the payload will be rejected by the LoRaWAN™ MAC, and won't be sent. Refer to the application note [LoRa Transmission strategy](#) for more data.

7.5.6 BLE beacon scan payload

Common header	Position information data								
Byte 0-4	Byte 5	Byte 6-11	Byte 12	Byte 13-18	Byte 19	Byte 20-25	Byte 26	Byte 27-32	Byte 33
Header with Opt=7	Age	MAC ADR0	RSSI0	MAC ADR1	RSSI1	MAC ADR2	RSSI2	MAC ADR3	RSSI3

Age: [Encoded form](#) of scan age with **lo=0**, **hi=2040**, **nbits=8**, **nres=0**. Expressed in seconds.

MAC ADRx: MAC Address of the BLE beacon x.

RSSIx: Receive Signal Strength Indication of the BLE beacon x. Non-encoded form (**negative value**, refer to the section [Two's complement Encoding](#) for information for the encoding).and expressed in dBm.

Notes

- 1- The payload contains the listened BLE beacons (up to 4, it is configurable using *ble_beacon_cnt* parameter), during *ble_beacon_timeout* delay.
- 2- If less than 4 BLE beacons are listened, the payload will be reduced.

7.5.7 BLE failure payload

Common header	Position information data
Byte 0-4	Byte 5
Header with Opt=8	Error

Error:

- 0x00: BLE is not responding
- 0x01: Internal error
- 0x02: Shared antenna not available
- 0x03: Scan already on going
- 0x04: BLE busy (should not occur)
- 0x05: No beacon detected
- 0x06: Hardware incompatibility
- 0xFF: Unknown/wrong BLE firmware version

7.6 Energy Status messages

This message should be used for a primary battery life estimation. It is not useful for micro tracker

7.7 Activity status messages

7.7.1 Activity operating mode

When the operation mode is activity, the activity status reporting has the following format:

Common header	Data	
Byte 0-4	Byte 5	Byte 6-9
Header with Type=0x07	0x01	Activity

Activity: Activity counter. Unsigned 32 bits value in big endian format (MSB first).

7.7.2 Side operating mode

When the activity is requested via the side operating mode (*periodic_activity_period* parameter not null) the status has the following format:

Common header	Data							
Byte 0-4	Byte 5	Byte 6-7	Byte 8-9	Byte 10-11	Byte 12-13	Byte 14-15	Byte 16-17	Byte 18-21
Header with Type=0x07	0x04	Window 1	Window 2	Window 3	Window 4	Window 5	Window 6	Global counter

Window x: value containing the activity counter during the xth time window. The window 6 is the most recent one and the window 1 is the oldest

Global counter: Global activity counter, it contains the activity since the beginning.

7.8 Configuration messages

This message reports the parameter values configured in the trackers. If the complete list is requested, several UL messages will be transmitted.

Common header	Data					
Byte 0-4	Byte 5	Byte 6-10	Byte 11-15	Byte 16-20	Byte 21-25	Byte 26-30
Header with Type=0x07	0x02	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Parameter 5

Parameter x: Configuration of the parameter **x**, coded on 5 bytes as follow:

Parameter x	
Byte (5*x+1)	Byte (5*x+2) - (5*x+5)
Parameter ID	Parameter value

Parameter ID:

Parameter	ID
ul_period	0x00
lora_period	0x01
pw_stat_period	0x02
periodic_pos_period	0x03
Reserved, do not use	0x04
geoloc_sensor	0x05
geoloc_method	0x06
Reserved, not used on micro trackers	0x07
motion_nb_pos	0x08
gps_timeout	0x09
agps_timeout	0x0A
gps_ehpe	0x0B
gps_convergence	0x0C
config_flags	0x0D
transmit_strat	0x0E
ble_beacon_cnt	0x0F

Parameter	ID
ble_beacon_timeout	0x10
gps_standby_timeout	0x11
confirmed_ul_bitmap	0x12
confirmed_ul_retry	0x13
motion_sensitivity	0x14
shock_detection	0x15
periodic_activity_period	0x16
motion_duration	0x17
Reserved, do not use	0x18
Reserved, do not use	0x19
ble_rssi_filter	0x1A
temperature_high	0x1B
temperature_low	0x1C
temperature_action	0x1D
transmit_strat_custom	0x1E

Parameter value: Unsigned 32 bits value in big endian format (MSB first).

Specials parameters

- **Firmware version** (Parameter ID equal to 0xFD or 0xFE) should be read as follow:

Parameter x				
Byte 5*x+1	Byte 5*x+2	Byte 5*x+3	Byte 5*x+4	Byte 5*x+5
Parameter ID	Parameter value			
0xFD or 0xFE	0x00	Firmware version	Firmware revision	Firmware iteration

Example

Parameter=0xfe00010881, Firmware version=0x01, Firmware revision=0x08, Firmware iteration= 0x81

- **Tracker orientation** (Parameters ID equal to 0xFA, 0xFB or 0xFC) can be negative. Refer to the section [Two's complement Encoding](#) for information for the encoding.

Parameter x	
Byte 5*x+1	Byte 5*x+2 - 5*x+5
Parameter ID	Parameter value
0xFA, 0xFB or 0xFC	X, Y or Z Axis

X, Y or Z Axis: Value measured on axis X, Y or Z of the accelerometer, it is expressed in mG. Refer to the section [Two's complement Encoding](#) for information for the encoding

- **BLE Bond status** (Parameter ID equals to 0xF8): Unsigned 32 bits value in big endian format (MSB first).
 - 0: the tracker is not bonded
 - 1: the tracker is bonded
 - 2: unknown state
- **Mode** (Parameter ID equals to 0xF9): Unsigned 32 bits value in big endian format (MSB first).
 - 0- Standby
 - 1- Motion tracking
 - 2- Permanent tracking
 - 3- Motion start/end tracking
 - 4- Activity tracking

7.9 Shock detection messages

Common header	Data				
Byte 0-4	Byte 5	Byte 6	Byte 7-8	Byte 9-10	Byte 11-12
Header with Type=0x07	0x03	Nb of shocks	Accelerometer shock data		
			X Axis	Y Axis	Z Axis

Nb of shocks: Number of shocks having an accelerometer value above the configured thresholds.

Accelerometer shock data:

- **X Axis:** Value measured on axis X of the accelerometer, it is expressed in mG
- **Y Axis:** Value measured on axis Y of the accelerometer, it is expressed in mG
- **Z Axis:** Value measured on axis Z of the accelerometer, it is expressed in mG

Notes

- 1- Signed 16 bit value on each axis, refer to the section [Two's complement Encoding](#) for information for the encoding
- 2- G is the terrestrial gravity, mG means milli G.

7.10 Frame pending messages

Byte 0	Byte 1
Type=0x00	ACK

When additional messages are available on a gateway, this uplink message is sent to trigger the gateway sending (if no other messages are pending).

ACK: Acknowledge token. Refer the section [Acknowledge token](#) for more details

Note

To shorter the payload, this message is only 2 Bytes long (no common header).

7.11 Shutdown message

Common header	Data
Byte 0-4	Byte 5
Header with Type=0x09	Shutdown cause

Shutdown cause:

- 0: User action: Long button press
- 1: Low battery
- 2: Downlink request
- 3: BLE request

Notes

- 1- This LoRaWAN™ message is sent even if the tracker is BLE connected
- 2- In shutdown payload, the operating mode is always OFF

7.12 Event message

Common header	Data	
Byte 0-4	Byte 5	Byte 6-12
Header with Type=0x0A	Event Value	Additional data

It notifies generic events.

Event Value:

- 0x00: **geolocation start** message: If activated (bit 6 of *config_flags set*), the event message is sent when the tracker begins a geolocation
- 0x01: **motion_start** message: If activated (bit 8 of *config_flags set*), the event message is sent when the tracker begins a motion.
- 0x02: **motion_end** message: If activated (bit 9 of *config_flags set*), the event message is sent when the end of a motion is detected.
- 0x03: **BLE connected**: Sent when a tracker is bonded and BLE connected to a mobile or a tablet
- 0x04: **BLE disconnected**: Sent when a tracker is bonded and BLE disconnected to a mobile or a tablet
- 0x05: **Temperature alert**: Sent if the measured temperature is below or above a configured threshold
- 0x06: **BLE Bond deleted**: Sent when the bond is deleted on the tracker

Additional data:

 ➤ **motion_end** messages:

Provides the orientation of the tracker, which can be negative.

Refer to the section [Two's complement Encoding](#) for the encoding.

Additional data with Event value=0x02		
Byte 6-7	Byte 8-9	Byte 10-11
X axis	Y axis	Z axis

X axis: X axis accelerometer value in mG

Y axis: Y axis accelerometer value in mG

Z axis: Z axis accelerometer value in mG

 ➤ **Temperature alert** messages:

Provides data about the measured temperature

Additional data with Event value=0x05				
Byte 6	Byte 7	Byte 8	Byte 9-10	Byte 11-12
State ≠ 3	Max Temperature	Min Temperature	High counter	Low counter
State = 3	reserved			

State:

- 0: Normal temperature
- 1: High temperature
- 2: Low temperature
- 3: Feature not activated

Max Temperature: Maximum temperature measured by the device.

Min Temperature: Minimum temperature measured by the device.

High counter: From the time a high temperature event is sent, this counter is incremented every 10 minutes (can be used to calculate the over temperature time).

Low counter: From the time a low temperature event is sent, this counter is incremented every 10 minutes (can be used to calculate the under temperature time).

Notes:

- 1- if the feature is not activated, values in additional data part are not valid.
- 2- The counters never reset.

8 DOWNLINK MESSAGES

These messages are sent from the server to the tracker through the LoRaWAN™ network. They are used to either configure or manage the tracker. Each message contains a header including:

- A message type
- An acknowledgement token

The remaining of the message depends on the message type described in the following table.

Message type	ID	Description
POD	0x01	Position on demand
Set Mode	0x02	Change the tracker operational mode
Request configuration	0x03	Request the actual configuration of the tracker
Start SOS mode	0x04	Turn on SOS mode
Stop SOS mode	0x05	Turn off SOS mode
Set Param	0x0B	Modify parameter(s)
Debug command	0xFF	Reset the tracker

Notes

- 1- Any unexpected message (unknown message type, bad length, ...) is discarded. However, the ack token is updated even if the message is discarded (if the payload is at least 2 bytes long).
- 2- The **LoRaWAN™ port** to be used for downlink is **2**.

8.1 Acknowledge token

It provides a way to indicate to the application that a given message has been received by the tracker.

The acknowledge token is transmitted in every uplink message, and it is updated when the tracker receives a LoRaWAN™ message. This way, each time the server receives a LoRaWAN™ uplink, it knows whether the previous message has been received.

The acknowledge token is four bits size. Its value ranges from 0 to 15 (0x0F).

Notes

- 1- The ack token value must be changed for each downlink.
- 2- It's up to the application to process or not the ack tokens.
- 3- It's up to the application to manage the confirmations. It can either wait for the matching ack token in the uplink message before sending another downlink or send multiple downlink and later waits for the acks.

8.2 Operational mode configuration

The operating mode can be remotely configured with a downlink LoRaWAN™ message built as follow:

Byte 0	Byte 1	Byte 2
0x02	ACK	Mode

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

Mode: operating modes. Acceptable values are:

- 0- Standby
- 1- Motion tracking
- 2- Permanent tracking
- 3- Motion start/end tracking
- 4- Activity tracking
- 5- Off mode

Example

Changing the operating mode to “motion track” (01) with an ack token of 3: **0x020301**.

Note

This version supports an additional way to update the operational mode based on a special configuration parameter. See [here](#) for more details

8.3 Position on demand

Whatever the state, a position can be requested from the tracker using the message:

Byte 0	Byte 1
0x01	ACK

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

Example

Position on demand message with ack token of 2: **0x0102**. The tracker will answer with a position message.

8.4 Request device configuration

Byte 0	Byte 1	Byte 2-21
0x03	ACK	Parameter ID list (optional)

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

Parameter ID list: List of requested parameters identifiers.

- Each single byte contains a single identifier.
- Parameter IDs are the one used to configure the device (see section [Configuration message](#)).
- Special parameters (described below) can be requested.
- The list can be empty. In this case, all parameters are requested.

Special parameter ID:

- Tracker orientation:
 - 0xFA: get the X axis accelerometer value in mG
 - 0xFB: get the Y axis accelerometer value in mG
 - 0xFC: get the Z axis accelerometer value in mG
provides the orientation of the tracker on each axis. The orientation can be negative, refer to the section [Two's complement Encoding](#) for information for the encoding)
- Firmware version:
 - 0xFD: get the BLE firmware version.
 - 0xFE: get the MCU applicative firmware version.
- BLE bond status:
 - 0xF8: get the BLE bond status
 - 0- No bond
 - 1- Bond
 - 2- Unkwown status (when BLE wasn't started at least once)
- Operating mode:
 - 0xF9
 - 0- Standby
 - 1- Motion tracking
 - 2- Permanent tracking
 - 3- Motion start/end tracking
 - 4- Activity tracking

Notes

- 1- The tracker answers this request with a Configuration uplink message (section [Configuration messages](#)).
- 2- Each uplink can contain up to 5 parameters.
- 3- If the number of parameters is greater than 5, the tracker will send the needed number of uplinks to fulfill the request.

8.5 Request temperature status

Byte 0	Byte 1
0x06	ACK

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

Note

The tracker answers this request with a temperature event message

8.6 SOS mode configuration

Turn on SOS mode of the tracker:

Byte 0	Byte 1
0x04	ACK

Turn off SOS mode of the tracker:

Byte 0	Byte 1
0x05	ACK

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

See section [SOS mode](#) to have more information about the SOS mode behavior.

8.7 Parameters configuration

Any parameter can be remotely modified with a downlink LoRaWAN™ message. Such messages are built according to the following format:

Byte 0	Byte 1	Byte 2	Byte 3-6
0x0B	ACK	Parameter ID	New value [31-00]

It is possible to modify up to 5 parameters in the same message by using the following format:

		Parameter 1		Parameter 2	
Byte 0	Byte 1	Byte 2	Byte 3-6	Byte 7	Byte 8-11
0x0B	ACK	ID	New value1 [31-00]	ID	New value2 [31-00]

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

The table below sum up all parameters and their identifiers (ID). The parameters described as “reserved” are not used for this tracker.

Parameter	ID
ul_period	0x00
lora_period	0x01
pw_stat_period	0x02
periodic_pos_period	0x03
Reserved, do not use	0x04
geoloc_sensor	0x05
geoloc_method	0x06
Reserved, not used on micro trackers	0x07
motion_nb_pos	0x08
gps_timeout	0x09
agps_timeout	0x0A
gps_ehpe	0x0B
gps_convergence	0x0C
config_flags	0x0D
transmit_strat	0x0E
ble_beacon_cnt	0x0F
ble_beacon_timeout	0x10

Parameter	ID
gps_standby_timeout	0x11
confirmed_ul_bitmap	0x12
confirmed_ul_retry	0x13
motion_sensitivity	0x14
shock_detection	0x15
periodic_activity_period	0x16
motion_duration	0x17
Reserved, do not use	0x18
Reserved, do not use	0x19
ble_rssi_filter	0x1A
temperature_high	0x1B
temperature_low	0x1C
temperature_action	0x1D
transmit_strat_custom	0x1E
ble_bond	0xF8
mode	0xF9

The parameters identifiers and the values are given in the following tables

8.7.1 Parameters for operational modes

Parameter	ID	Unit	Range	Description
<i>mode</i>	0xF9		0-5	Operational mode of the tracker: 0- Standby 1- Motion tracking 2- Permanent tracking 3- Motion start/end tracking 4- Activity tracking 5- Off mode
<i>ul_period</i>	0x00	second	60 - 86400 (min 30 for US)	Period of position or activity messages in motion, start/end, activity or permanent operating mode
<i>lora_period</i>	0x01	second	300 - 86400	Period of LoRa heartbeat messages
<i>geoloc_sensor</i>	0x05	none	0 - 11	Geolocation sensor profile used in main operating mode and SOS mode: 0- WIFI only 1- GPS only 2- LPGPS (AGPS/GPS) 3- Reserved (do not use) 4- Reserved (do not use) 5- Reserved (do not use) 6- WIFI-GPS only (WIFI then GPS if WIFI fails in one geolocation cycle) 7- WIFI-LPGPS only (WIFI then LPGPS if WIFI fails in one geolocation cycle) 8- Reserved (do not use) 9- WIFI-LPGPS first, then WIFI-GPS until timeout, then back to WIFI-LPGPS 10- BLE scan only 11- BLE-GPS only (BLE then GPS if BLE fails in one geolocation cycle)
<i>motion_nb_pos</i>	0x08	none	1-60	Number of positions to report during motion events (motion start/end mode only).
<i>motion_duration</i>	0x17	second	60 - 3600	Period required to detect the end of a motion

Example:

To modify the heartbeat period to 1 hour, the command **0x0B020100000E10** should be sent.

Description:

- (0x0B): set the parameter
- (0x02): with an ack token of 2
- (0x01): heartbeat message period
- (0x 00 00 0E 10): to a value of 3600s = 1 hour

8.7.2 Parameters for side operation modes

Parameter	ID	Unit	Range	Description
<i>periodic_pos_period</i>	0x03	second	0, 900 - 604800	Period of the periodic position report. When set to 0, the reporting is disabled.
<i>geoloc_method</i>	0x06	none	0-6	Geolocation policy used for the side operating modes: 0- WIFI 1- GPS 2- LPGPS (AGPS/GPS) 3- WIFI-GPS only (WIFI then GPS if WIFI fails in one geolocation cycle) 4- WIFI-LPGPS only (WIFI then LPGPS if WIFI fails in one geolocation cycle) 5- BLE scan only 6- BLE-GPS only (BLE then GPS if BLE fails in one geolocation cycle)
<i>periodic_activity_period</i>	0x16	second	0,1800-86400	Period of the periodic activity report The value must be a multiple of 6 When set to 0, the reporting is disabled

Example:

To modify the periodic position period to 12 hours, the command **0x0B01030000A8C0** should be sent.

Description:

- (0x0B): set the parameter
- (0x01): with an ack token of 1
- (0x03): periodic position message period
- (0x 00 00 A8 C0): to a value of 43200s = 12 hours

8.7.3 Parameters for GPS and low power GPS geolocation modes

Parameter	ID	Unit	Range	Description
GPS				
<i>gps_timeout</i>	0x09	second	30-300	Timeout for GPS scans before sending a GPS timeout message.
<i>gps_ehpe</i>	0x0B	meter	0-100	Acceptable GPS horizontal error for GPS geolocation
<i>gps_convergence</i>	0x0C	second	0-300	Time let to the GPS module to refine the calculated position
<i>gps_standby_timeout</i>	0x11	second	0-28800	Duration of the GPS standby mode before going OFF. When 0, no standby timeout is applied
Low power GPS				
<i>agps_timeout</i>	0x0A	second	30-250	Timeout for LPGPS scans before sending the timeout message.

Example:

To modify the *gps_convergence* time to 5 minutes, the command **0x0B040C0000012C** should be sent.

Description:

- (0x0B): set the parameter
- (0x04): with an ack token of 4
- (0x0C): *gps_convergence* time
- (0x 00 00 01 2C): to a value of 300s = 5 minutes

8.7.4 LoRa parameters

Parameter	ID	Unit	Range	Description
<i>transmit_strat</i> ⁽¹⁾⁽⁴⁾	0x0E	none	0-4	Transmit strategy in motion: 0- Single fixed. Single TX. using a fixed data rate. 1- Single random: Single TX. using a random data rate within [DR0-DR5]. 2- Dual random: First TX using a random data rate within [DR4-DR5], next TX using a random data rate within [DR0-DR3]. 3- Dual fixed: First TX using a random data rate within [DR4-DR5]. Next Using a fixed data rate. (not recommended) 4- Network ADR. The LoRaWAN™ network controls the number of transmissions. 5- Activate the strategy defined with <i>transmit_strat_custom</i> parameter
<i>transmit_strat_custom</i> ⁽³⁾⁽⁴⁾	0x1E	none		bit 0: ADR activation in static (0: enabled) bit 1: Transmission type: <ul style="list-style-type: none"> • 0: single transmission • 1: double transmission bit 2-4: First transmission, data rate distribution: <ul style="list-style-type: none"> • 0: Random • 1: Bell Curve • 2: Ring bit 5-7: Second transmission, data rate distribution: <ul style="list-style-type: none"> • 0: Random • 1: Bell Curve • 2: Ring bit8-15: Bitmap representing each data rate to select for the first transmission (from DR0 to DR7) ⁽⁵⁾ . bit 8 is DR0, then Bit 9, DR1 and so on. bit 16-23: Bitmap representing each data rate to select for the second transmission (from DR0 to DR7) ⁽⁵⁾ . bit 16 is DR0, then Bit 17, DR1 and so on.
<i>confirmed_ul_bitmap</i> ⁽²⁾	0x12	none		Bitmap enabling the LoRaWAN™ confirmation of specific type of uplink message
<i>confirmed_ul_retry</i> ⁽²⁾	0x13	none	0-8	The number of retries for each confirmed uplink when the confirmation is not received

Notes

- (1) Refer to the section [LoRaWAN™ Strategy used](#) for more details
- (2) Refer to the section [Confirmed uplink](#) for more details
- (3) See the application note [LoRa Transmission strategy](#) for more data
- (4) For trackers configured in US region:
 - DR5 is not used and it is replaced by DR4.
 - If the selected datarate (DR) is not valid due to the payload length, the payload is sent using DR+1
- (5) If no data rate is selected, the default will be the minimum available for the current band.

Examples:

To modify the transmit strategy to 2, the command **0x0B050E00000002** should be sent.

Description:

- (0x0B): set the parameter
- (0x05): with an ack token of 5
- (0x0E): *transmit_strat* parameter
- (0x 00 00 00 01): to a value of 1 (single random)

To use custom strategy, and set the tracker in double transmission, even in static with DR1, 2 for the first transmission and DR3 and 4 for the second transmission, the commands **0x0B050E00000005** (enable custom strategy) and **0x0B061E00180602** (to set the custom strategy) should be sent

transmit_strat_custom parameter:

Bitmap for 2 nd transmission DR0 to 7								Bitmap for 1 st transmission DR0 to 7								DR distribution						Single / Double	ADR
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	2 nd transmit			1 st transmit				
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0

8.7.5 BLE parameters

Parameter	ID	Unit	Range	Description
<i>ble_beacon_cnt</i>	0x0F	none	1-4	This parameter provides the maximum number of BLE beacons to provide in payload
<i>ble_beacon_timeout</i>	0x10	second	1-5	BLE scan duration
<i>ble_rssi_filter</i>	0x1A	dBm	-100 - -40	RSSI value to filter BLE beacons with BLE-GPS geolocation mode. (negative value , refer to the section Two's complement Encoding for information for the encoding).
<i>ble_bond</i> ⁽²⁾	0xF8	none	0	Remove the bond on the tracker ⁽¹⁾

Notes:

(1) *ble_bond* parameter:

- Write: only the value 0 is supported (remove the bond)
- Read: provide the BLE bond status. See in section [Special parameter](#) for more details

(2) This parameter can't be added in the configuration file

Example:

To modify the *ble_beacon_cnt* parameter to three BLE beacons max reported, the command **0x0B060F00000003** should be sent.

Description:

- (0x0B): set the parameter
- (0x06): with an ack token of 6
- (0x0F): *ble_beacon_cnt* parameter
- (0x 00 00 00 03): to a value of 03 (max numbers of BLE beacon reported in payload)

8.7.6 Miscellaneous parameters

Parameter	ID	Unit	Range	Description
<i>pw_stat_period</i>	0x02	second	0, 300 - 604800	Period of the Energy status report. When 0, no energy status report is transmitted. Not used for micro trackers, should be set to 0
<i>config_flags</i>	0x0D	none	0-0xffff	Configuration flags: bit 0: Frame pending mechanism ⁽¹⁾ bit 1: Activate long button press to switch to off mode bit 2: Double short press configuration: Alert (0) vs SOS (1) bit 3: Send a configuration uplink message in response to a configuration modification downlink. Used to confirm the action. bit 4: WIFI payload with Cypher (0) or without Cypher (1) ⁽²⁾ bit 5: Activate BLE communication interface ⁽⁷⁾ bit 6: First WIFI scan when geolocation starts. If disabled (0), WIFI position is replaced by a geoloc start message ⁽³⁾ bit 7: Led blinks when a GPS fix is received. Set to enable the feature, reset to disable bit 8: Set to enable the sending of a motion start message ⁽³⁾ bit 9: Set to enable the sending of a motion end message ⁽³⁾ bit 10: Set to enable a new OTA join when leaving the mode OFF ⁽⁴⁾ bit 11: Asymmetric BLE pairing: 0 accepted, 1 rejected ⁽⁵⁾⁽⁶⁾ bit 12: Set to enable Long WIFI payload ⁽⁸⁾

Example:

To modify the *config_flags* parameter to 0x1F, the command **0x0B030D0000001F** should be sent.

Description:

- (0x0B): set the parameter
- (0x03): with an ack token of 3
- (0x0D): *config_flags* parameter
- (0x 00 00 00 1F): to a value of 0x1F:

Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	0	0	0	0	0	1	1	1	1	1

Notes

- 1) Refer to section [Frame pending messages](#) for more details
- 2) In old MCU applicative firmware version WIFI position payload were all encrypted, this parameter is for backward compatibility only and only non-cyphered payload should be use in new application
- 3) Refer to section [Event message](#) to have details about **geoloc_start**, **motion_start** and **motion_end** payload
- 4) Force a new join to the LoRaWAN™ network when the tracker is turned on after it was in OFF mode due to a downlink or a user action
- 5) Refer to section [Asymmetric BLE pairing](#) for more details, it is only useful when the tracker is used BLE bonded with a mobile or a tablet
- 6) When this bit is modified, the buzzer plays a melody according to the BLE bonding state:
 - Tracker bonded: *BLE bond success* melody.
 - Tracker not bonded: *BLE bond on going* melody.
- 7) The tracker needs to be turned off and on to activate the BLE module
- 8) See the application note [LoRa Transmission strategy](#) to know how to set DR working with long payloads

8.7.7 Accelerometer parameters

The *motion_sensitivity* parameter is used to set the minimum acceleration to be measured to validate a motion of the tracker.

The *shock_detection* parameter is used to set the shock level to trigger a shock detection message

Parameter	ID	Unit	Range	Description
<i>motion_sensitivity</i>	0x14	%	0-100	Accelerometer configuration. 0 is default configuration. 1-100 configures the accelerometer sensitivity from 1 to 100%.
<i>shock_detection</i>	0x15	%	0-100	This parameter provides the configuration of the sensitivity of the shock detection from 1 to 100%. A value of 0 disables the shock detection. Note: When enabled, the <i>motion_sensitivity</i> parameter must be set to a nonzero value and <i>shock_detection</i> should be strictly less than <i>motion_sensitivity</i>

8.7.8 Temperature monitoring parameters

These parameters are used to configure temperature monitoring

Parameter	ID	Unit	Range	Description
<i>temperature_high</i>	0x1B	°C	-44 – 85, 255	Configure the high threshold temperature 255 = disabled
<i>temperature_low</i>	0x1C	°C	-44 – 85, 255	Configure the low threshold temperature 255 = disabled
<i>temperature_action</i>	0x1D	none	0 - 3	Configure the action to be done when entering critical state: 0: No action 1: Geolocation disabled if <i>temperature_high</i> is reached 2: Geolocation disabled if <i>temperature_low</i> is reached 3: Geolocation disabled if <i>temperature_low</i> or <i>temperature_high</i> is reached

Notes

- 1- If parameter *temperature_high* or *temperature_low* is modified during the life of the tracker, you may need to reset the tracker to clear the temperature monitoring counters.
- 2- Critical state is entered if an over or under temperature is detected.

8.8 Debug command

Debug downlink commands allow to trigger specific behavior.

Byte 0	Byte 1	Byte 2	Byte 3
0xFF	ACK	Debug CMD ID	Action (optional)

ACK: Acknowledge token. Refer to the section [Acknowledge token](#). **Max value is 0x0F.**

Debug CMD ID:

- 0x01 Reset the device
- 0x05 Trigger a heartbeat message

Action: this byte can be used when **Debug CMD ID=0x01**

- 0x00 Reset the device
- 0x01 Reset the Device +go back to initial configuration of the tracker
- 0x02 Reset the Device +go back to initial configuration of the tracker + delete the bond on the tracker

Note

The initial configuration is the one used the last time the MCU applicative firmware was flashed

8.9 Two's complement Encoding

Some parameters as well as some values inside uplinks are coded in two's complement.

This encoding provides positives and negatives values depending on the setting of the MSB (Most Significant Bit):

- MSB=0, the number is positive and doesn't need any transformation
- MSB=1, the number is negative. To have the actual value, each bit of the hexadecimal number should be toggled (transforming the 0 bit to 1 and the 1 bit to 0) then add 1 to the result.

Examples:

In the following, the notation prefix 0x is used for hexadecimal representations and 0b for binary.

Example 1. Hexadecimal value on 4 bits:

0xA (0b1010) gives $0b0101 + 1 = 0b0110 = -6$
 0x3 (0b0011) = 3

Example 2. Hexadecimal value on 8 bits:

0xF5 (0b11110101) gives $0b00001010 + 1 = 0b00001011 = -11$
 0x6B (0b01101011) gives 107

Example 3. Hexadecimal value on 16 bits:

0x0xfdF5 (0b1111110111110101) gives $0b0000001000001010 + 1 = 0b0000001000001011 = -523$
 0x506B (0b01101011) gives 20587

9 DEFAULT DELIVERED MICRO TRACKER CONFIGURATION

- mode = 1 (motion tracking)
- lora_period = 600 seconds (10 minutes)
- ul_period = 300 seconds
- pw_stat_period = 0 (disabled)
- periodic_pos_period = 86400 seconds
- geoloc_sensor = 6 (WIFI/GPS)
- geoloc_method = 3(WIFI/GPS)
- motion_nb_pos = 1
- gps_timeout = 300 seconds
- agps_timeout = 250 seconds
- config_flags = 159 (0x9F)
 - Frame pending mechanism: Activated
 - Long button press to switch to off mode: Enabled
 - Double short press configuration: SOS activated
 - Send a configuration confirmation uplink message: Activated
 - WIFI payload without Cypher: Enabled
 - BLE advertising: Disabled
 - First WIFI scan when geolocation starts. Disabled, (Send a geoloc start message instead)
 - Led blinks when a GPS fix is received. Activated
 - Motion start message: Disabled
 - Motion end message: Disabled
 - OTA join when leaving the mode OFF: Disabled
 - Asymmetric BLE pairing: Activated (0)
 - **Long WIFI payload**: Disabled (0)
- gps_ehpe = 5 meters
- gps_convergence = 150 seconds
- gps_standby_timeout=7800 seconds
- motion_duration= 120 seconds
- **transmit_strat= 3** (Dual fixed)in EU region, 4(Network ADR) in other regions
- periodic_activity_period= 0 (disabled)
- ble_beacon_cnt=0x04
- ble_beacon_timeout=3 seconds
- confirmed_uplink_bitmap= 0 (none)
- confirmed_uplink_retry= 3
- motion_sensitivity= 0
- shock_detection= 0 (disabled)
- ble_rssi_filter= -100 dBm
- **temperature_high=255** (deactivated)
- **temperature_low=255** (deactivated)
- **temperature_action=0** (none)

Notes

- 1- Parameters new in V1.9-0 have their names bolded.
- 2- Parameter default values modified in V1.9-0 have their values bolded and italic.

10 CONFIGURATION FOR B2C APPLICATION

- mode = 1 (motion tracking)
- ul_period = 60 seconds
- lora_period=600seconds (10 minutes)
- pw_stat_period = 0 (disabled)
- periodic_pos_period = 0 (disabled)
- geoloc_sensor = 6 (WIFIGPS)
- geoloc_method = 4(WIFI/LPGPS)
- motion_nb_pos = 1
- gps_timeout = 300 seconds
- agps_timeout = 40 seconds
- config_flags = 443
 - Frame pending mechanism: Activated
 - Long button press to switch to off mode: Activated
 - Double short press configuration: Alert activated
 - Send a configuration confirmation uplink message: Activated
 - WIFI payload without Cypher: Activated
 - BLE advertising: Activated
 - First WIFI scan when geolocation starts. Disabled, (Send a geoloc start message instead)
 - Led blinks when a GPS fix is received. Activated
 - Motion start message: Activated
 - Motion end message: Disabled
 - OTA join when leaving the mode OFF: Disabled
 - Asymmetric BLE pairing: Activated (0)
 - **Long WIFI payload**: Disabled (0)
- gps_ehpe = 5 meters
- gps_convergence = 100 seconds
- gps_standby_timeout=7800 seconds
- motion_duration= 120 seconds
- transmit_strat=2 (Dual random) if tracker in EU region, 4(Network ADR) in other regions
- periodic_activity_period= 0 (disabled)
- ble_beacon_cnt= 0x04
- ble_beacon_timeout= 3 seconds
- confirmed_uplink_bitmap= 0 (none)
- confirmed_uplink_retry= 3
- motion_sensitivity= 0
- shock_detection= 0 (disabled)
- ble_rssi_filter= -100 dBm
- **temperature_high**=255 (deactivated)
- **temperature_low**=255 (deactivated)
- **temperature_action**=0 (none)

11 CONFIGURATION EXAMPLES

This chapter provides some configuration profiles examples depending on particular use cases. The parameters can be modified depending on the expected position accuracy, the environment type (indoor, outdoor) and the expected battery life.

Notes

- 1- Default parameter value are provided in the section [Default Micro tracker configuration file](#)
- 2- Configuration parameters in bold are the relevant one for his profile

11.1 Profile 1: Accurate on demand positioning

Use case: Long battery lifetime, few accurate positions.

The proposed configuration uses:

- **Standby** operating mode
- **On demand** positions (via downlink)
- **Accurate on demand positioning**
 - Outdoor: GPS only
 - Indoor/Outdoor: WGPS
 - Indoor BLE positioning: BLE only

Proposed configuration

	Outdoor (GPS)	Indoor/Outdoor (Multi technology)	Indoor (BLE)
Operating mode	Standby	Standby	Standby
lora_period	600 seconds	600 seconds	600 seconds
ul_period	120 seconds	120 seconds	120 seconds
geoloc_sensor	1 (GPS)	6 (WGPS)	10 (BLE)
geoloc_method	1 (GPS)	3 (WGPS)	5 (BLE)
period_pos_period	0 (disabled)	0 (disabled)	0 (disabled)
pw_stat_period	0 (disabled)	0 (disabled)	0 (disabled)
gps_timeout	300 seconds	300 seconds	300 seconds
agps_timeout	55 seconds	55 seconds	55 seconds
motion_nb_pos	3	3	3
motion_duration	120 seconds	120 seconds	120 seconds
gps_ehpe	5 meters	5 meters	5 meters
gps_convergence	180 seconds	180 seconds	180 seconds
config_flags	0x1F	0x1F	0x1F
transmit_strat	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions
periodic_activity_period	0 (disabled)	0 (disabled)	0 (disabled)
ble_beacon_cnt	0x04	0x04	0x04
ble_beacon_timeout	3 seconds	3 seconds	3 seconds
gps_standby_timeout	20 minutes (2*lora_period)	20 minutes (2*lora_period)	20 minutes (2*lora_period)
confirmed_uplink_bitmap	0x00	0x00	0x00
confirmed_uplink_retry	3	3	3
motion_sensitivity	0 (default)	0 (default)	0 (default)
shock_detection	0x00	0x00	0x00
ble_rssi_filter	-100	-100	-100

Side operating modes

The following functions can be added to this profile:

- Shock detection: configure the *shock_detection* parameter
- Motion information: enable **motion_start** and **motion_end** events, via the *config_flags* parameter
- Periodic position reporting: configure the *period_pos_period* parameter

11.2 Profile 2: Accurate Daily periodic position

Use case: few periodic accurate positions.

The proposed configuration uses:

- **Standby** operating mode
- **Accurate daily positioning**
 - Outdoor: GPS only
 - Indoor/Outdoor: WGPS
 - Indoor BLE positioning: BLE only

Proposed configuration

	Outdoor (GPS)	Indoor/Outdoor (Multi technology)	Indoor (BLE)
Operating mode	Standby	Standby	Standby
<i>lora_period</i>	600 seconds (10 minutes)	600 seconds (10 minutes)	600 seconds (10 minutes)
<i>ul_period</i>	120 seconds	120 seconds	120 seconds
<i>geoloc_sensor</i>	1 (GPS)	6 (WGPS)	10 (BLE)
<i>geoloc_method</i>	1 (GPS)	3 (WGPS)	5 (BLE)
<i>period_pos_period</i>	86400 seconds	86400 seconds	86400 seconds
<i>pw_stat_period</i>	0 (disabled)	0 (disabled)	0 (disabled)
<i>gps_timeout</i>	300 seconds	300 seconds	300 seconds
<i>agps_timeout</i>	55 seconds	55 seconds	55 seconds
<i>motion_nb_pos</i>	3	3	3
<i>motion_duration</i>	120 seconds	120 seconds	120 seconds
<i>gps_ehpe</i>	5 meters	5 meters	5 meters
<i>gps_convergence</i>	180 seconds	180 seconds	180 seconds
<i>config_flags</i>	0x1F	0x1F	0x1F
<i>transmit_strat</i>	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions
<i>periodic_activity_period</i>	0 (disabled)	0 (disabled)	0 (disabled)
<i>ble_beacon_cnt</i>	0x04	0x04	0x04
<i>ble_beacon_timeout</i>	3 seconds	3 seconds	3 seconds
<i>gps_standby_timeout</i>	0 seconds	0 seconds	0 seconds
<i>confirmed_uplink_bitmap</i>	0x00	0x00	0x00
<i>confirmed_uplink_retry</i>	3	3	3
<i>motion_sensitivity</i>	0(default)	0(default)	0(default)
<i>shock_detection</i>	0x00	0x00	0x00
<i>ble_rssi_filter</i>	-100	-100	-100

Side operating modes

The following functions can be added to this profile:

- Shock detection: configure the *shock_detection* parameter
- Motion information: enable **motion_start** and **motion_end** events, via the *config_flags* parameter
- **Position on demand** (via downlink)

11.3 Profile 3: Hourly periodic position with medium accuracy

Use case: periodic medium accurate positions.

The proposed configuration uses:

- **Standby** operating mode
- **Accurate daily positioning**
 - Outdoor: GPS only
 - Indoor/Outdoor: WGPS
 - Indoor WIFI positioning: WIFI only

Proposed configuration

	Outdoor (GPS)	Indoor/Outdoor (Multi technology)	Indoor (WIFI)
Operating mode	Standby	Standby	Standby
lora_period	600 seconds	600 seconds	600 seconds
ul_period	120 seconds	120 seconds	120 seconds
geoloc_sensor	1 (GPS)	6 (WGPS)	0 (WIFI)
geoloc_method	1 (GPS)	3 (WGPS)	0 (WIFI)
period_pos_period	3600 seconds (1 per hour)	3600 seconds (1 per hour)	3600 seconds (1 per hour)
pw_stat_period	0 (disabled)	0 (disabled)	0 (disabled)
gps_timeout	300 seconds	300 seconds	300 seconds
agps_timeout	55 seconds	55 seconds	55 seconds
motion_nb_pos	3	3	3
motion_duration	120 seconds	120 seconds	120 seconds
gps_ehpe	10 meters	10 meters	10 meters
gps_convergence	90 seconds	90 seconds	90 seconds
config_flags	0x1F	0x1F	0x1F
transmit_strat	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions
periodic_activity_period	0 (disabled)	0 (disabled)	0 (disabled)
ble_beacon_cnt	0x04	0x04	0x04
ble_beacon_timeout	3 seconds	3 seconds	3 seconds
gps_standby_timeout	3605 seconds	3605 seconds	3605 seconds
confirmed_uplink_bitmap	0x00	0x00	0x00
confirmed_uplink_retry	3	3	3
motion_sensitivity	0 (default)	0 (default)	0 (default)
shock_detection	0x00	0x00	0x00
ble_rssi_filter	-100	-100	-100

Side operating modes

The following functions can be added to this profile:

- Shock detection: configure the *shock_detection* parameter
- Motion information: enable **motion_start** and **motion_end** events, via the *config_flags* parameter
- **Position on demand** (via downlink)

11.4 Profile 4: Accurate positions at start and end moving (including start/end events message)

Use case: Accurate positions sent at the beginning and the end of a motion.

The proposed configuration uses:

- **Start/end tracking** operating mode
- **Geolocation strategy**
 - Outdoor: GPS only
 - Indoor/Outdoor: WGPS
 - Indoor BLE positioning: BLE only

Proposed configuration

	Outdoor (GPS)	Indoor/Outdoor (Multi technology)	Indoor (BLE)
Operating mode	Start/end tracking	Start/end tracking	Start/end tracking
lora_period	600 seconds (10 minutes)	600 seconds (10 minutes)	600 seconds (10 minutes)
ul_period	90 seconds	90 seconds	90 seconds
geoloc_sensor	1 (GPS)	6 (WGPS)	10 (BLE)
geoloc_method	1 (GPS)	3 (WGPS)	5 (BLE)
period_pos_period	0 (disabled)	0 (disabled)	0 (disabled)
pw_stat_period	0 (disabled)	0 (disabled)	0 (disabled)
gps_timeout	180 seconds	180 seconds	180 seconds
agps_timeout	55 seconds	55 seconds	55 seconds
motion_nb_pos	3	3	3
motion_duration	120 seconds	120 seconds	120 seconds
gps_ehpe	5 meters	5 meters	5 meters
gps_convergence	90 seconds	90 seconds	90 seconds
config_flags	0xB1F	0xB1F	0xB1F
transmit_strat	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions
periodic_activity_period	0 (disabled)	0 (disabled)	0 (disabled)
ble_beacon_cnt	0x04	0x04	0x04
ble_beacon_timeout	3 seconds	3 seconds	3 seconds
gps_standby_timeout	7200 seconds	7200 seconds	7200 seconds
confirmed_uplink_bitmap	0x00	0x00	0x00
confirmed_uplink_retry	3	3	3
motion_sensitivity	0 (default)	0 (default)	0 (default)
shock_detection	0x00	0x00	0x00
ble_rssi_filter	-100	-100	-100

Side operating modes

The following functions can be added to this profile:

- Shock detection: configure the *shock_detection* parameter
- **Position on demand** (via downlink)
- Periodic position reporting: configure the *period_pos_period* parameter

11.5 Profile 5: Motion tracking

Use case: Accurate positions sent every 120s during a motion.

The proposed configuration uses:

- **Motion tracking** operating mode
- **Geolocation strategy**
 - Outdoor: GPS only
 - Indoor/Outdoor: WGPS
 - Indoor BLE positioning: BLE only

Proposed configuration

	Outdoor (GPS)	Indoor/Outdoor (Multi technology)	Indoor (BLE)
Operating mode	Motion tracking	Motion tracking	Motion tracking
lora_period	600 seconds (10 minutes)	600 seconds (10 minutes)	600 seconds (10 minutes)
ul_period	120 seconds	120 seconds	120 seconds
geoloc_sensor	1 (GPS)	6 (WGPS)	10 (BLE)
geoloc_method	1 (GPS)	3 (WGPS)	5 (BLE)
period_pos_period	0 (disabled)	0 (disabled)	0 (disabled)
pw_stat_period	0 (disabled)	0 (disabled)	0 (disabled)
gps_timeout	180 seconds	180 seconds	180 seconds
agps_timeout	55 seconds	55 seconds	55 seconds
motion_nb_pos	3	3	3
motion_duration	120 seconds	120 seconds	120 seconds
gps_ehpe	10 meters	10 meters	10 meters
gps_convergence	120 seconds	120 seconds	120 seconds
config_flags	0x1F	0x1F	0x1F
transmit_strat	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions
periodic_activity_period	0 (disabled)	0 (disabled)	0 (disabled)
ble_beacon_cnt	0x04	0x04	0x04
ble_beacon_timeout	3 seconds	3 seconds	3 seconds
gps_standby_timeout	7200 seconds	7200 seconds	7200 seconds
confirmed_uplink_bitmap	0x00	0x00	0x00
confirmed_uplink_retry	3	3	3
motion_sensitivity	0 (default)	0 (default)	0 (default)
shock_detection	0x00	0x00	0x00
ble_rssi_filter	-100	-100	-100

Side operating modes

The following functions can be added to this profile:

- Shock detection: configure the *shock_detection* parameter
- Motion information: enable **motion_start** and **motion_end** events, via the *config_flags* parameter
- **Position on demand** (via downlink)
- Periodic position reporting: configure the *period_pos_period* parameter

11.6 Profile 6: Permanent tracking

Use case: Accurate positions sent every minute.

WARNING: this mode is very consuming for the battery and should be used only for a short period

The proposed configuration uses:

- **Permanent tracking** operating mode
- **Geolocation strategy**
 - Outdoor: GPS only
 - Indoor/Outdoor: WGPS
 - Indoor BLE positioning: BLE only

Proposed configuration

	Outdoor (GPS)	Indoor/Outdoor (Multi technology)	Indoor (BLE)
Operating mode	Permanent tracking	Permanent tracking	Permanent tracking
lora_period	600 seconds	600 seconds	600 seconds
ul_period	60 seconds	60 seconds	60 seconds
geoloc_sensor	1 (GPS)	6 (WGPS)	10 (BLE)
geoloc_method	1 (GPS)	3 (WGPS)	5 (BLE)
period_pos_period	0 (disabled)	0 (disabled)	0 (disabled)
pw_stat_period	0 (disabled)	0 (disabled)	0 (disabled)
gps_timeout	180 seconds	180 seconds	180 seconds
agps_timeout	55 seconds	55 seconds	55 seconds
motion_nb_pos	3	3	3
motion_duration	120 seconds	120 seconds	120 seconds
gps_ehpe	10 meters	10 meters	10 meters
gps_convergence	30 seconds	30 seconds	30 seconds
config_flags	0x1F	0x1F	0x1F
transmit_strat	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions	2 (Dual random) EU 4 (ADR) other regions
periodic_activity_period	0 (disabled)	0 (disabled)	0 (disabled)
ble_beacon_cnt	0x04	0x04	0x04
ble_beacon_timeout	3 seconds	3 seconds	3 seconds
gps_standby_timeout	7200 seconds	7200 seconds	7200 seconds
confirmed_uplink_bitmap	0x00	0x00	0x00
confirmed_uplink_retry	3	3	3
motion_sensitivity	0 (default)	0 (default)	0 (default)
shock_detection	0x00	0x00	0x00
ble_rssi_filter	-100	-100	-100

Side operating modes

The following functions can be added to this profile:

- Shock detection: configure the *shock_detection* parameter
- Motion information: enable **motion_start** and **motion_end** events, via the *config_flags* parameter

12 TRACKER RESET

The tracker can be reset by entering the following button sequence:

- 4 short clicks,
- 1 long press
- 2 short clicks
- 1 long press and maintain the button pressed until the end of the boot-mode melody

13 APPLICATION NOTES REFERENCES

	Name	Version	Description
1	ble application_note	V1.0	It should be used to develop an application using BLE communication
2	battery-percentage	V1.0	It provides the methodology to determine the remaining charge of the battery (expressed in percentage). Both battery types, primaries and rechargeable battery (Lithium) are addressed in this document.
3	LoRa_Transmission_strategy	V1.1	It is provided to: <ul style="list-style-type: none"> • Remind the basics of the LoRa network • Remind the tracker configuration parameters. • Provide the network capability of each supported region • Suggest the best setting for each region based on the application needs.

14 GLOSSARY

Acronyms	Description
BLE	Bluetooth Low Energy
DR	Data Rate
GPS	Global Positioning System
TBD	To Be Defined
ADR	Adaptive Data Rate
MCU	MicroController Unit