Sense Asset+

User Guide

Revision History

Date	Version	Notes	Author
12-07-2023	01	New Document	KM

INTRODUCTION

The Sense Asset+ is a ruggedized, multi-technology, battery operated IoT device that supports both indoor and outdoor tracking with a multi-year battery life for superior ROI and performance, batteries are user replaceable. As well as harnessing the power of LoRa and Bluetooth Low Energy (BLE) these intelligent devices include GNSS and an accelerometer to provide tracking and position accuracy over long distances. Sense Asset+ is equipped with bright LED lights and a buzzer to aid locating the device via BLE connection. Sense Asset+ is equipped with NFC to configure the device as per application requirements.

LoRa is an IoT focussed communications technology that enables communication with physical gateways which then communicate via a cellular or IP network to a cloud or locally hosted network server and then to a subsequent application server. LoRa is a secure communication standard that delivers secure 128-bit AES end to end encryption.

Bluetooth Low Energy (BLE) - the power efficient version of Bluetooth is compatible with a huge range of devices and infrastructure and available with iOS, Android or generic protocols. Command can be transmitted over BLE to device to activate LEDs and Buzzer to aid tracking.

The Sense Asset+ is a perfect choice when high volumes of devices with low communication needs are required. It is very power efficient to ensure a long life from the replaceable batteries and very robust for outdoor use.

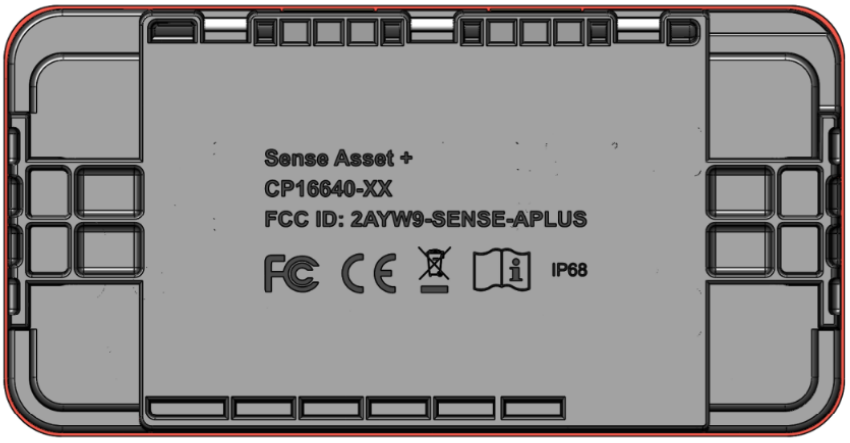
FCC Statement

FCC ID: 2AYW9-SENSE-APLUS
This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

WARNING Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC product marking:



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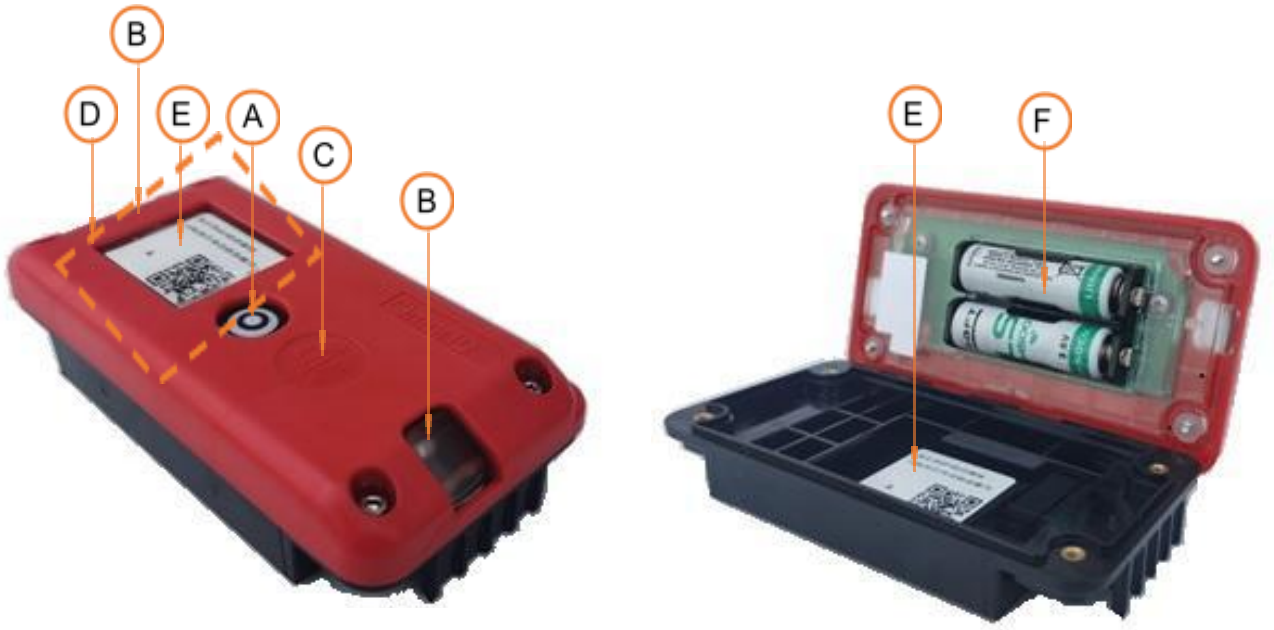
1. Device Features

Sense Asset+ is equipped with the following features:



Item	Description	Function
A	Push Button	Write NFC settings Deactivates LED/Buzzer alert mode Triggers sending of Motion Beacon to server
B	LED Light (x2)	Alarm/Alert Power up
C	Buzzer	Alarm/Alert
D	NFC Antenna	Used for device configuration
E	Label (x2)	BLE & LoRa MAC address QR code
F	Batteries	Replaceable batteries (2 x 3.6v 14500 batteries)
G	LED Light	RGBW debug

2. Device Operation

On device power up following battery installation the device will do the following:

1. POST (Power on Self-Test on Boot)
2. LoRa Join
3. Heartbeat beacon
4. GNSS activity
5. Position beacon
6. Heartbeat beacon (if Device is stationary)

2.1. POST (Power on Self-Test)

During the POST (Power on self-test) a boot sequence is performed to aid the user in identifying that hardware features are functional.

Result of POST is announced through audible tones and RGB LED (in case of any hardware failure).

Hardware is tested during POST:

- 2xSide LEDs
- Buzzer
- NFC
- Accelerometer
- LoRa communication
- GNSS Activity

At the end of the test if the last tone is ascending then it indicates a positive test result, if it is descending then it indicates hardware failure. If hardware failure is detected the RGB LED which is positioned next to the piezo under the case upper starts flashing RED.

2.2. Device Function

Sense Asset+ is designed for tracking and monitoring applications over LoRa and BLE and has the following built-in sensors:

- Accelerometer
- GNSS

Sense Asset+ utilizes its accelerometer and announces unconfirmed LoRa beacon when state changes to moving using the Motion Engine. Once the device is stationary, the device activates the Position Engine to determine its updated position and transmits this over LoRa

The Position Engine will initially initiate a BLE scan to identify nearby Reference tags, if no reference tags are identified within the RSSI Threshold the GNSS algorithm is turned on to obtain the position. BLE scan is configurable and can be disabled if Reference tags are not used.

The device transmits a BLE advertisement at a configurable period of 2.5, 5 or 10sec. This advertisement Is used to enable activation of the Alert feature over BLE it can also be used as a means to determine the zonal position of the device if BLE gateways are deployed within the vicinity of the device.

Note: This device will not provide position while moving, if this is required, please contact Omni-ID to discuss this requirement.

The device achieves long battery life by limiting the position update activity to provide updates only after the asset have ceased movement for configurable period. If an asset has not moved, then Heartbeat beacon is announced at configurable heartbeat rate.

The reported position allows the operator to get close to the device (5-10m) and the Alert Mode can be activated over BLE or LoRa which lights the two ultra bright LEDs and sounds the Buzzer to aid the operator to locate and identify the correct asset.

2.3. Operation Flow Chart

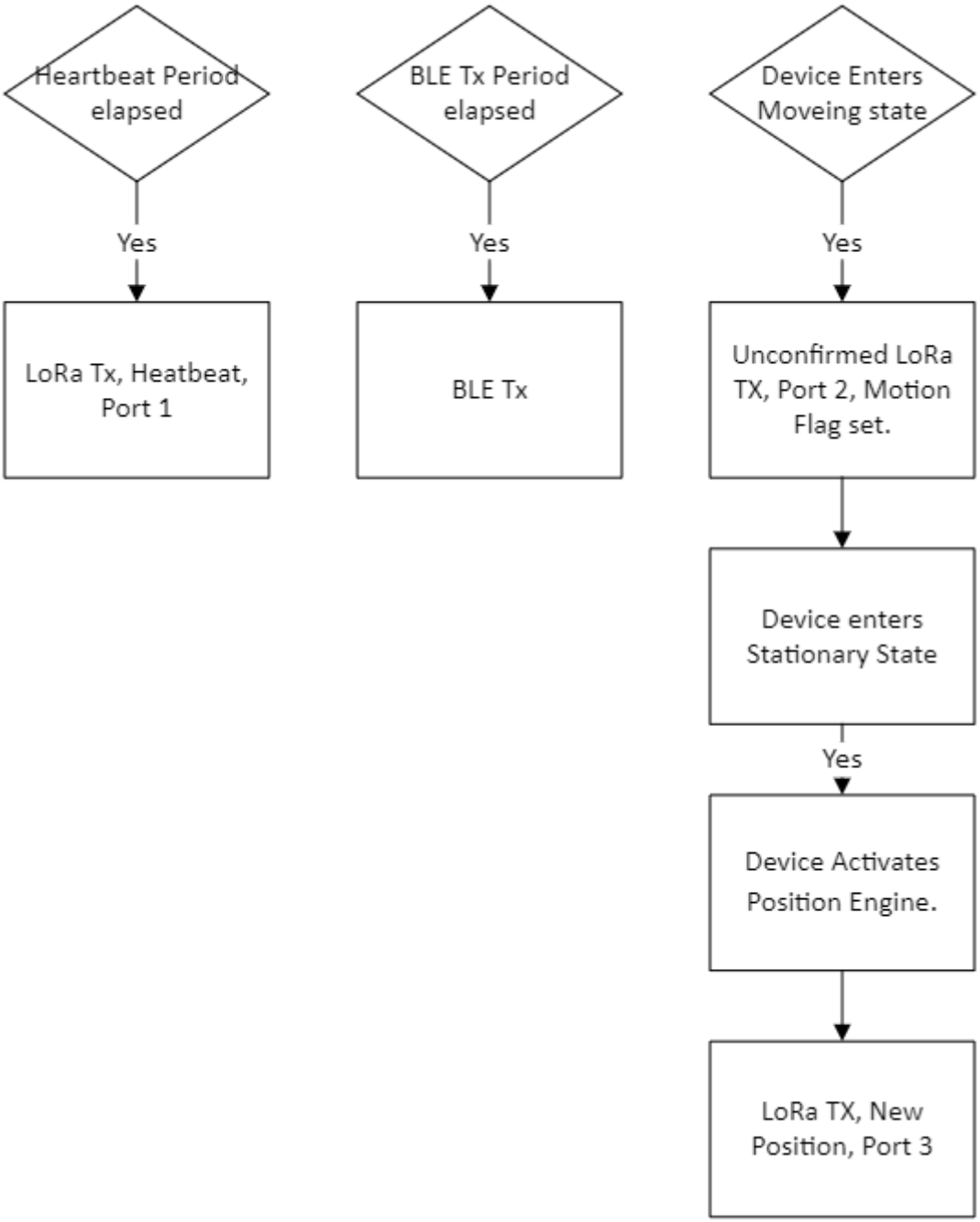
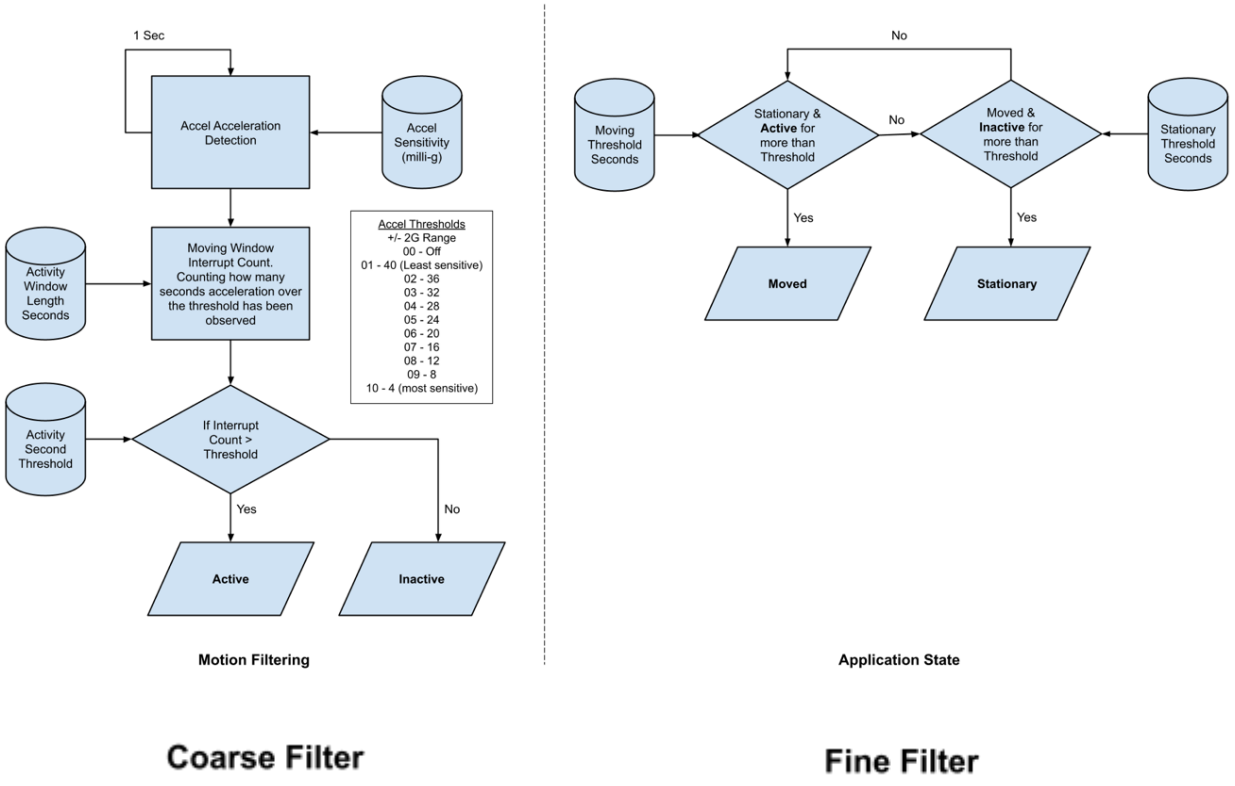


Figure 1: Device Top level operation once joined to LNS

3. Motion Engine



Asset + benefit from a two-stage filter mechanism to determine if the device is moving or stationary, the purpose of this two-stage filter is to be able to filter out both short spurious unintended accelerometer interrupts and filter out slightly longer period of stop or start such as when an asset stop moving for short period of time due to obstruction on route to eliminate excessive GNSS and LoRa activity.

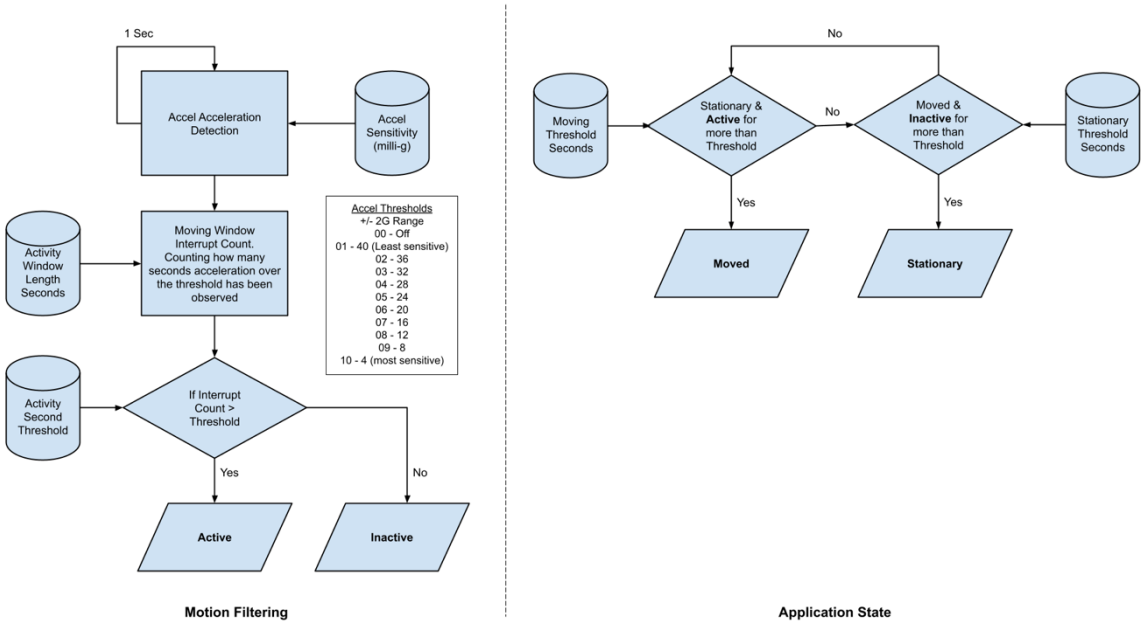


Figure 2. Motion Engine.

The first stage filter is a **Coarse filter** to filter out the odd unintended accelerometer interrupts such as when a heavy item is dropped adjacent to the device. This can be seen as a short time based filter on detected acceleration. The second stage filter is the **Fine Filter** to remove short periods of stop to avoid unnecessary GPS triggers and filter out short periods of motion start.

3.1. Coarse Filer

The Coarse filter takes accelerometer interrupts as an input and as an output will set the device state into either **Active** or **Inactive**, which are the two inputs for the further Fine filter.

The Coarse Filter uses the following NFC configurable variable:

- Motion Threshold
- Activity Window (Seconds)
- Activity Threshold (Seconds)

The accelerometer generates an interrupt when it senses movement, this interrupt is the trigger for activity and occurs when the detected acceleration events are over the **Motion Threshold** (NFC programable Accelerometer threshold 0-10, where 0 is off and 10 is most sensitive). The accelerometer is configured to generate a maximum of 1 interrupt per second.

For the device to be set into **Active** state, the device needs to detect more interrupts than the Activity threshold during the configurable Activity Window.

Active state True when number of interrupts > **Activity Threshold** during **Activity Window**.

The **Activity window** specifies the length of a ring buffer that captures a history of events over its period. With a maximum of 1 event per second.

For example a 20 second **Activity window**, with an **Activity Threshold** of 2, requires a minimum of 3 interrupts within a 20 second window for the device to be set to Active state.

*Example 1: after 3 seconds: 20 sec Activity window, Activity threshold 2, device has just detected 3 consecutive interrupts and the device is now set to **Active***

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	**1**	**1**	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coarse State:	**Active**																			

*Example 1: after 21 seconds: 20 sec Activity window, Activity threshold 2, device has detected 3 consecutive interrupts, however at 21 seconds the first interrupt is no longer in the window and as no further interrupts have been detected the device is now set to **Inactive***

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
Coarse State:	**Inactive**																			

*Example 2: 20 sec Activity window, Activity threshold 2, the device has detected interrupts at second 1, 15 and 16 the device will then be **Active** state after 16 seconds. Then **Inactive** four seconds later if no further events are detected, as the first event at second 1 is now outside of the moving window*

After 16 sec:

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**	0	0	0	0
Coarse State:	**Active**																			

After 20 sec:

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	0	0	0	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Coarse State:	**Inactive**																			

If there are more triggers than the **Activity Threshold** within the **Activity window** period the device is deemed to be In **Active stave**, if less than it is in **Inactive state.**

Activity / **Inactivity** can be thought of as a short time-based filter on detected acceleration.

3.2. Fine Filter

The Fine Filter uses the filtered Active or Inactive state of the Coarse filter as an input to then determine if the device is either **Moved** or **Stationary**.

The Fine Filter uses the following NFC configurable variable:

- Stationary -> Moved Threshold (Seconds)
- Moved -> Stationary Threshold (Minutes)

In the **Stationary** state the counter is increased while the Coarse filter output is **Active**. The device is required to be in **Active** state for longer than the NFC configurable **Stationary to Moving** time for the device to transition to **Moved** state. The counter is reset on change of state.

In the **Moved** state the counter is increased with Coarse filter output of **Inactive** and reset with **Active** state. Once the counter has detected **inactive state** is above the NFC configurable **Moved to stationary** time the device transition to **Stationary State** and the counter cleared.

Example 3: after 3 seconds: 20 sec Activity window, Activity threshold 2, Stationary to Moved threshold 5 Sec, device has just detected 3 consecutive interrupts and the device is now set to ***Active***

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	**1**	**1**	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coarse State:	**Active**																			
Fine Filter counter	**1 sec (Just started)**																			
Fine state:	**Stationary**																			

Example 3: after 5 seconds: No further triggers detected; device moves to ***Moved state:*** *if no further interrupts are detected the device will remain in moved state for 14 seconds*

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	0	0	0	0	**1**	**1**	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0
Coarse State:	**Active**																			
Fine Filter counter	**5 sec**																			
Fine state:	**Moved**																			

Example 3: after 21 seconds: 20 sec Activity window, Activity threshold 2, device has detected 3 consecutive interrupts, however at 21 seconds the first interrupt is no longer in the window and as no further interrupts have been detected the device is now set to ***Inactive***

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
Coarse State:	**Inactive**																			
Fine Filter counter	**0 sec (rest as Coarse state now Inactive)**																			
Fine state:	**Between States**																			

Example 4: 20 sec Activity window, Activity threshold 2, Stationary to Moved threshold 5 Sec, moved to stationary threshold 1800sec (30min) device has detected 2 or less interrupts within each window for a total of 1800secounds. The device is has been ***inactive*** *for 1800 sec and is transitioning to* ***Stationary*** *state*

Sec:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Interrupts:	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0
Coarse State:	**Inactive**																			
Fine Filter counter	**1800 sec (30 min)**																			
Fine state:	**Stationary**																			

Note that in the above example if 3 interrupts had been detected within a window at any point, the stationary counter up to 1800sec would have been reset to 0 as the device would have transitioned to **active** state at that point.

Variable	Description	Range	Default	Units
Motion Threshold	Sets the accelerometer interrupt threshold (see table x for detail)	0 to 10	10	
Activity Window	Circular window in which accel interrupts are counted	TBD 0 to 255	20	Sec
Activity Threshold	Threshold for the number of events that have to be exceeded in the window to trigger the **Active** / **Inactive** state. Eg if 2, then 3 events are required	TBD 0 to 255	4	Sec
Stationary to Moving Threshold	Number of seconds in the **Active** state needed before a transition from **Stationary** to **Moved** is allowed	0 to 15240	1	Sec
Moved to Stationary Threshold	Number of seconds in the **Inactive** state needed before a transition from '**Moved**' to '**Stationary**' is allowed	0 to 15240	1800	Sec

4. Position Engine

The device is equipped both with BLE Reference tag identification and a GNSS positioning to determine the current position.

The BLE Reference tag identification is ideal for use indoors uses and provides an alternative to GNSS where satellite coverage is limited. This requires BLE tags to be deployed at fixed points within the area of deployment. The device initiates a BLE scan and if if detects reference tags within its vicinity it transmits the ID of the reference tag over LoRa for BLE Zonal positioning or trilateration.

If no reference tags are detected, then the GNSS positioning algorithm is initiated.

The BLE reference tag scan is performed first to avoid activating the GNSS module while indoors. GNSS activity is a very high current consumption activity and can significantly reduce the life of the product if frequently activated indoors.

The BLE Reference tag scan can be omitted by disabling it in the settings.

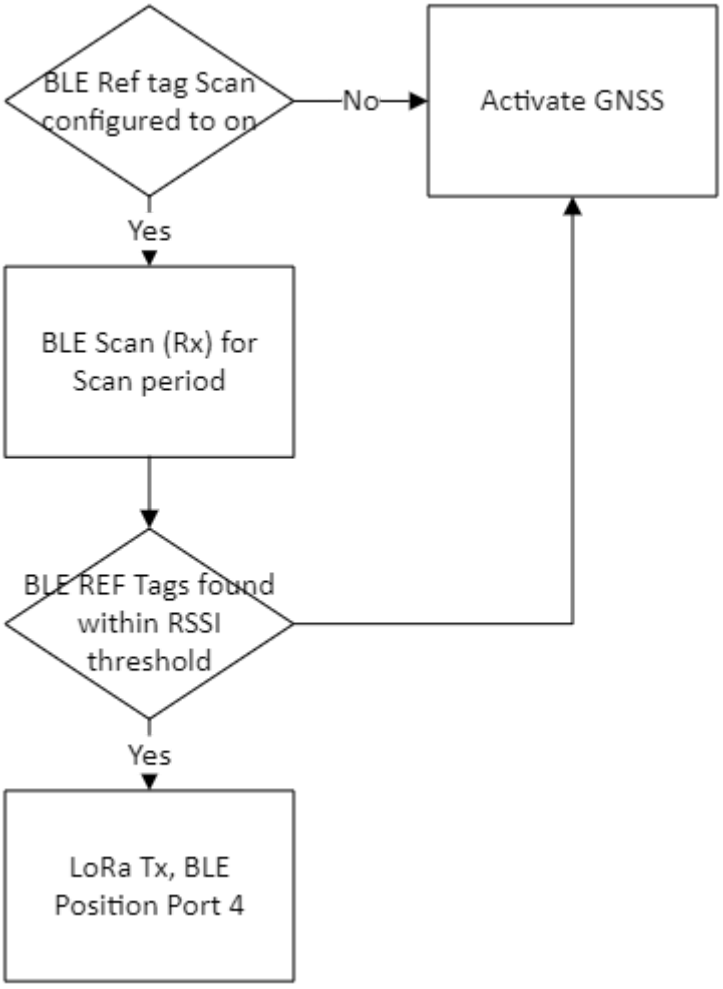


Figure 3:Position Engine Flow Diagram

4.1. BLE Reference tag Positioning -

For indoor positioning Sense Asset+ utilizes BLE communication.

BLE Reference tags are used indoor with fixed known coordinates which are beaconing/advertising their ID at higher rate than Asset+ device.

On movement stop, Sense Asset+ opens a receive window to listen to BLE reference devices.

If indoor BLE reference tags are detected within the configurable threshold, the BLE mac address and corresponding RSSI's are transmitted over LoRa for end application to process payload and put dot on indoor Map to provide indoor position. If Reference tags are not identified the device will activate the GNSS positioning algorithm.

The End Application can either show Dot on the Map by utilising coordinates of the reference Tag with highest RSSI (Zonal positioning) or can use third party

Trilateration software using multiple reference Tags and their RSSI values to determine a more accurate position.

When deploying BLE reference tags careful configuration of the BLE transmit power is required to ensure no blead through to adjacent zones.

Note that theoretically the range of a BLE reference tag can be in excess of 200m, therefore careful configuration of each reference tag is required to avoid detecting reference tags in adjacent areas where GNSS may be the preferred source for position.

The device transmits BLE Advertisements every 10 seconds which can be used for Zonal positioning if BLE gateways are deployed. When the device enters stationary state if BLE reference tags is enabled will perform a BLE Scan to detect reference tags.

4.2. GNSS Positioning

For outdoor positioning Sense Asset+ utilizes GNSS.

On movement stop, if no BLE reference tags are detected or if the BLE scan is disabled, the device attempts to acquire the GNSS position and posts it over LoRa.

The new position beacon is a confirmed uplink as default and is retransmitted if no acknowledgement is received from the network server. Position packets can be configured as unconfirmed uplinks to reduce traffic.

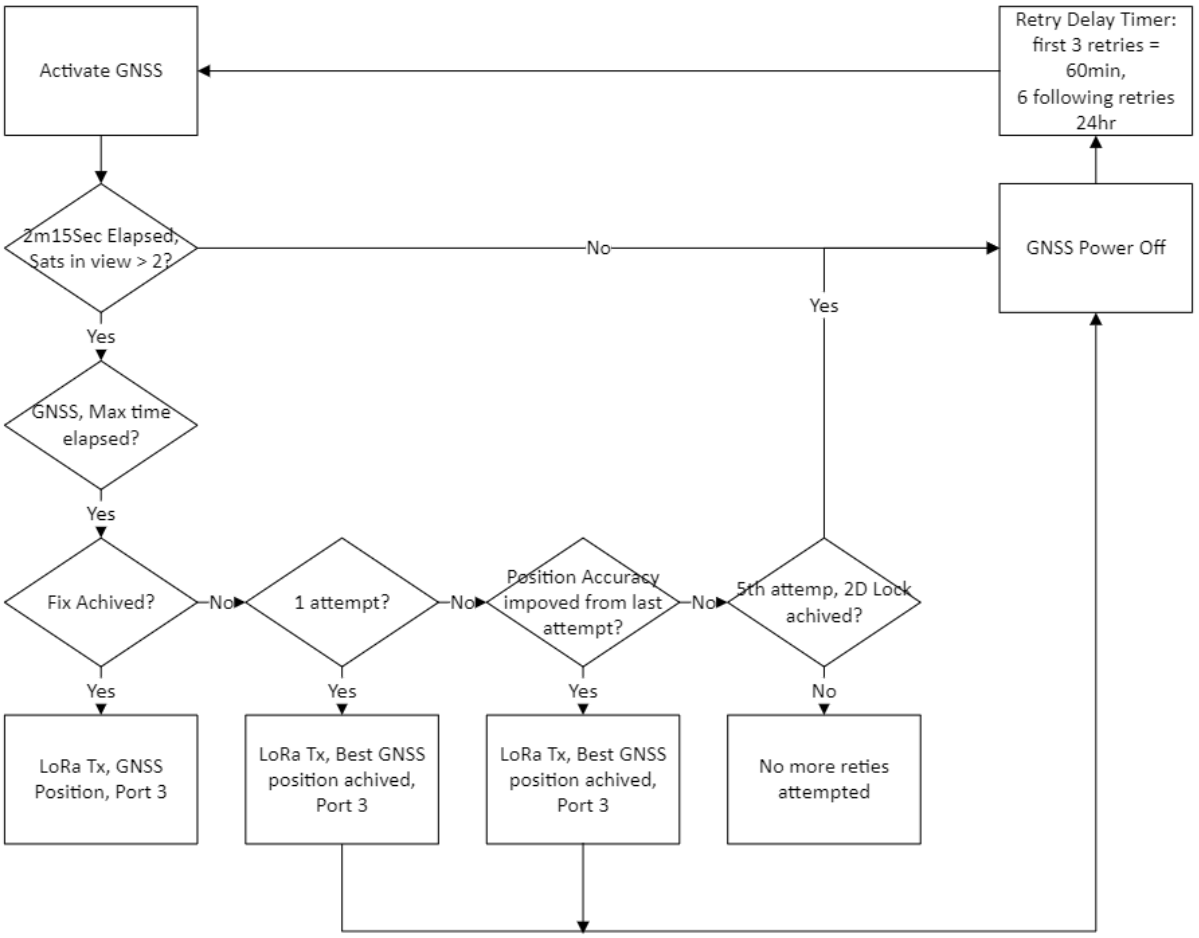


Figure 4: GNSS operation flow chart

4.2.1. GNSS Activity

The GNSS module is activated when the device state changes to stationary. Outdoor positional data is announced post GNSS activity.

GNSS activity will start after movement has stopped and device state changed from moved to stationary. If user configured DOP was achieved in response to 1st GNSS activity then there will be no further GNSS retries, but if DOP values were below user configured then device will go through GNSS retries.

Position achieved after 1st GNSS activity is by default transmitted as a confirmed uplink (confirmed beacon and needs acknowledgement from Network Server) even if device failed to acquire GNSS fix for any reason (being indoor, etc).

4.2.2. GNSS Timeout and GNSS Retry Functionality

If there were less than 3 Satellite vehicles visible during GNSS activity for 2 minutes and 15 seconds, then GNSS activity will stop, and device will go for GNSS retry.

The device will attempt to acquire a GNSS lock up to 11 times (if 1st attempt failed, then 3 further retries 60 minutes apart and then further 7 retries each 24 hrs apart). After GNSS time out the GNSS is switched off to conserve battery life.

on the 5th attempt if a 2D fix is not achieved no further retries will be attempted. A 2D fix occurs when the DOP is not achieved and requires a minimum of 3 satellites in view whereby longitude and latitude is calculated but altitude may not be available

Position beacon in response to GNSS retry will only be announced if the new position acquired is better than previous position otherwise no position beacon will be announced.

Note:

- Button press and / or Motion state will invalidate the GNSS algorithm and trigger the process to restart once the device enters stationary
- GNSS retry function is independent of Heartbeat, Heartbeat beacons are transmitted throughout the retry process.
- GNSS is disabled when the device is not joined to LoRa Network

4.3. Manual position update request

The device can be triggered at any point to perform either a BLE reference tag update or GNSS position update by sending a downlink position update request.

Note that in Class A LoRa operation the device will have to send an uplink before opening a Rx window where the position update request will be received by the device and therefore it may take up to 1 heartbeat period for the device to receive the request. In Class B the device will receive the downlink command at the next ping slot period.

5. Sense Asset+ - Communication

Sense Asset+ supports LoRa Class A, B and C which uses OTTA (Over the Air Authentication) procedure to join a LoRa network.

By default Asset+ operates as Class A device but device can be configured to operate as Class B or Class C device either by using supplied Sense Config PC APP or OTA (over the air) via LoRa downlink command

Class A idle average current consumption: 64uA

Class B: 70.3uA

Class C: 7.17mA

Sense Asset+ utilises LoRa and BLE as communication protocols and has the following beacon types:

- Heartbeat Beacon- LoRa Unconfirmed Uplink (configurable 1-255 Hrs)
- Motion Beacon (MB)- LoRa Unconfirmed Uplink
- Outdoor Position Beacon- LoRa Confirmed Uplink
- Indoor Position Beacon- LoRa Confirmed uplink

- BLE Beacon (configurable beacon Rate)

5.1. LoRa Communication

5.2. Device to Gateway

Packets sent over the air from the device to the gateway:

- LoRa network join request
- Device payload (Either DBR, MB beacons, Position beacons, ack retry beacon)

5.3. Gateway to Device

Packets sent over the air from Gateway to Device:

- Message acknowledgments in response to Join Request

Message acknowledgement against confirmed beacon (Position beaconLoRa control and synchronisation messages, such as Data Rate configuration messages from gateway to device

- FOTA Transmission
- Downlink Commands, such as configuration update & Alert Activation (LED and Buzzer Alert commands)

5.4. LoRa Network Join Request

Sense Asset+ uses OTTA (Over the Air Authentication) procedure to join a LoRa network.

During the join procedure the device transmits a join request and waits for a response from a network server to establish a session.

To join a network the end device starts the join procedure by transmitting join request containing:

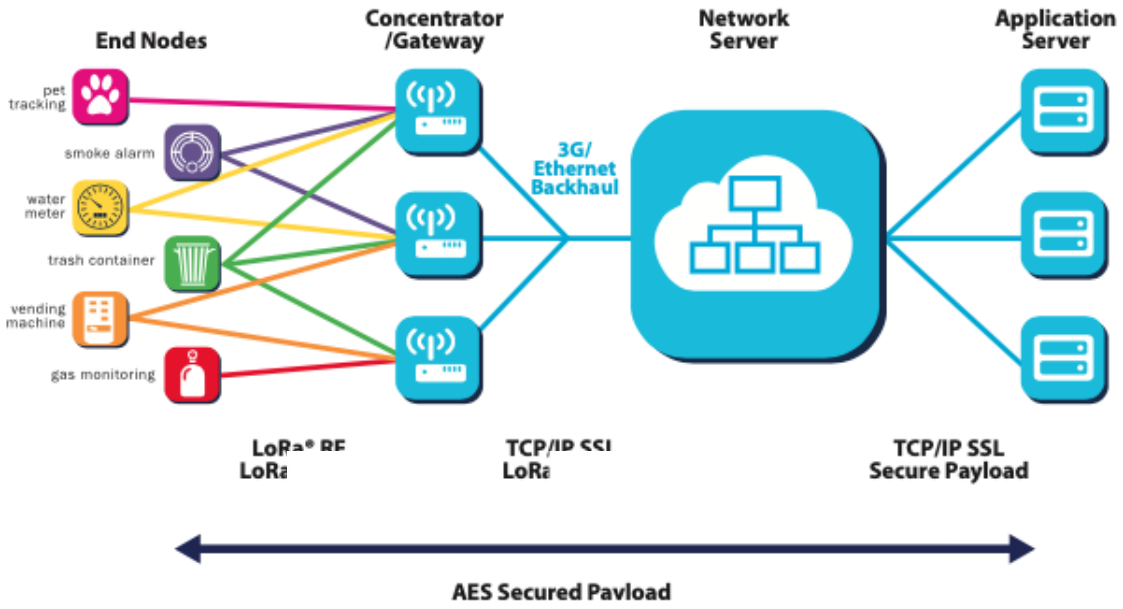
- DevEUI (Device's unique ID, 64 bits)
- AppEUI (Application Unique ID, user configurable, 64bits)
- APPKey (Application Key, user configurable, 128bits)
- DevNonce (Unique randomly generated number to prevent replay attack)

An App key needs to be preconfigured in the network server and is used to validate that the device has permission to communicate with the network.

These values are user configurable, and devices can be supplied pre-configured with alternative values as part of service bureau customisation service.

Once the network server accepts the join request the device then generates the following session keys based on App Key:

- NwSKey (Network Session Key): To be shared with Network server
- AppSKey (Application Session Key): To be shared with application server, this ensures end to end encryption of payload data. Beacons are then received by LoRa gateway and forwarded to network server which will push data to the end application server



LoRa Network Infrastructure

If more than one gateway is in communication range with the device, the network server sends join acceptance message via the gateway which is closest to the end device based on received RSSI vale of a gateway.

The device will remain joined to the network, the following conditions will initiate network join attempt:

- Device power cycle, (battery replaced)
- Firmware update over the air
- Device settings updated to switch LoRa off (over NFC or LoRa downlink) followed by switch On (Via NFC only).
- Any Changes to LoRa related configurations.

5.5. Join Retry Procedure

The device will attempt to Join the network on successful completion of the power up self test routine. Should the device fail to receive Join acceptance from the LNS it will attempt to re-join.

The device will attempt a total of 9 join attempts at a time interval of 40 sec between attempts with a randomization of +/-2 sec per attempt.

A further 78 join attempts are performed ts a time interval of 10min with randomization of +/- 2sec per attempt

The initial 88 attempts will take approximately 13hr to complete, after which a single join attempt is attempted every 1hr +/-2sec until the Join is accepted.

5.6. Heartbeat Beacon -

The default beacon rate is the frequency at which the device transmits LoRa beacons under normal conditions (not moving).

The DBR beacon is transmitted every 24 hours (by default). This is configurable (1-255 Hrs) via Sense Config PC app.

While in DBR state, if last position beacon wasn't acknowledged then last position beacon will be re-transmitted rather than heartbeat beacon.

The heartbeat timer is randomized with 0-10% random time +0-10sec added each time the heartbeat timer is reset.

Heartbeat beacon timer is reset after Motion Beacon & New position beacon.

5.7. MB (Motion Beacon)

Motion beacons are transmitted under the following situations:

- Motion detected: The device transmits a single beacon when it senses motion. The device will only send 1 motion detected triggered beacon while moving

- On push of the Button

The Motion beacon is transmitted with 0-10sec random added delay

5.8. GNSS Position Beacon

Device starts GNSS activity after Device's state has changed from stationary to moved and tries to get GNSS Fix, after GNSS activity outdoor position beacon is posted over LoRa as confirmed uplink with below information in payload:

- Latitude
- Longitude
- PDOP
- HDOP
- VDOP
- SATs used

5.8.1. ACK. Retry Functionality

Position beacon requires acknowledgement (Ack) from Network Server/End Application and if ACK is not received then Device starts ACK retry process. There will be 9 groups of ack retries with backoff timer between groups and each group contains 8 quick retries (1-20 seconds apart), Total 72 Ack retries are announced at random channels. Single cycle of Ack retries (72) can take up to 4 hrs. If all Ack retries have exhausted and Ack is still not received, then at heartbeat beacon time heartbeat beacon will be replaced with last Position beacon which didn't get ACK and from this point Ack Retries Procedure will start again.

5.9. Firmware Over the Air (FUOTA)

Asset+ supports Firmware Update Over the Air (FUOTA), the advantage of FUOTA is it allows the delivery of updates over the air to many devices at the same time in an efficient and secure manner. By default, Device performs normal operation as Class A device unless configured as Class B or Class C device.
If device is operating as Class A device then FUOTA Application/LNS will queue up FUOTA job schedule downlink commands for device/group of devices which device will receive after it transmits next LoRa Tx(Class A Device opens 2 Rx windows post every Tx). Device will start receiving FW in small chunks in shape of LoRa packets sent by NS after Device has transitioned from Class A to Class B/C(whatever was chosen while scheduling Job from FUOTA application/LNSIf device is operating as Class B device then LNS will schedule FUOTA job for device/group of devices and on Ping slot device will receive FUOTA job schedule command from LNS and will get ready to receive small chunks of FW as downlink messages from LNS. LNS will transmit FW packets synced with device's ping slots (Class B device opens RX window at ping slot)

If device is operating as Class C device then LNS will que up FUOTA job schedule commands for device as downlink which device will receive as soon as downlink is transmitted (Rx window is always open if device is operating as Class C device) and will get ready to receive FW in small chunks of packets at scheduled time
Once FOTA is completed then Device will reboot and will start functioning as Class A device.

Recommended FUOTA Parameters (US region)
FUOTA can be scheduled in presence of multiple LoRa gateways but it is recommended to keep one gateway active which is closest to devices FUOTA is intended to and de-activate rest of the gateways if in close proximity of master gateway.
Fregmentation: Forward Error correction
Redundancy: Minimum 50%

Tx channel: any except 923.3MHz(Avoid scheduling FUOTA on 923.3MHz channel in USA since this is noisy channel)
Multi Packet support: Disabled
Packet delay: Minimum 4000mSeconds(Normal FUOTA packet get analysed with in 1500 mSeconds but Parity fragment need more time to be analysed for forward error correction)
If device is operating as Class A device then FUOTA job to be scheduled for after next heartbeat beacon+10%(e.g if HBR is 24 Hrs then FUOTA job to be scheduled approximately 26.4 Hrs in advance)

(To be updated post FW completed)

5.10. LED and Buzzer Alert Activation Over LoRa

(To be updated post FW completed)

5.11. Sense Asset+ Data Payload Breakdown

Position Payload - Outdoor GPS Position:

Position	Name	Description	UoM	Unit Type
0-3	Latitude	BIT 31-0 (0-4,294,967,295) This value should be divided by 1,000,000	Decimal minutes	int32_t
4-7	Longitude	BIT 31-0 (0-4,294,967,295) This value should be divided by 1,000,000	Decimal minutes	int32_t
8	PDOP Value	BIT 3-0 (0-15)	Unitless	uint8_t
	HDOP Value	BIT 7-4 (0-15)	Unitless	
9	VDOP Value	BIT 3-0 (0-15)	Unitless	uint8_t
	SATs Used	BIT 7-4 (0-15)	Each	

Position Payload - Indoor Reference Tag:

Position	Name	Description	UoM	Unit Type
0	Mac 0	BIT 7-0 (0-255)	Unitless	uint8_t
1	Mac 1	BIT 7-0 (0-255)	Unitless	uint8_t
2	Mac 2	BIT 7-0 (0-255)	Unitless	uint8_t
3	Mac 3	BIT 7-0 (0-255)	Unitless	uint8_t
4	Mac 4	BIT 7-0 (0-255)	Unitless	uint8_t

5	Mac 5	BIT 7-0 (0-255)	Unitless	uint8_t
6	RSSi	BIT 7-0 (0-255)	Unitless	uint8_t
7	Index Total Tags Discovered	BIT 3-0 (0-255) BIT 7-4 (0-255)	Unitless	uint8_t

Motion Payload:

Position	Name	Description	UoM	Unit Type
0	Hardware Version	BIT 7-0 (0-255)	Unitless	uint8_t
1	Firmware Version	BIT 7-0 (0-255)	Unitless	uint8_t
2	Battery Voltage	BIT 7-0 (0-255) (This value should be divided by 10)+2.9	Unitless	uint8_t

DBR (Daily Heartbeat Payload):

Position	Name	Description	UoM	Unit Type
0	Hardware Version	BIT 7-0 (0-255)	Unitless	uint8_t
1	Firmware Version	BIT 7-0 (0-255)	Unitless	uint8_t
2	Battery Voltage	BIT 7-0 (0-255) (This value should be divided by 10)+2.9	Unitless	uint8_t

5.12.LoRaWAN Downlinks

Downlink commands can be sent to device via LNS on Port 1 for below purpose,

Device Configuration

Alert activation/de-activation

Note: Downlink commands can be sent to device as confirmed downlinks or non-confirmed downlinks

	Data	ID (Unsigned	Configuration Type	(Bits)	Unit s	Sample Commands [Default Values]	Decimal / ASCII	Range	Remarks
Alert Service	Debug Toner Activation/Deactivation	0x00	Unsigned	4		0010	1	00:Deactivate 10:Activate	
	Alert Start/Stop	0x01	Unsigned	4		0110	1	00:Deactivate 10:Activate	Starting the Alert service triggers a switch in LoRaWAN to class B and which will revert back when the button on the board is pressed. Else it will remain in the same Class
	Buzzer Duty Cycle	0x02	Unsigned	16	mS	0200FA	250	0~65535	
	Buzzer On Frequency	0x03	Unsigned	16	Hz	030EA6	3750	0~65535	
	Buzzer Off Frequency	0x04	Unsigned	16	Hz	04128E	4750	0~65535	
	Alert Duration	0x05	Unsigned	16	S	05012C	300	0~65535	
Motion Engine	Config DBR period	0x10	Unsigned	8	Hours	1018	24	1~255	
	Accelerometer Threshold	0x11	Unsigned	8		1109	9	0~10	
	Window	0x12	Unsigned	8		1214	20	1~255	
	Threshold	0x13	Unsigned	8		130F	15	0~255	
	GNSS Max Lock Timeout	0x14	Unsigned	8	Minutes	140F	15	1~25	
	DOP Threshold	0x15	Unsigned	8		150A	10	1.0~10.0 (10:1.0, 100:10.0)	
	GNSS Forced Uplink	0x16	Unsigned	4		1610	1	00:Deactivate 10:Activate	
	BLE Scan Forced Start and Send Uplink	0x17	Unsigned	4		1710	1	00:Deactivate 10:Activate	When triggered, the device will search for any reference tags in range and if found, there will be Tag data uplinks and if not it will switch to GNSS location retrival
	Motion Stationary to Moved	0x18	Unsigned	16		180001	1	0~65535	
	Motion Moved to Stationary	0x19	Unsigned	16		190384	900	0~15240	
BLE	BLE Advertising Name	0x20	String	64		2053656E7365412B00	SenseA+		end
	BLE Set Gain	0x21	Signed	8	dBm	21F4	-12	-20dBm -16dBm -12dBm -8dBm -4dBm 0dBm 3dBm 4dBm	
	BLE Beacon Rate	0x22	Unsigned	16	mS	222710	10000	Off: 0 2.5 Sec: 2500 5 Sec: 5000 10 Sec: 10000	
	BLE Enable Reference Tag Scan	0x23	Unsigned	4		2310	1	00:Deactivate 10:Activate	
	BLE Scan Window Length	0x24	Unsigned	16	mS	242710	10000	1000~65535	
	BLE RSSI threshold	0x25	Signed	8	dBm	25B5	-75	-128~127	
	BLE Set Reference Tag Filter Name or UUID	0x26	Unsigned	128		264F6D6E692D494400	Omni-ID		Make sure to append '00' at the end
LoRaWAN	LoRaWAN Enable/Disable	0x30	Unsigned	4		3010	1	00:Deactivate 10:Activate	
	LoRaWAN Maximum Datarate Set	0x31	Unsigned	8		31FF	5~255:ADR	0:DR0 1:DR1 2:DR2 3:DR3 4:DR4 5~255:ADR	
	LoRaWAN Class	0x32	Unsigned	4		3200	Class A	00: Class A 10: Class B 20: Class C	
	LoRaWAN Ping Slot period	0x33	Unsigned	8		3307	7	0:SMTC_MODEM_CLASS_B_PINGS_1_SLOT_1_S 1:SMTC_MODEM_CLASS_B_PINGS_2_SLOT_2_S 2:SMTC_MODEM_CLASS_B_PINGS_4_SLOT_4_S 3:SMTC_MODEM_CLASS_B_PINGS_8_SLOT_8_S	
	LoRaWAN Class B timeout & switch to Class A	0x34	Unsigned	8	Minutes	3408	8	3 - 255	
	LoRaWAN Confirmed Uplink Enable/Disable	0x35	Unsigned	4		3510	1	00:Deactivate 10:Activate	
	LoRaWAN Sub-band Hopping Enable/Disable	0x36	Unsigned	4		3610	1	00:Deactivate 10:Activate	Enabling this allows the uplinks to communicate in unique and random channels where the sub-bands are hopping sequencially
Device	mode	0x40	Unsigned	4		4010	1	10:Awak	
	** Above data does not reflect the actual address nor the order of how the data is being								
	** Port number 1 is to be used for downlink								

Table x

6. Alert Mode

Sense Asset+ is designed to provide complete Track and Trace functionality. GNSS and BLE can be used to find the device in outdoor/indoor settings, when the operator reaches close proximity to Asset, the LEDs and Buzzer can be activated over BLE or over LoRa to easily identify the correct asset.

Alert mode is activated over BLE using the NRF Connect BLE App and is used to aid locating the device in close proximity by sounding the buzzer and lighting the LEDs or it can be activated over LoRa by sending downlink command to device

When the alert is triggered, a tone is played at a stable frequency for a configurable period before switching to another frequency for the same period. The duration of this alternating tone is user configurable. During an active alert the LEDs at each end of the device will light following the timings of the tones.

Activity duration is configurable.

Note: While in alert state and the tone sounding, acceleration data is ignored for the duration of alert activity, therefore if the asset is moved during buzzer/LED activity the motion alarm will not be transmitted over LoRa and the location will not be updated in this time.

Pressing the push button will stop an active alert

6.1. Alert activation over BLE

6.1.1. Services and Characteristics

Tag has custom BLE Services and characteristics and to operate the Tag, applications can connect to the Tag over BLE and read/write characteristics of the Tags custom service.

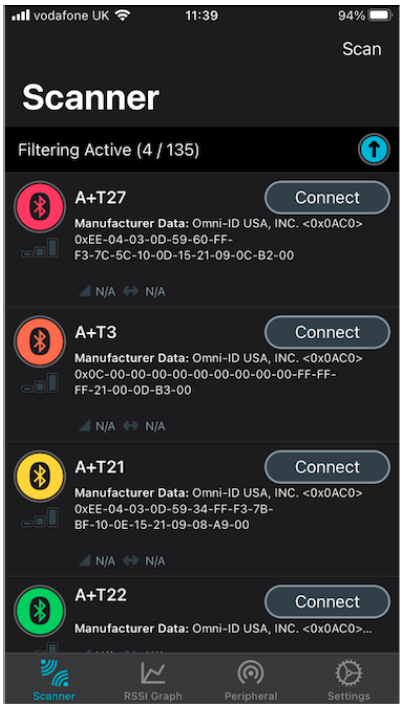
Connection is not encrypted.

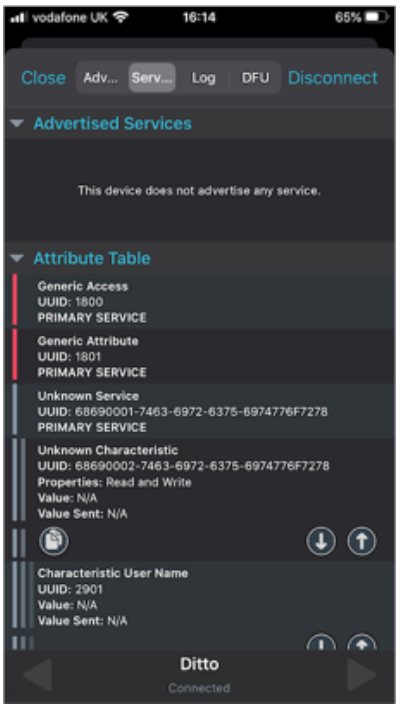
6.2. Alert Service

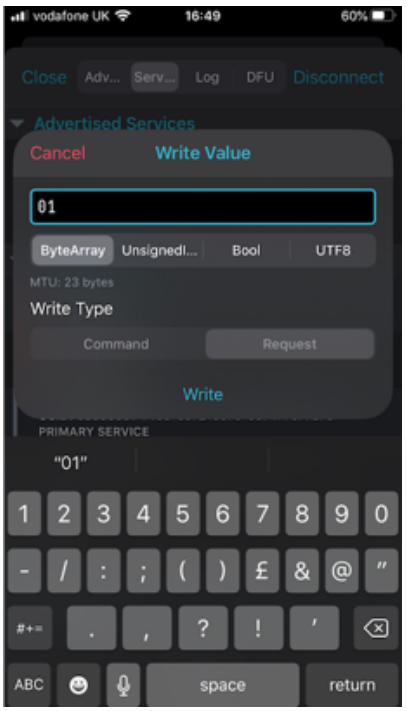
Service UUID: 68690002-7463-6972-6375-6974776F7278

UUID	Description	R/W	Size
0002	Alert Trigger 0x00 = Alert not active/Stop alert, 0x01 = Alert active/Start alert	R/W	uint8_t

6.3. Activating Alert Mode using NRF Connect BLE App - IOS Device



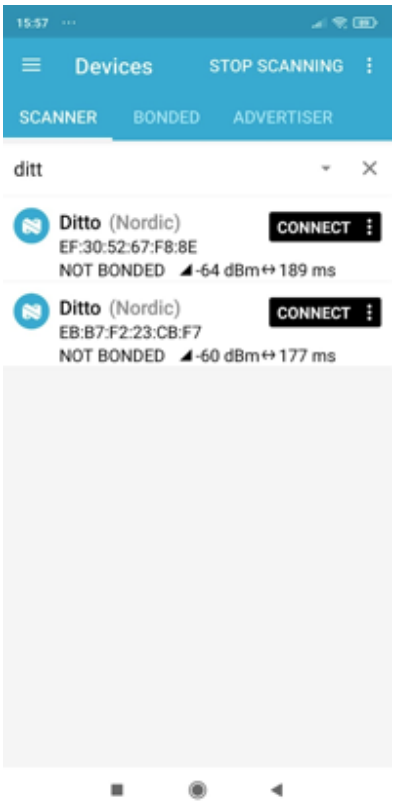


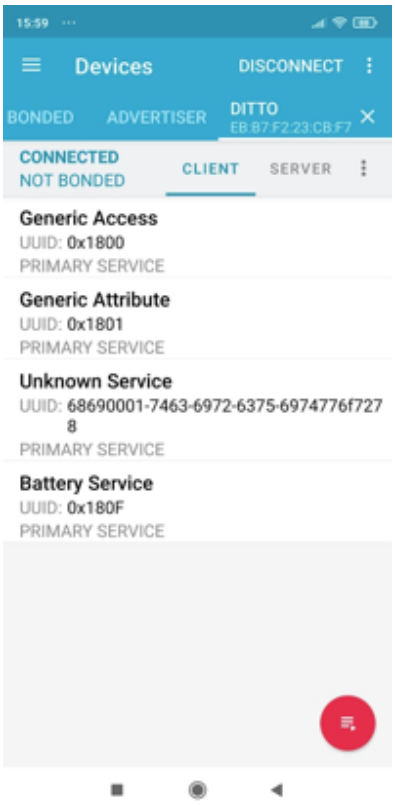


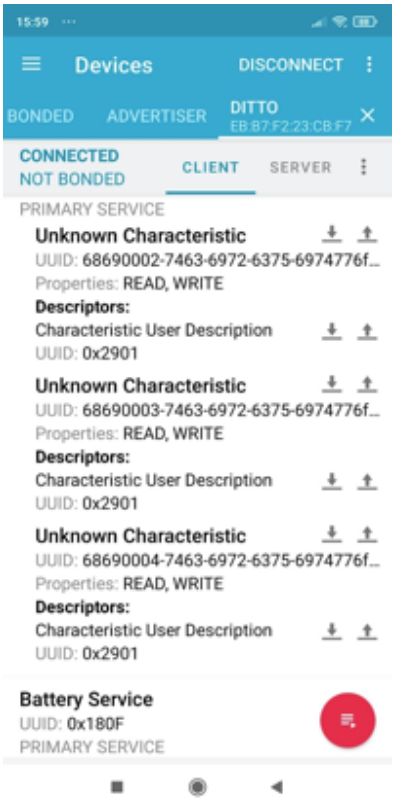
- Select Device (Connect)
- Select ‘Service’ from top bar
- Select up arrow  on ‘Unknown Characteristic’
- Enter 01 in write box and select ‘Write’ to activate Alert Mode
- Press the button on Sense Asset+ to stop active alert

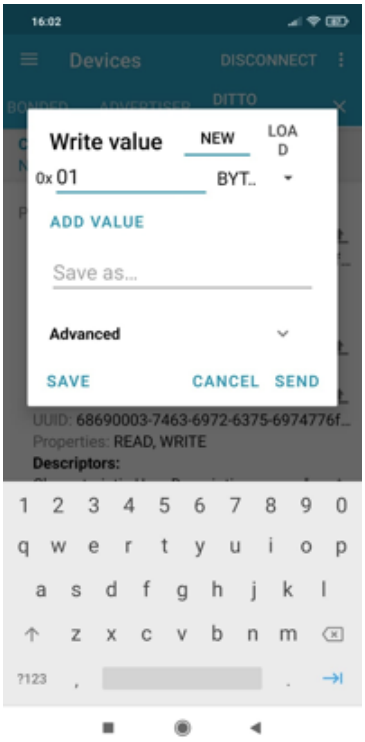
- Enter 00 in write box and select ‘Write’ to de-activate the Alert Mode

6.4. Activating Alert Mode using NRC Connect BLE App - Android Device









6.5. Activating Alert Over LoRa

Downlink command over LoRa on Port 1 can be sent to device to activate alert.

Send command 0110 as downlink to device on Port 1 to activate Alert

Send command 0100 as downlink to device on Port 1 to de-activate Alert

Note: Device response time depends on multiple factors like Class device is operating on, ping slot (if In Class B)

MOTION IGNORED DURING ALER Activity

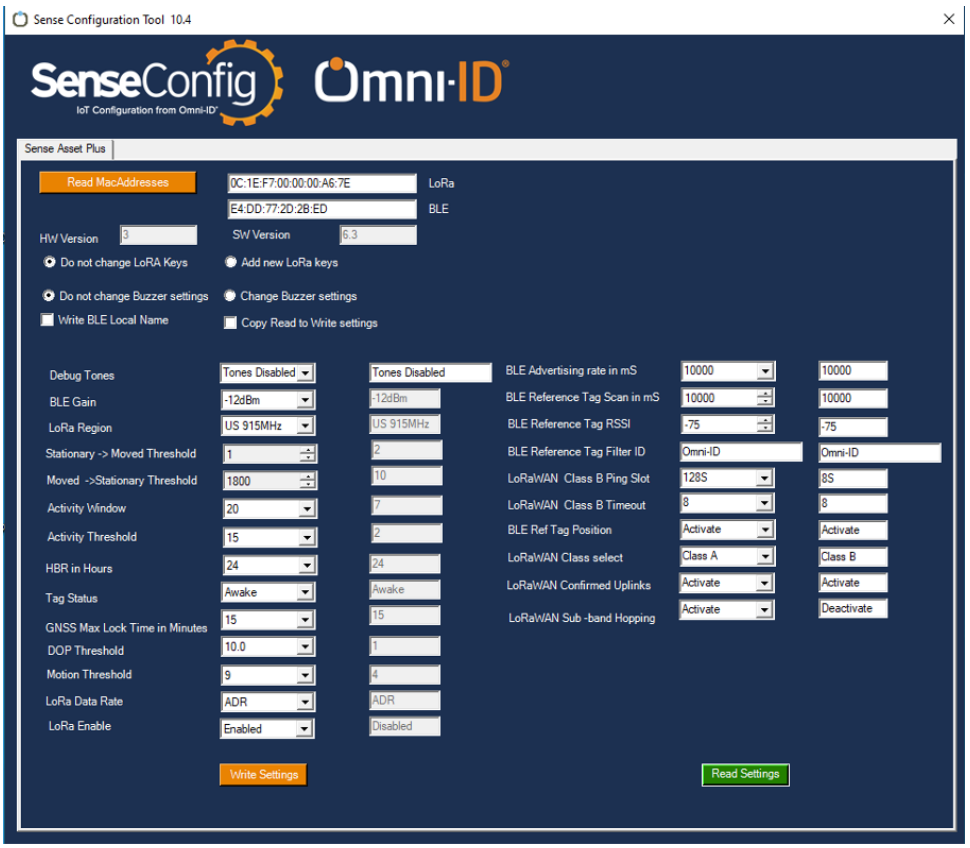
7. Device Configurable Settings

The device settings are configured via NFC using the Sense Config tool or over the air by sending downlink commands to device as un-confirmed downlink or confirmed downlink

Omni-ID provides both a PC software that works with ST Microelectronics M24LR Discovery NFC PCB tool or alternatively an Android application. For further information refer to Omni-ID ‘Sense Config PC App User Guide’ and ‘Sense Config Android App User Guide’.

These settings are written to the device memory using the NFC writer, use the push button to transfer the values to the device.

NFC Antenna location



Sense Config example

7.1. Device Configurable Parameters

The following are the configurable parameters:

- App EUI/Join EUI: 16 Hex Characters
- App Key: 32 Hex Characters
- BLE Local Name
    - 10 Characters
- Debug Tones: Tones Enabled/Disabled
- BLE Gain: The following steps are available
    - -40dBm, -20dBm, -16dBm, -12dBm, -8dBm, -4dBm, 0dBm, and +4dBm
- Stationary -> Moved Threshold: 0-15240 Sec
    - Number of seconds in the Active state needed before a transition from Stationary to Moved is allowed
- Moved -> Stationary Threshold: 0-15240 Sec
    - Number of seconds in the Inactive state needed before a transition from 'Moved' to 'Stationary' is allowed
- Motion Threshold:0-10
    - 1 is least sensitive
    - 10 is most sensitive
    - 0 = off
- Activity Window: 0-255 Hours Seconds
    - Window in which accel interrupts are counted
- Activity Threshold: 0-255
    - Threshold for the number of events that have to be exceeded in the window to trigger the Active / Inactive state.
- Data Rate: A,0,1,2,3,4(depending on region selected), NOTE: This setting relates specifically to the post moment data rate
    - ADR (Adaptive Data Rate), at ADR the network server dictates the data rate and automatically adjusts bit rate to optimize battery life and communication distance for heartbeat beacon and motion beacon) as well as for LoRa Position Beacons (GNSS position beacon/BLE reference Tag based Position Beacon)
    - If value other than ADR is selected then heartbeat beacon and motion beacon will be transmitted at data rate dictated by network server but position beacon will be transmitted at configured data rate (e.g. If device is configured with DR:2 and network dictated Data rate is 3 then Heartbeat beacon and Motion Beacon will be announced at DR3 but position beacon will be announced at any of the data rates from 0,1,or 2. After Position beacon device will revert back to network dictated Data Rate).
      this Setting is used in large site to ensure communication is established seamlessly when a device moves a significant distance away from the gateway. Assuming a device is near the gateway

ADR will command it transition to DR3, as the device moves away from the gateway DR3 will results in a failed communication link and via the Retry process of the confirmed uplink the DR will gradually be reduces. This could cause delay of a number of hours before communication is re-established. Setting the setting to DR0 will force the device to switch to DR0 post movement to ensure communication link with the gateway.

- DBR in Hours: 1-255 Hours
- Tag Status: Asleep/Awake
    - This function can be used to put the tag to sleep and to awaken the tag from sleep
    - Asleep - , Device is in deep sleep, No BLE or LoRa activity
    - Awake - LoRa, GNSS and BLE active
- GNSS Max Lock Time in Minutes: 1-25 Minutes
    - Maximum time GPS module remains active while attempting to get GPS Fix/lock (Look for available satellites, choose suitable satellites depending on RSSI values and try to get GPS Fix
- DOP Threshold: Values can be set between 1-10 in increments of 0.1
- BLE Advertising rate in ms
    - Off: 0
    - 2.5 Sec: 2500
    - 5 Sec: 5000
    - 10 Sec: 10000
- BLE Reference Tag Scan in ms
    - 1000~65535
- BLE Reference Tag RSSI
    - -128~127
- BLE Reference Tag Filter ID
    - 16 Byte String (Default:Omni-Id)
- BLE Ref Tag Position
    - Deactivate (Device will not run BLE Scan after change in state from moved to stationary but will activate GNSS to acquire position and position beacon based on GNSS will be transmitted at port 3 over LoRa)
    - Activate (Device will run BLE Scan to look for BLE reference Tags after state changes from moved to stationary and if Reference Tags found then position beacons based on BLE reference Tags will be transmitted on Port 4 over LoRa)
- LoRa Region
    - EU 868MHz
    - US 915MHz
- LoRa Data Rate
    - 0:DR0
    - 1:DR1
    - 2:DR2

    - 3:DR3
    - 4:DR4
    - 5~255:ADR
- LoRa Enable
    - 0 = Lora Disabled/Not Powered
    - 1 = Lora Powered/Used if applicable
- LoRaWAN Class B Ping Slot-Seconds (Interval at which device will open Rx window)
- 1,2,4,8,16,32,64
- LoRaWAN Class B Timeout-Minutes (Time after which Device will come out of Class B and will revert to Class A if time sync messages from LNS not received)
    - 3 - 255
- LoRaWAN Class Select
    - Class A
    - Class B
    - Class C
- LoRaWAN Confirmed Uplinks
    - 0:Deactivate (Position beacons will be transmitted as non-confirmed uplinks)
    - 1:Activate (Position beacon will be transmitted as confirmed uplinks)
- LoRaWAN Sub-band Hopping
    - 0:Deactivate
    - 1:Activate
- Buzzer Frequency On: 0~65535 Hz (The frequency used in the On Period)
- Buzzer Frequency Off: 0~65535 Hz (The frequency used in the off Period)
- FreqAlert Buzzer duty Cycle: 0~65535 milliSeconds (between alternating the Buzzer to the ‘On’ and ‘Off’) frequencies.
- Alert Activity Duration: 0~65535 Seconds (Time duration for which alert will be active for)

Notes:

- Devices are preconfigured with default EUI (App EUI) and Key (App Key) values, these values are available on request.
- Lower the DOP threshold the higher accuracy on position will be achieved, however, to achieve the higher accuracy GNSS module will take longer time to acquire precise position and therefore the GNSS max should be set accordingly.
- There is the trade-off between higher position accuracy, and battery life reduction due to increased GNSS module up time.
- Push button is not required when configurations are pushed to device over LoRa

- Device will reboot on push of button after changing configurations related to LoRa like Join EUI/App EUI,APP Key, LoRa region or LoRa enable via NFC. As part of the boot sequence the device will initiate a join request to the LNS
- To change configurations on device using LoRa downlink commands please refer to Table x on page 37 and DO014036-01 Asset+ LoRa downlink commands Test Cases

8. Sense Asset+ Battery Information

Sense Asset+ battery is to be considered low at 3.2 Volts, LoRa and GNSS will stop working at 3.1 Volt, LEDs will stop working at 2.1 Volts and device will stop transmitting BLE beacons at 1.7 volts. When the device heartbeat and motion payload indicate that the battery voltage has reached 3.2volts please schedule a maintenance request to replace the devices batteries ASAP.

Sense Asset+ is designed to allow the batteries to be easily replaced whilst in service and still attached to asset.

WARNING Only the specified battery type should be used with this device. Failure to use the correct battery type may result in a malfunction or damage to the battery or device.

Recommended battery specification:

Sense Asset+ uses two non-rechargeable lithium primary 3.6v batteries.

Recommended Batteries:

- Saft LS14500
- HBC ER14505

Do not use:

Sense Asset+ will not work if used with 1.2-1.5v alkaline AA batteries (widely available for consumer goods).

Sense Asset+ will boot and power up with only one battery installed, however it is recommended to always the device with two batteries of the same type installed.

9. Battery Replacement

WARNING Only the specified battery type should be used with this device. Failure to use the correct battery type may result in a malfunction or damage to the battery or device.

WARNING Always replace the batteries in a dry and clean environment to prevent water and debris from getting inside the device.

WARNING Always dispose of old batteries in an environmentally responsible way.

WARNING Under tightening will cause case to leak.

WARNING Overtightening the screws will cause damage to the brass inserts.

To replace the batteries in Sense Asset+ you will need to untighten and torque tighten four 2.5mm hexagonal head captive screws to 7kgf-cm (0.7Nm). We recommend using the following tools:

We recommend using a t-handle key to manually tighten the screws and then a torque screwdriver* to ensure the screws are correctly tightened after the use of the t-handle:

2.5mm hex T-Handle key:
https://uk.rs-online.com/web/p/hex-keys/1923643/ RS PRO Hex Key Set, T Shape 2.5mm

Torque screwdriver:
https://uk.rs-online.com/web/p/torque-screwdrivers/8757552 Wera 1/4 in Hex Pre-Settable Torque Screwdriver, 0.3 → 1.2Nm

Alternatively you can use an electronic screwdriver with torque setting, and then a torque screwdriver* to ensure the screws are correctly tightened after the use of the electronic screwdriver:

Electric screwdriver with torque setting:
https://www.bosch-professional.com/gb/en/products/bosch-go-06019H2170 Bosch GO Cordless Screwdriver (recommended torque setting 3)

* Make sure the torque screwdriver torque setting is set with a calibrated torque measurement device before use.

9.1. Remove the Batteries

To remove the batteries:

1. Unscrew the four captive screws (Fig 1).
2. Open the case by lifting the edge of the case cover opposite to the hinge side (Fig 2).
3. Carefully remove the two batteries, noting correct polarity.
4. Dispose of old batteries in an environmentally responsible way.

Fig 1

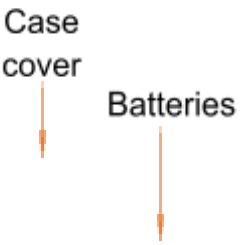


Fig 2

9.2. Install the Batteries

To install the batteries:

WARNING Only the specified battery type should be used with this device. Failure to use the correct battery type may result in a malfunction or damage to the battery or device.

---

1. Noting the correct polarity, install the two batteries into the case cover, make sure the batteries are clipped firmly and securely in position (Fig 3).
2. Make sure the gasket on the case lower is sitting flat and in the correct position to maintain a good seal when closed (Fig 4).
3. Close the case cover and torque tighten four captive screws to 7kgf-cm (0.7Nm), make sure the gasket has fully compressed to ensure IP68 rating (Fig 5).

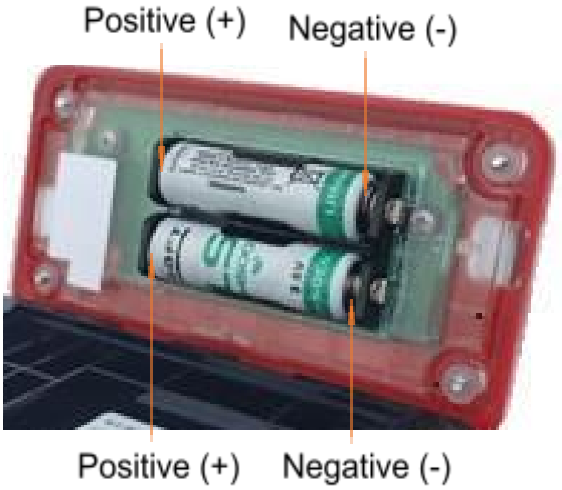


Fig 3

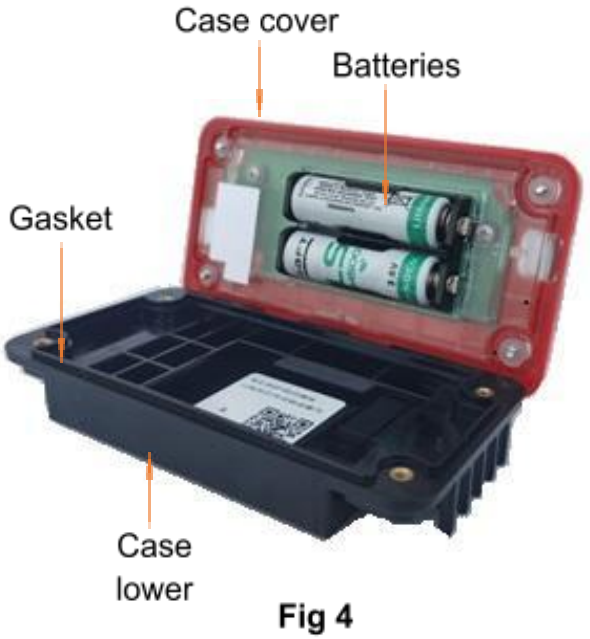


Fig 4

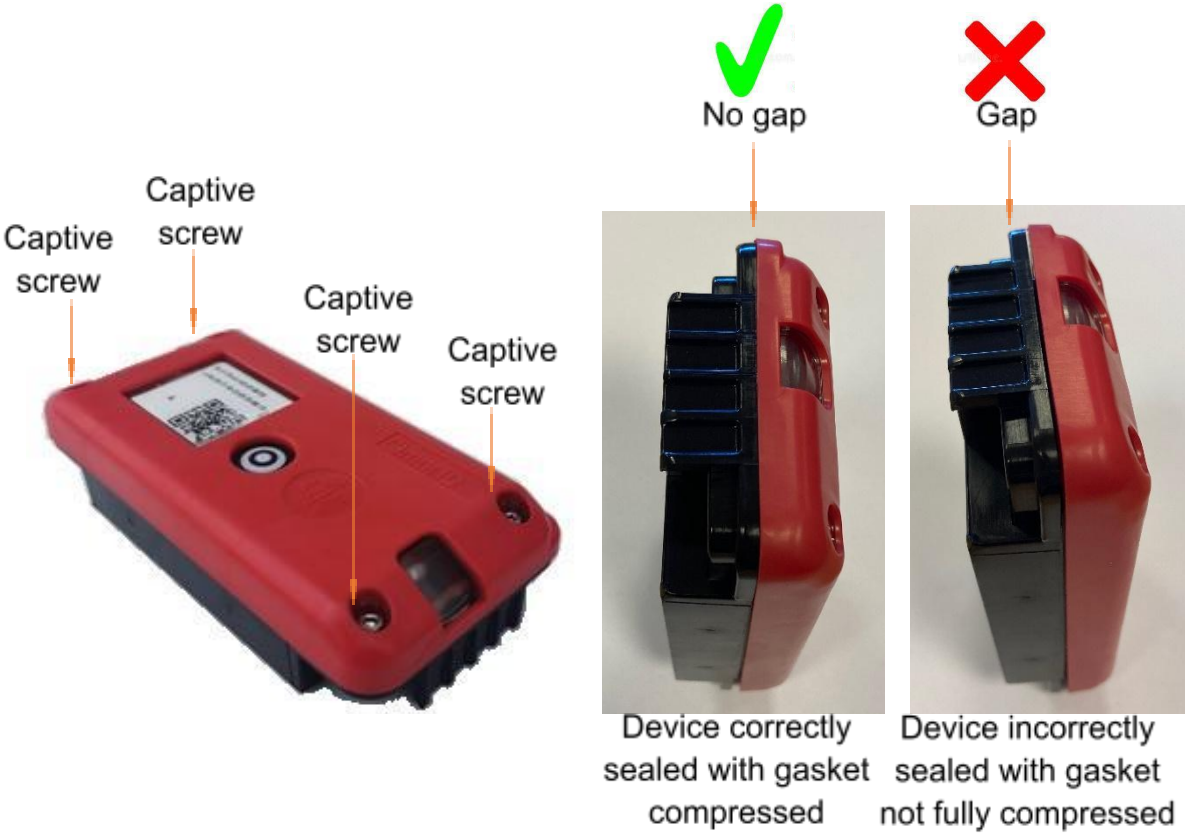

Captive screw
Captive screw
Captive screw
Captive screw
No gap
Gap
Device correctly sealed with gasket compressed
Device incorrectly sealed with gasket not fully compressed

Fig 5

10. Attaching Sense Asset+

Sense Asset+ must be attached to asset in such a way that it is pointing up and has clear line of sight view of the sky to ensure maximum accuracy on the GNSS position.

11. Sense Asset+ Demo Kit

To facilitate product evaluation, demonstrations and POC's Omni-ID can provide a demo kit that is optimised for rapid deployment in simple environment.

The Demo Kit contains a MultiTech Conduit LoRa gateway pre-configured with onboard network server which will run node red to process device's payload.

This removes the need to obtain and configure a network server for simple single gateway environment. Node red is used to parse device payload into individual elements and forwarded in JSON format to any Omnisphere over HTTP.

The Demo Kit comes with 2 months of free access to Omnisphere (Omni-Id's Cloud Based IOT Platform) which receives data from Asset+ devices, parses it and displays in GUI to evaluate Asset+ functionality.

Alternatively, a network server can be used, and the parsing of the data can be built into customer's application directly, to do this the gateway can be configured to act as a packet forwarder.

12. Care and Maintenance

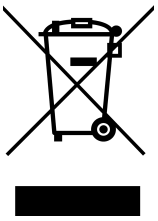
Your Sense Asset+ is a product of superior design and craftsmanship and should be treated with care. The following suggestions will help you protect your warranty coverage.

- Do not attempt to open and disassemble the device more than required to replace the battery
- Do not submerge the device in deep water (> 1m)
- Do not use harsh chemicals, cleaning solvents or strong detergents to clean the device. Only use water and soap or a dry cloth to clean the surface of the device
- Do not paint the device
- Keep the device out of reach of small children
- Only use the recommended battery type
- Keep new and used batteries away from children

If the device does not screw together firmly and securely, stop using the product and keep it away from children

13. Recycling and Disposal

Always return your used electronic devices, batteries and packaging materials to dedicated collect point. This way you help prevent uncontrolled waste disposal and promote the recycling of materials.



Disposal of Electrical and Electronic Equipment. This crossed-out wheeled-bin symbol indicates that this product should not be treated as household waste. Instead hand it over to the appropriate collection point for the recycling of electrical and electronic equipment in accordance with local environmental regulations for waste disposal.

Disposal of Waste Batteries. This product contains a battery. Do not dispose of them with other household waste. Instead, hand them over to the appropriate collection point for recycling. The battery does not contain Mercury (Hg), Cadmium (Cd) or Lead (Pb).

Ensuring correct product and battery disposal prevents potential negative impact on the environment and human health.

14. Datasheet

PROVISIONAL DATASHEET | COMPANY CONFIDENTIAL

Omni-ID part of HID

Sense IoT
Intelligent, Powerful IoT Devices

TRUST CONFIDENCE QUALITY

[Products] you can identify with

Sense Asset + (Quuppa)

Sense Asset + (Quuppa) is a rugged asset tracker device which uses the advanced Angle of Arrival technology, in combination with the Quuppa Intelligent Locating System it delivers a highly accurate Real Time Location System. It benefits from a high capacity user replaceable batteries which allows the product to be serviced in the field and extends the product life. The device is equipped with an LED which can be used to enable picking applications.

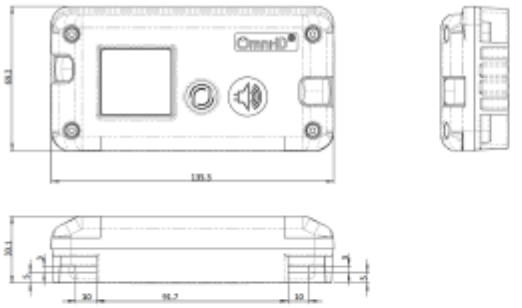
The Asset + comes with attachment options for cable ties and rivets. The rugged construction of the device makes it suitable for a huge range of IoT and IIoT applications in harsh environments. This product is also available with Ex certification for use in explosive environments.

Quuppa Bluetooth Ex

Physical Specifications

Material	Polycarbonate, overmoulded durable, shock resistant TPE (thermoplastic elastomer)
Size	135.3 x 69.2 x 33.1 mm, 5.32 x 2.72 x 1.30 in
Weight (g)	59
Attachment	Cable tie (std), rivet (optional)

Dimensions



Measurements shown in mm

Specifications

Radio Protocol	Bluetooth, Operating Quuppa intelligent locating system (RTLS). Supports backchannel communication & FOTA update.
Frequency Range	CH 37 (2.402), Quuppa Proprietary (2.401, 2.403, 2.481) & 2.478 GHz
Battery Type	2x replaceable SAFT LS14500 2.6Ah
Battery Capacity	5.2AH
Battery Life	4.5 years with Asset tag configuration, Triggered 1hr/day & Default 23hrs /day, LED activated 20 times per day (ambient temperature).
Sensors	Push button, 3 axis accelerometer
Visual Indicator	Red LED

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Omni-ID part of HID

Sense IoT
Intelligent, Powerful IoT Devices

TRUST CONFIDENCE QUALITY

[Products] you can identify with

The Sense Asset + device is ideal for applications requiring asset tracking and identification using the Ultra Bright LED such as:

- Hospitals
- Warehouse management
- Facilities management
- Asset management
- Manufacturing facilities
- Container management
- Ports construction and mining
- Cold chain condition monitoring

Configurable Parameters

Tx power +6dBm to -12dBm
Accelerometer threshold (rate & sensitivity)
Default state Tx rate 0.1Hz to 2hz
Triggered state Tx rate 1Hz to 33Hz
Response mode (Rx rate)
Payload parameters
State time out

Certifications

CE, FCC, RoHS, NFC, Bluetooth, Ex, Quuppa, EX 1A 11C T4 GA, EX IA 111C T200 135 C Da, EX 11 1 GD, EX ia 1 MA, EX 1M1, Tamb -20C to +55C, Cl I, II, III Div 1 Groups A-G, T4, EX ia, Cl I Zone 0, AEx ia IIC T4 Ga, Zone 20 AEx ia IIIC T135C Da, Ex ia 11C T4 Ga, Ex ia IIIC T135C Da, -20C < Tamb < 55C

Related System Components

BLE Technology Evaluation Kit	Sense Asset (Quuppa), Sense Lite (Quuppa), Sense Badge Lite (Quuppa), Sense Badge Lite (Quuppa), Sense Badge Lite (Quuppa + Prox), Quuppa Evaluation Kit

Environmental Specifications

Operating Temperature	-20°C to +55°C
IP Rating	IP68
Shock & Vibration Tolerance	MIL-STD-810 G

Ordering Information

Warranty	1 year
Part Number / Order Codes / Order Numbers	TBC - Standard
	TBC - Rivet option
	TBC - Ex option