smartparking SYSTEMS

Ecoh 915
LoRa WAN 902-928 MHz (US915)

MANUAL

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1. INTRODUCTION

The Intercomp - Smart Parking Sensor **Ecoh 915** developed by Intercomp, allows citizens to detect available parking slots in the on-street parking

It's part of the complete Smart Parking Systems Solutions for the management of the on street paid parking in the city.

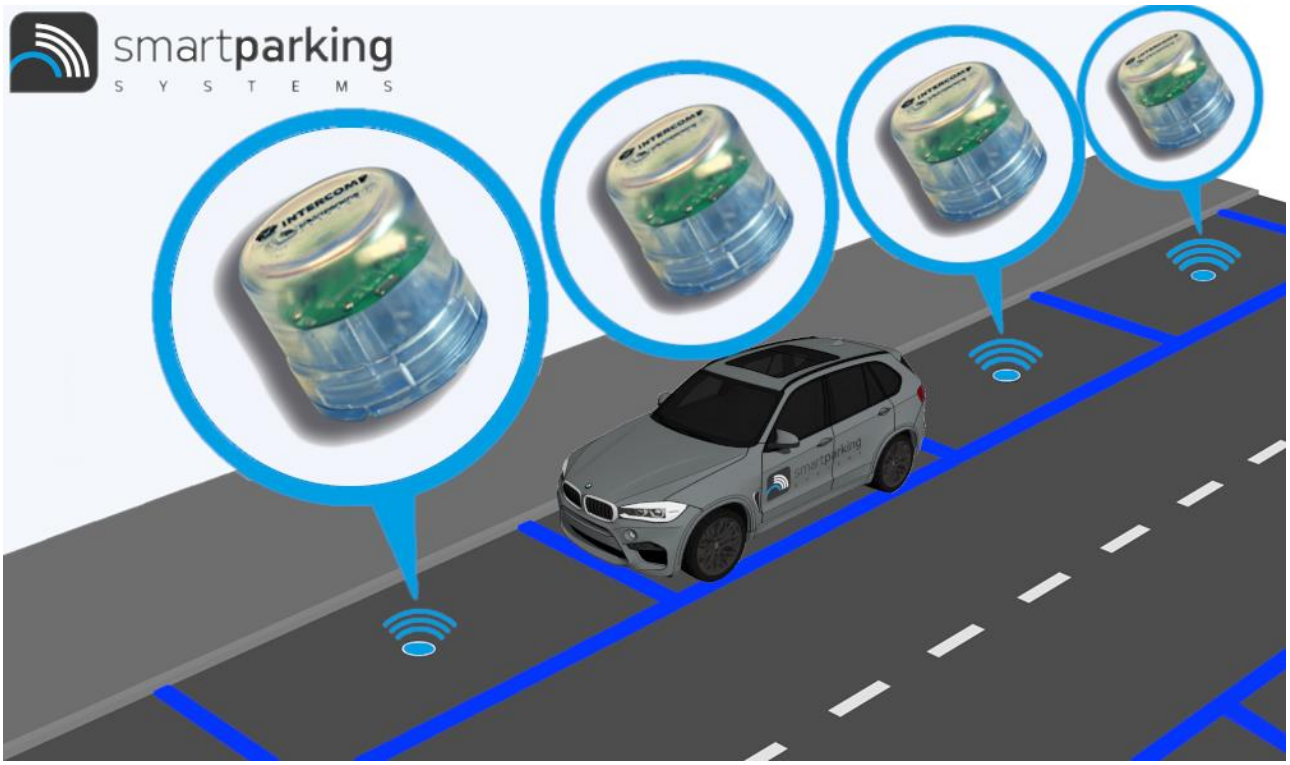


Figure : Ecoh sensor in a street parking

The sensor applies intelligent algorithms to detect changes in the state of the parking slot. Then data is transmitted with the LoRaWAN radio to the destination server/platform.

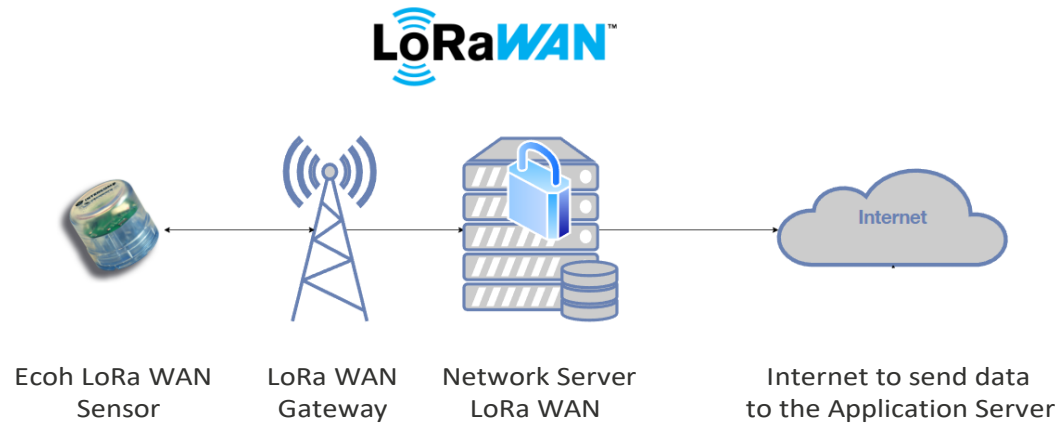


Figure : Simplified LoRa Wan network architecture

The Ecoh 915 sensor provisioning has been enormously improved. The sensors are delivered with default time settings and also unique LoRaWAN identifiers and keys. So it is easy to use the default settings to register all sensors in the LoRaWAN network server at a time.

The Ecoh 915 sensor improves the detection and stability performance thanks to unique algorithms developed by Intercomp.

2. LORAWAN NETWORK ARCHITECTURE

The LoraWan network architecture of Smart Parking is based on the next elements:

- Smart Parking Sensor
- LoRaWAN base station
- LoRaWAN Network Server
- Intercomp POLIS platform on Intercomp Cloud or Customer Server

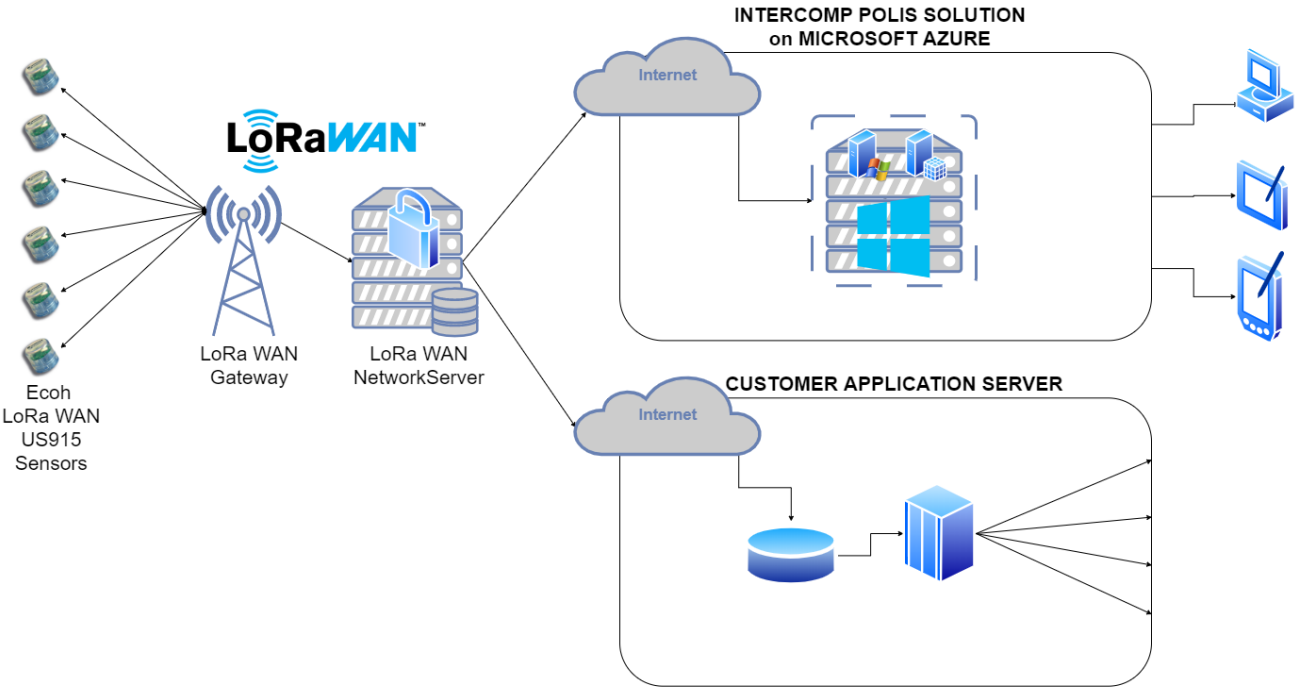


Figure : Smart Parking network architecture

3. SMART PARKING SENSOR

A Smart Parking Sensor is the device installed in each parking slot able to recognize the presence of a vehicle. When the device detects a change of the parking slot status (free/busy), it sends a frame to the LoRaWAN base station.

The Smart Parking Sensors can be used to give the availability parking information to users only (on VMS panels or directly in the Smart Parking user App), or to manage the availability and the payments of parking.

To have a good efficiency, sensors must have a precision of detection over 95%, and it has to checks the presence of a vehicle with a fast frequency (eg. every 5 or 10 seconds).

Another important characteristic of a Smart Parking Sensor is the impact at aesthetic level and the risk level for pedestrians and cyclists.

To solve all these, Intercomp Smart Parking Sensors are built for in-ground installation, totally under the pavement.

Figure : Ecoh LoRa WAN Smart Parking Sensor

4. INTERCOMP ECOH SMART PARKING SENSOR

4.1. Hardware description

The Smart Parking Sensor is based on 2 different pieces: the base and the external enclosure. The base of the Smart Parking Sensor includes the PCB, the battery, the antenna and the internal enclosure piece.

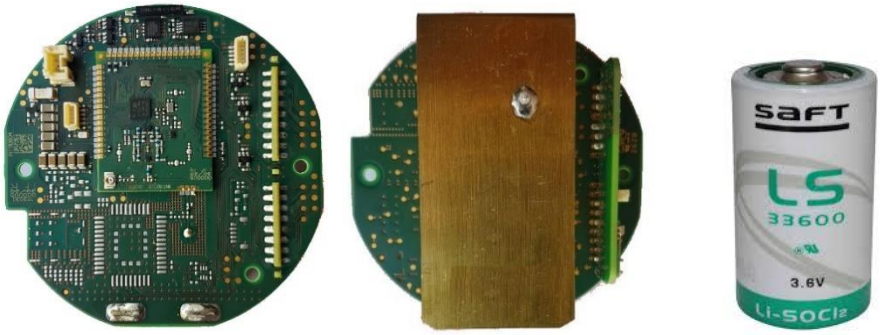


Figure: Base of a Smart Parking Sensor

The base is screwed to the external enclosure piece:

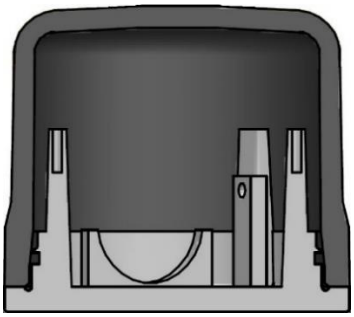


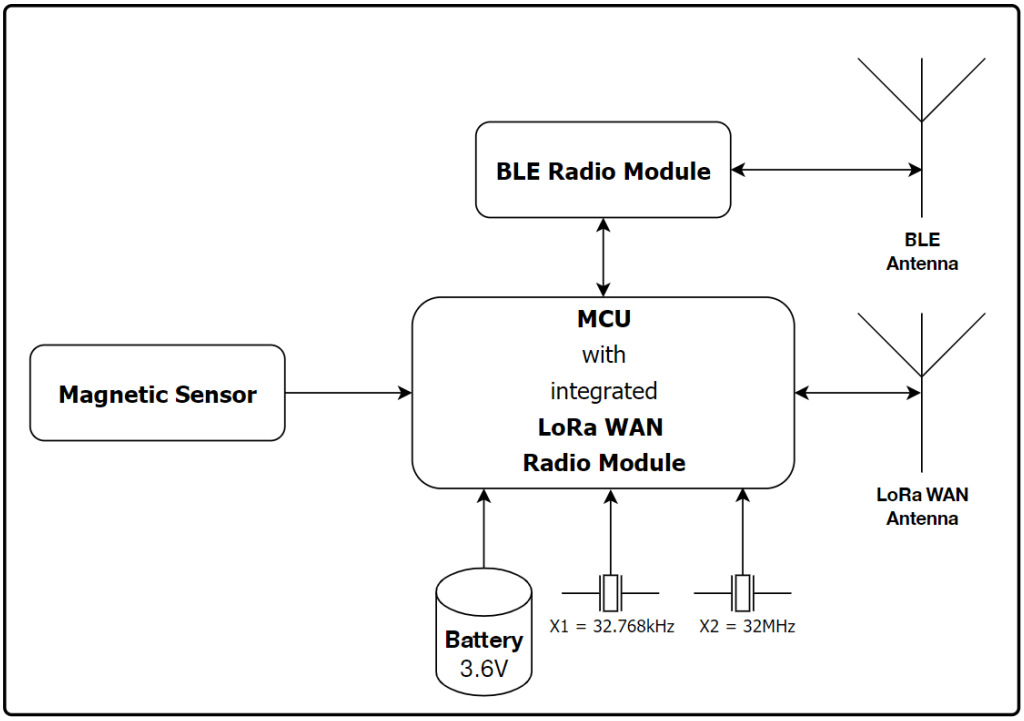
Figure : External enclosure

The next table shows the basic Smart Parking Sensor characteristics.

Power supply	Built-in lithium-thionyl chloride (Li-SOCl2) batteries;
Expected lifetime	> 10 years*
Configurable sampling time	Min: 5 s / max: 30 min
Radio protocol	LoRaWAN module integrated in the STM32WLE5 MCU
Detection	Last generation magnetic-resistive device
Provisioning	Without LoRa WAN Keys or with the Keys supplied by customer
Other communication	BLE 5.0 radio module for Maintenance App and to send Sensor's Id.
Sensor configuration	Via "SensorConfiguration" (Windows Desktop App) using a USB connection and via Android App
LoRaWAN configuration	Via "SensorConfiguration" (Windows Desktop App) using a USB connection and via Android App
On field setup	Via SmartPhone Sensor Configuration APP using a BLE connection
Operating temperature	-40 to +85 °C

(*) Under normal circumstances and depending on settings (sampling time 10 sec., maintenance advertising at 6sec., no busy advertising and up to 50 packets / day at SF7

4.2. Block diagram



4.3. Sensor versions

Intercomp provides the next versions of Smart Parking:

Reference	Version	Operating frequency	LORAWAN
Ecoh 868	Smart Parking for European market	865,000 – 868,000 MHz 868,000 – 868,600 MHz 869,400 – 869,650 MHz 2400 – 2483,5 MHz (BLE)	(LoRaWAN EU863-870)
Ecoh 915	Smart Parking for North America market	902.0 to 928.0 MHz 2400 – 2483,5 MHz (BLE)	(LoRaWAN US902-928)

4.4. LoRaWAN regions

The Smart Parking Sensor supports the next LoRaWAN regions:

LoRaWAN region	Supported by
EU 863-870 MHz ISM Band (Europe)	Smart Parking EU
US 902-928 MHz ISM Band (United States)	Smart Parking US

If you are interested in further information about LoRaWAN country regulations, please refer to the **LoRa Alliance regional parameters document**.

4.5. LoRaWAN protocol and parameters

LoRaWAN is a Low Power Wide Area Network (LPWAN) protocol. It is a spread-spectrum modulation technique at extremely low data-rates which permits sending data achieving long ranges.

The most important LoRaWAN parameters are:

- LoRaWAN EUI: Read-only, 8-byte, unique identifier which defines each LoRaWAN module in the market.
- Device EUI: Read/write, 8-byte identifier configured into the LoRaWAN module to be used as operating identifier. By default, the "LoRaWAN EUI" of the module is factory-configured as "Device EUI" in the Smart Parking Sensor.
- Join mode: ABP or OTAA. Defines how the module joins the network. Different keys are needed for each method.
- Device address: Needed for ABP. The 4-byte address of the the LoRaWAN module. Must be unique in its own sub-network.
- Network Session Key: Needed for ABP. The 16-byte AES key. Used to generate Message Integrity Check.
- Application Session Key: Needed for ABP. The 16-byte AES key. Used to encrypt data.
- Application EUI: Needed for OTAA. The 8-byte application identifier. Needed for opening an OTAA session and exchange encryption keys.
- Application Key: Needed for OTAA. The 16-byte key. Needed for opening an OTAA session and exchange encryption keys.
- Data-rate: Defines the transmission rate (bits per second). Each data-rate setting combines different Spreading Factor (SF) and bandwidth (BW). By default, all LoRaWAN regions use the same data-rate (DR 0). However, depending on the region, that means different SF and BW:
  - LoRaWAN EU863-870 version: SF12 / 125 kHz
  - LoRaWAN US902-928 version: SF10 / 125 kHz
- ADR: Adaptive Data Rate setting which can be enabled or disabled. If ADR is enabled, the server will optimize the data-rate based on the information collected from the network: the RSSI / SNR of the last received packets.

If you are interested in further information about LoRaWAN specifications, please refer to the LoRa Alliance specifications document.

4.6. Magnetic Reset switch

The magnetic reset switch can be used to wake-up sensor from deep-sleep mode before its installation.

Magnetic Reset switch is a component, located in the external side of the PCB. To activate the switch is necessary to close to it a magnet for 3 times with a frequency of 1 second (more or less), even outside the case, in the position shown in the figure. To individuate the exact position outside the case, where apply the magnet, the reference is the arrow on the top of the case (see the red dot in the right pic.). It is necessary to pass with the magnet close to that point for 3 times with a frequency of 1 second (+/-).

Figure: Reset switch position in the PCB and in the complete sensor

In the complete sensor, the red dot
Indicates the reset switch position

4.7. Sensor setup

4.7.1. "Ready to install" state

All **Ecoh 915** sensors delivered are configured with the parameters and keys communicated by customer. Usually the ID assigned to each sensor are the same of the parking bay where it will be installed.

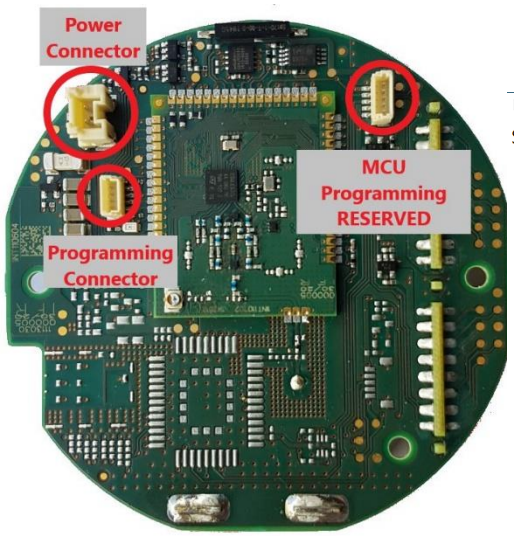
If any configuration was requested, sensors will be delivered with a standard parameters and user **must** complete the configuration before to install them.

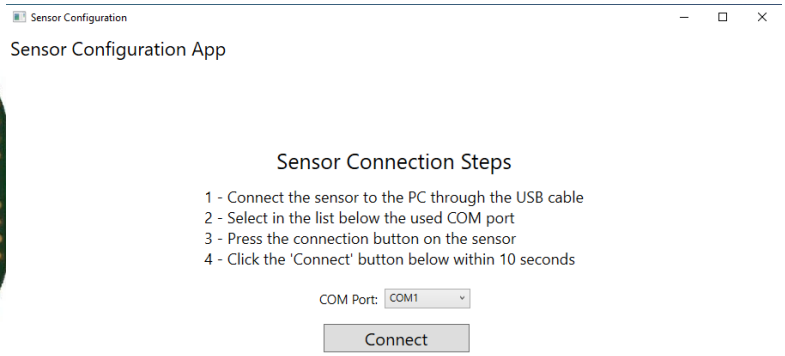
It's suggested to prepare the sensors for final installation in a lab to speed up the installation processes in the field.

The **Ecoh 915** sensor has a power-on process in order to put the device into a "ready for use " state.

Sensor Configuration App for Windows and the USB programming cable are needed to proceed.

- Step 1: Connect the USB cable to the PC and connect the 2 connectors, one for power and one for TX-RX to sensor;
- Step 2: Run Sensor Configuration App and select the correct COM port (verify it in Windows Device Manager);
- Step 3: When sensor will enter in programming mode a red LED on PCB will become fixed.
- Step 4: Within 10 seconds click on Connect button on Sensor Configuration App.





When connection will be executed, the SensorConfigurator App will read and show all the parameters set in the sensor.

The available commands for sensors are shown in the follow table

Calibration	To set Sensor at its magnetic zero.
Sampling time	Vehicle detection frequency
Keep Alive Time	Keep Alive message frequency
LoRa Wan Parameters	All the LoRa WAN keys and configurations
Slot Number	The parking bay number to assign to sensor
Magnetic Thresholds	The intervention thresholds, to determinate the free or busy status
Day/Night mode	Start – end hourly for night mode (Low Consumption)
Set Date Time	To set the actual date time
LoRa Wan Use Cases	To set the common used LoRa WAN Use Cases (in ABP and OTAA).
FW Upgrade	To upgrade the sensor's firmware

To configure other parameters please contact Intercomp team.

4.8. Sensor sealing

The sealing is an extreme important procedure. From this it depends the sensor's functionality.

The product to use to seal the sensor **must be DOWSIL™ 7091 Adhesive Sealant** (hiips://www.dow.com/en -us/pdp.dowsil-7091-adhesive-sealant.02436621h.html), or with the exactly the same specifications, with these recommended procedure:

Do this procedure in a clean and dry ambient, with humidity <60%

- Clean very well the contact surfaces
- Put the sealeant in the correct position
- Close the box and insert and tighten the screws
- Wait 48 hours before to install sensors

At the following link is possible to see a video demonstration of the Sealing Procedure. hiips://smartparkingsystems.com/tech -video/

!!! ATTENTION !!!

The use of a sealant product with different specification (eg a simple silicon sealant), it could have detrimental effects on sensors even in the short term. The expansions of materials due to temperature variations, and the use of a non-compliant product can favor the penetration of humidity inside the sensor box.

4.9. How the sensor works

4.9.1. Frame types

The Smart Parking architecture manages different uplink and downlink frames. The next table shows the Uplink frames:

Frame type	#num	Description
Keep Alive	1	Keep alive packet, sent every xxxx seconds without any status change.
Measurement	2	Used to inform a Parking Status change
Command ACK	3	Used to confirm a "Configuration command downlink" was applied

The next table shows the Downlink frames:

Frame type	#num	Description
Configuration downlink	3	Used to update the sensor parameters. After the customer sets up a new sensor configuration in the Remote Configuration Form a new "Configuration downlink" frame is enqueued into the LoRaWAN network server's downlink queue.
Ack Message received		Used to confirm the packet reception from the management platform

To get the last payloads documentation ask for it to Intercomp's team

4.9.2. LoRa WAN Keys and AppEui

At the order, the customer can require to set all the keys and the AppEui, ready for its network.
Otherwise all the sensors will be delivered with all the Lorawan keys set to zero.

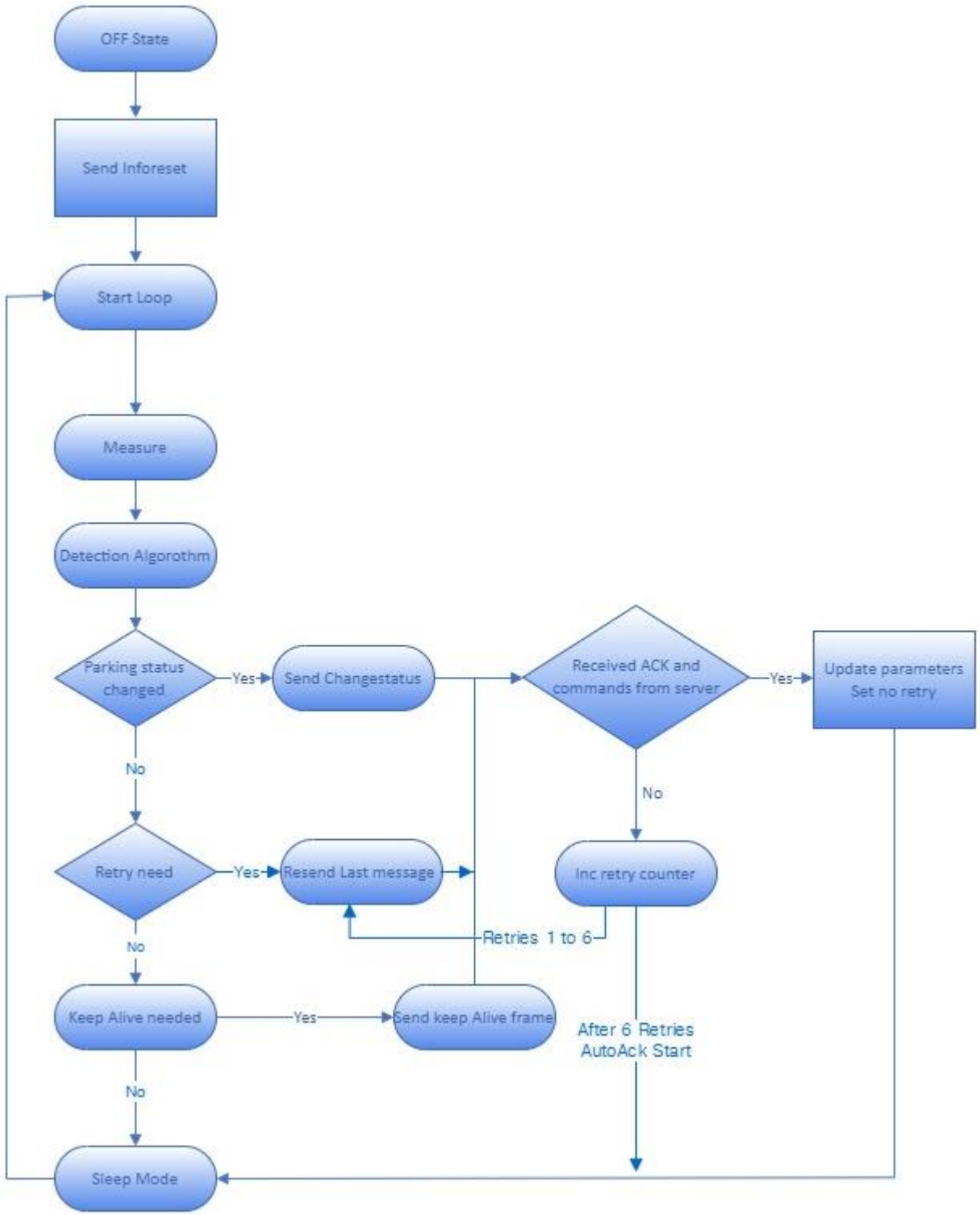
AppSKey = 0x00000000000000000000000000000000;
NwkSKey = 0x00000000000000000000000000000000;
AppKey = 0x00000000000000000000000000000000;
AppEUI = 0x0000000000000000;
All the keys and AppEui can be set via Sensor Configuration SW.

It will be possible to set the keys and AppEui before installation and before to seal the sensors, using the programmation cable and the WPConfig software supplied by Intercomp.

If the order require **sealed sensors**, keys and AppEui **MUST BE SET** during production procedure.

4.9.3. Sensor program flowchart

Figure : Smart Parking Sensor program flowchart



4.10. Sensor parameters

4.10.1. Parameters description and ranges

The Smart Parking Sensor has different parameters that change the timing and detection performance of the sensor. The next table shows the sensor parameters:

Parameter	Range	Description
Sampling period	5 sec.* to 30 min. (*minimum suggested)	Seconds elapsed between each measurement cycle (not linear scale).
Keep-alive time	60 min* to 24 hours (*minimum suggested)	Hours elapsed since last uplink message which triggers a new Keep-alive frame (not linear scale).
AutoACK	1 to 7	Sensor gives itself an ACK after x retries without an ACK from the network
Address Set	1 to 65534	Range of sensor ID (associated to park ID)
LoRa WAN Use Cases ABP	1 or 2	ABP confirmed packet and wait answer from customer platform ABP confirmed packet and NOT wait answer from customer platform
LoRa WAN Use Cases OTAA	1 or 2	OTAA confirmed pack and wait answer from customer platform OTAA confirmed pack and NOT wait answer from customer platform Daily rejoin (default NOT daily rejoin) Re-join if needed (if the gateway does not respond to the sensor, it will join with the LoRa WAN base parameters (14dBm @ SF12)
LoRaWAN DevEUI	8-byte identifier	Defines the device EUI used by the LoRaWAN radio
LoRaWAN DevAddr	4-byte identifier	Defines the device address used by the LoRaWAN radio in ABP mode
LoRaWAN NwkSKey	16-byte key	Defines the LoRaWAN Network Session Key used by the LoRaWAN radio in ABP mode
LoRaWAN AppSKey	16-byte key	Defines the LoRaWAN Application Session Key used by the LoRaWAN radio in ABP mode
LoRaWAN AppKey	16-byte key	Defines the LoRaWAN Application Key used by the LoRaWAN radio in OTAA mode
LoRaWAN AppEUI	8-byte identifier	Defines the LoRaWAN Application EUI used by the LoRaWAN radio in OTAA mode

4.10.2. Operational description

ECOH US915 is a magnetic sensor for Smart Parking vehicle detection.
It's based on a magneto-resistive chip, able to detect the presence of a metallic mass close to it.
This device measures the magnetic earth field, and the variations induced by metal masses placed in its vicinity.
The measurement is made on three axis and the sum of these three values gives the total result.

Important:
The LoRaWAN identifiers and keys must be registered in the LoRaWAN network server before starting the node in order to receive data.
For OTAA mode: DevEUI, AppEUI and Appkey.
For ABP mode: DevEUI, DevAddr, NwkSKey and AppSKey.

The use of three thresholds allows sensor to identify the status of free or busy of the parking bay.
ECOH US915 after its installation needs to be calibrated at its magnetic zero.
When it's operational, it samples every x seconds (adjustable from 5 sec. to 30 min.), the status of the magnetic field.
If the magnetic value is same the previous read it returns in sleep mode.
If the magnetic value exceeds the set thresholds it switch on the LoRa WAN radio and it transmit the packet (free or busy plus timestamp and other parameters) to the LoRa WAN network and through this to the backend and to the front end software.
If for a long time sensor doesn't detect any variation, it transmit a Keep Alive message to the backend. Keep Alive can be set from 60 minutes to 24 hours, it depends from the use of sensors and from the performances required by the customer.
Power is guarantee by a high power LiSoCl2 not rechargeable battery, with 17000 mA/h at 3.6V.

4.10.3. Understanding Info and Keep-aliveframes

In the regular working mode, "Sampling" and "Keep-alive" parameters are used. So the sensor normally sleeps for a specific time then wakes-up for sampling (measurement) and applies the algorithm detection in order to detect changes in the parking slot.

If a change is detected from ’free’ to ’occupied’ or viceversa, then an "Info" frame is sent. If no change occurred during the last "Keep-alive" time, then a Keep-alive frame is sent. Besides, if a sensor error is detected, a Keep-alive frame sending is forced in order to inform about this issue.

Example parameters used:

- Samplig: 10 seconds
- Keep-alive: 1 hour

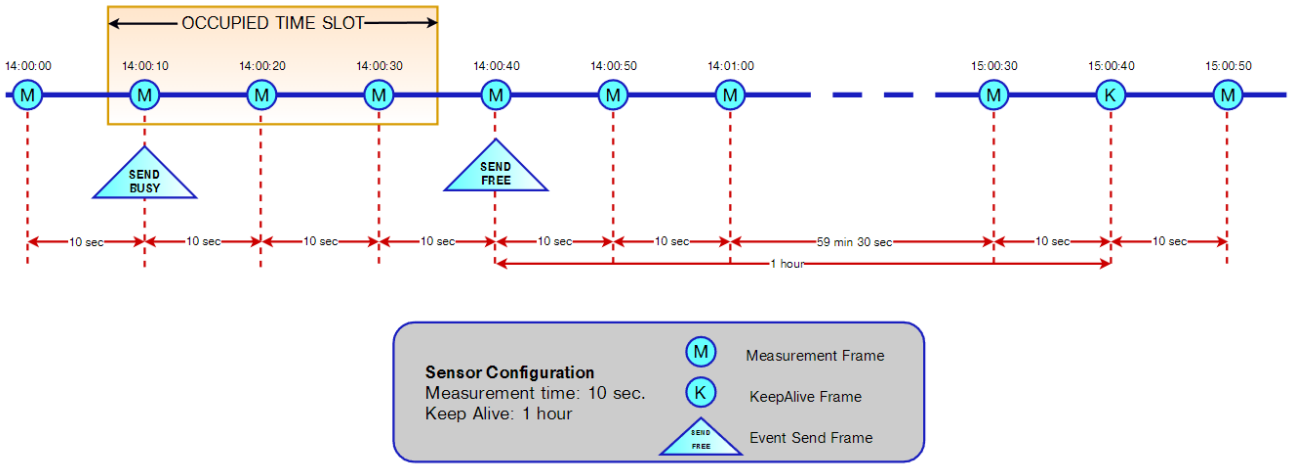


Figure : Example Info and Keep-alive frames

4.10.4. Factory default values

Intercomp provides all Smart Parking Sensors with factory default parameters.

Parameter	Default value
Sampling period	10 sec
Keep-alive time	1 hour
BLE Adv. for mainten.	6 sec.
BLE Adv. for busy status	Disabled
LoRaWAN join mode	1 (OTAA, confirmed packet, no wait ACK from server)
LoRaWAN DevEUI	Unique device Id
LoRaWAN DevAddr	Set by NS in ABP activation
LoRaWAN NwkSKey	0000 0000 0000 0000 0000 0000 0000 0000 (or the key indicated by customer)
LoRaWAN AppSKey	0000 0000 0000 0000 0000 0000 0000 0000 (or the key indicated by customer)
LoRaWAN AppKey	0000 0000 0000 0000 0000 0000 0000 0000 (or the key indicated by customer)
LoRaWAN AppEUI	00 00 00 00 00 00 00 00 (or the key indicated by customer)
LoRaWAN ADR	Enabled

All needed changes MUST be done before the sensor sealing procedure.

4.11. Configure new parameter values

The Sensor Configuration App (for Windows desktop) and the Parking Sensor App (Android) allow the user to configure new parameters to the sensor. The 1st one is a desktop application which implies opening the sensor enclosure and plug a micro-USB cable to the sensor. The 2nd one is a smartphone app, delivered by Intercomp direct to the customer, which permits to remotely change some of the sensor parameters.

Regarding the time and sensor parameters, the same values are set to all sensors manufactured by Intercomp. The default values can be seen in the previous section. However, the customer can configure the time and sensor settings using both Configuration Manager App (if sensors are not already sealed) and Sensor Configuration App.

Regarding the LoRaWAN parameters, if the customer require to have random LoRa WAN keys set by Intercomp during production phase, all keys will be randomly generated for each sensor and kept secret. The DevEUI set to the sensor is the LoRaWAN hardcoded EUI which is unique for each radio chipset. However, the customer can configure/modify all LoRaWAN parameters using the SensorConfiguration App or the ParkingSensor App.

Note: For further information about this matter please refer to the next "Sensor Configuration App" and "ParkingSensor App" sections.

5. SENSOR CONFIGURATION APP

Intercomp Sensor Configuration App is a software tool developed by Intercomp that allows users install new firmware versions and to set all the configuration of the new Intercomp devices in a few clicks.

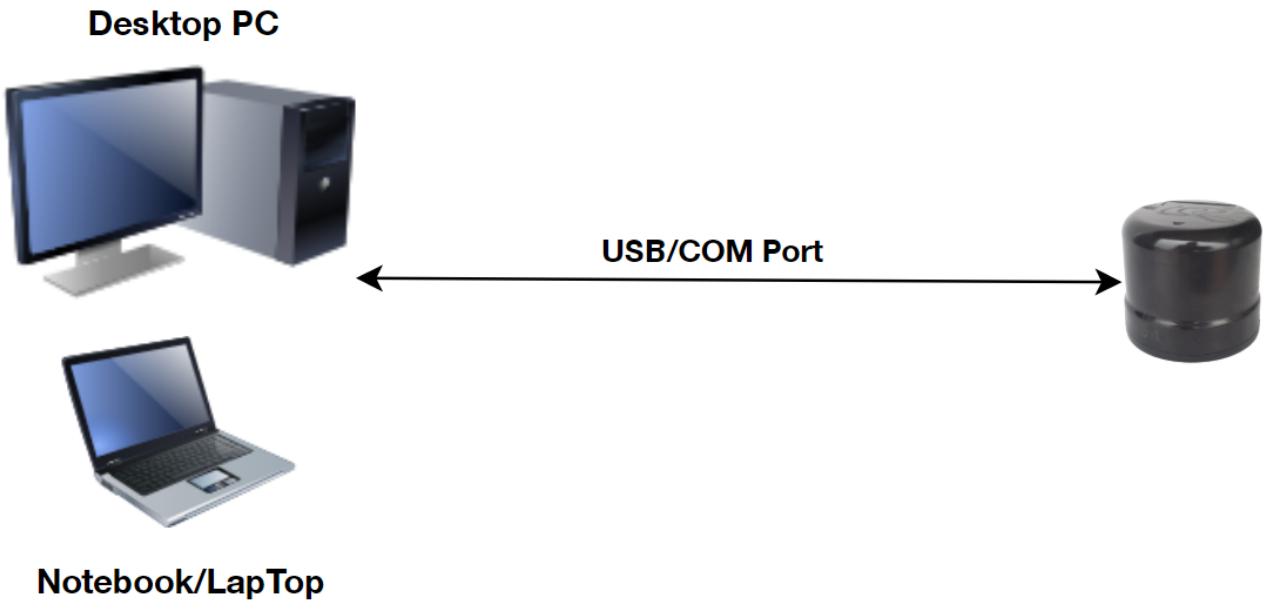


Figure : Configuration Manager App is connected to the sensor via USB cable

5.1. How to install the Sensor Configuration App

Sensor Configuration app require a standard Windows 10 PC. SensorConfiguration App will be downloadable for Intercomp Customer, for the Intercomp customer. They will be receive all the instructions to download it.

A **Ecoh USB cable** is needed to connect PC to the sensor.

5.1.1. Start Configuration Manager App on Windows

Run the installation file supplied by Intercomp in your PC

5.2. Upgrading the Configuration Manager App

Occasionally, some improvements and new services will be released. In this case, the new version of Configuration Manager App will be published in the download page. Please check on it for the new versions.

5.3. Sensor Configuration App sections

Sensor Configuration is developed for ECOH Sensor series only.

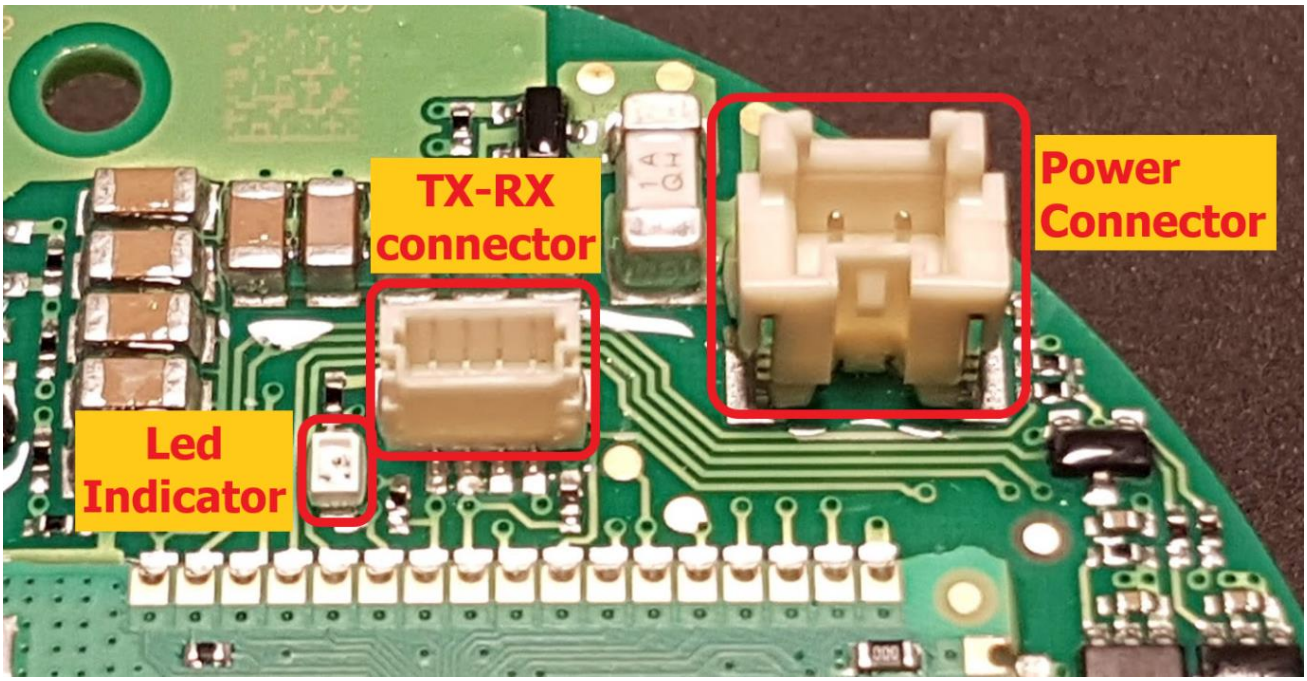
The main sections are:

- Information, to see all the parameters configured in the sensor;
- General Settings, to modify the general functionality of sensor;
- Network Settings, to set all the parameters of the network available;

5.4. How to plug the Smart Parking Sensor

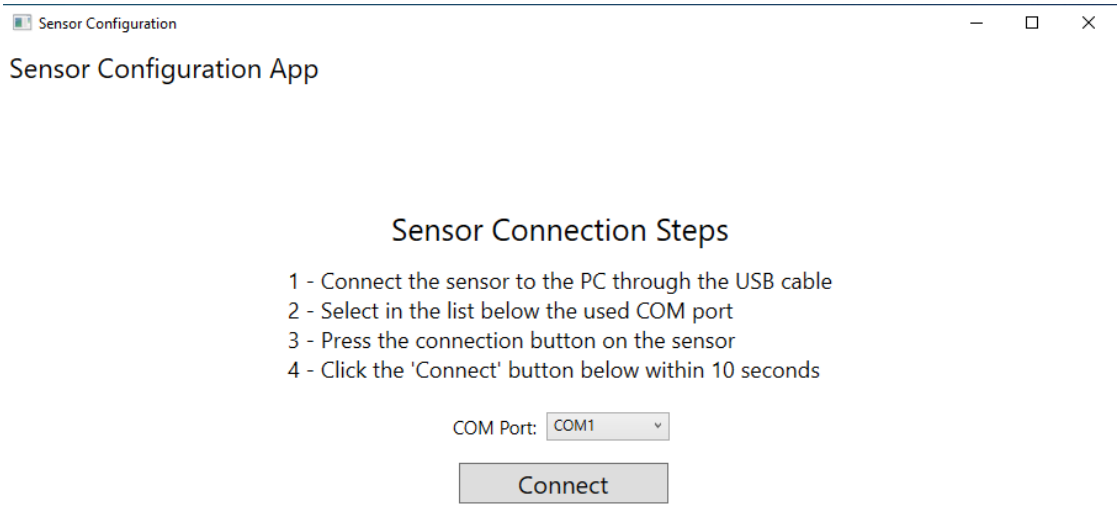
Before using the Sensor Configuration App, you must connect sensor to USB cable, and power on the sensor.

The Ecoh USB cable has 2 connectors on the sensor side, one for Power and one for TX-RX. After the connection of the power wait 10 seconds for sensor startup, and then push the switch to enable the connection with Sensor Configurator App.



Before to press the Connect button select the correct COMx port number to use.

The Ecoh USB cable includes in the USB connector a FTDI USB – RS232 converter. If you don't find any COMx port, please check on Windows Device Manager if the USB driver is correctly installed.



5.5. General Settings (change sensor parameters)

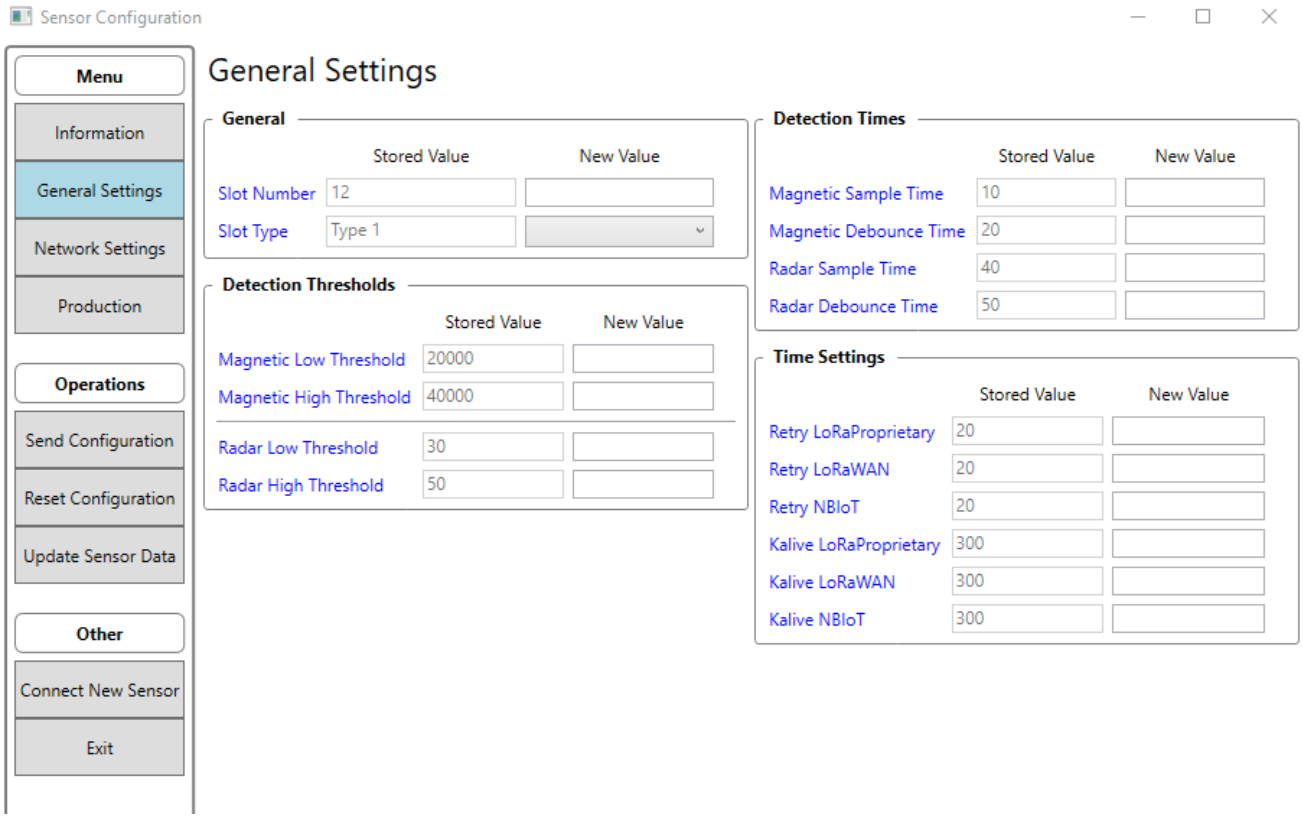


Figure : Sensor Configuration App General Settings

With this menu is possible to see actual sensor's configuration and modify all the parameters with new ones.

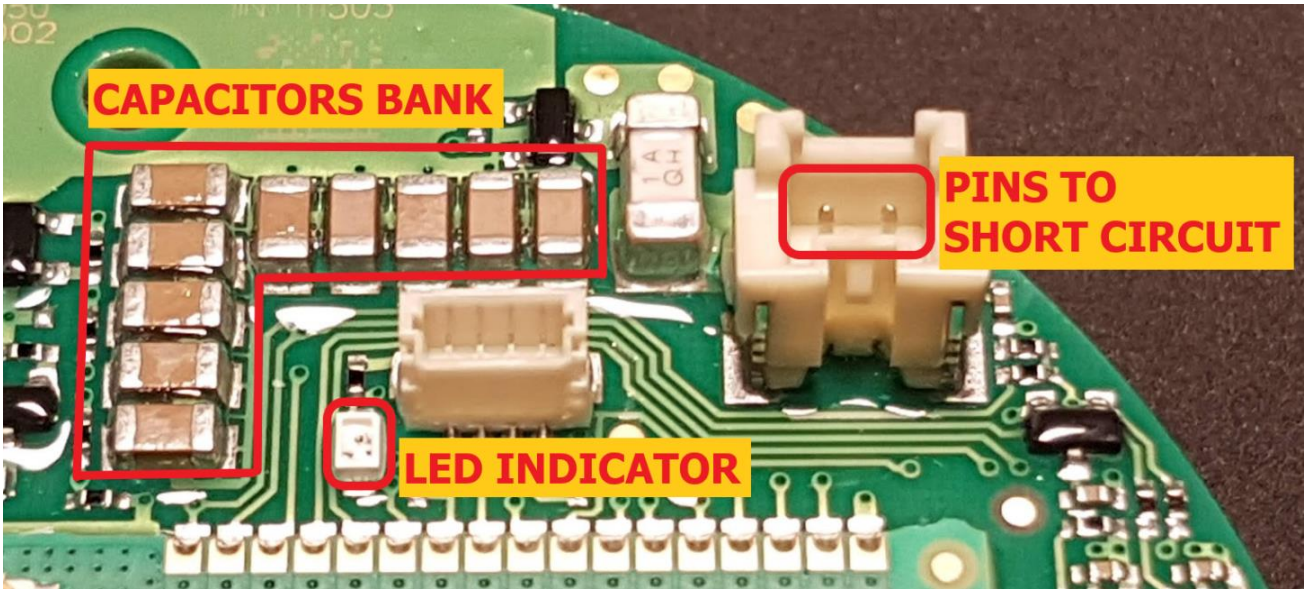
When new parameters are set, clicking on the button Send Configuration, these will be written in the sensor memory.

PLEASE READ CAREFULLY THE NEXT PAGE.

!!! ATTENTION !!!

If one or more changes made with Sensor Configurator app though USB cable are related to LoRaWAN or NB-IoT network (keys or network parameters)**, sensor MUST be restarted to enable the new configuration.**

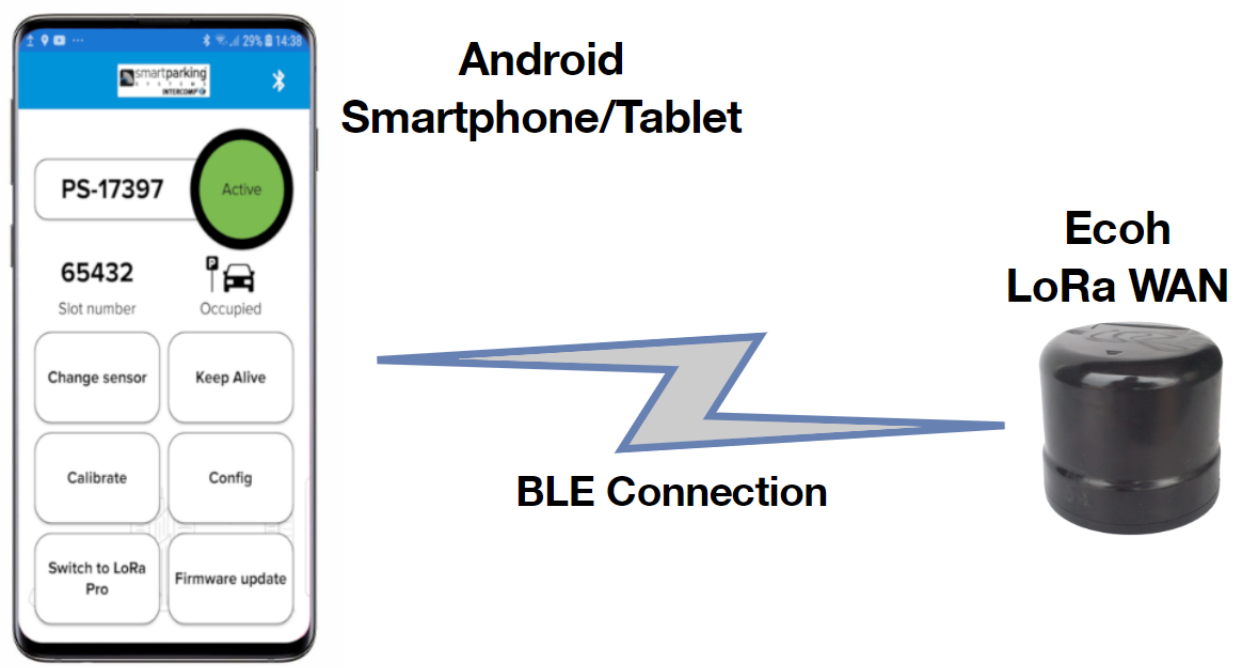
To do this, please remove the power connector and wait up to 5 minutes for the capacitor discharge or to do it faster, with a little screwdriver, shortcircuit the power pins inside the power connector, to discharge immediately the capacitors bank. To understand if sensor is restarting with the new configuration, when the power connector will be plugged again, the red **LED indicator** close the connectors must be on for around 2 seconds (see the follow image).



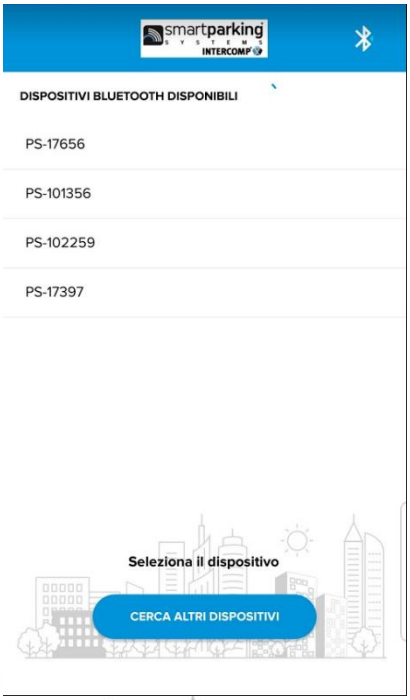
6. PARKING SENSOR APP

Parking Sensor App is the Android based app for the on-site management of sensor. It can be used to sends commands to sensors directly on the field, for example to calibrate them and to modify parameters.

Parking Sensors App uses a BLE connection protected to communicate with Ecoh Sensor.



Parking Sensor App is distributed by Intercomp directly to its distributor or customer and it's not published on Android Store.

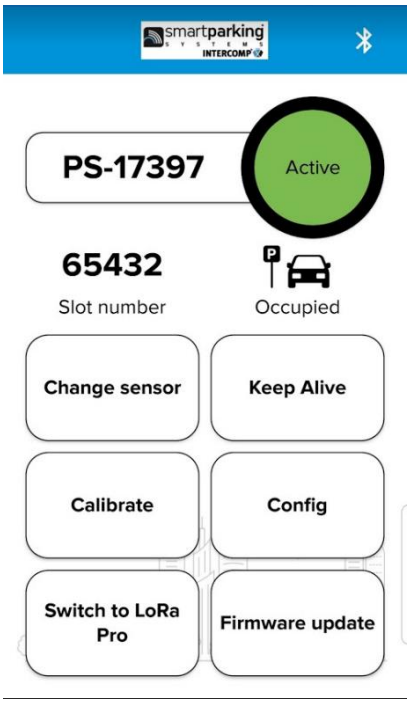


The installation of Parking Sensor in an Android device does not require particular permissions or authorization. It only uses the BLE radio to weak-up sensors and to send to them commands or to retrieve the actual configuration.

When it starts it shows the sensor's id received. Clicking on one id a connection will be established with that sensor.

If the selected sensor is present in the sensor's configuration file of the customer, that contains all the permission keys of the sensors, the home page of the configuration will be opened.

If the sensor is not present in the sensor's configuration file, app will ask to insert the PIN code for association, and the Login Key of the sensor.



When a connection is established the home page it will be shown.

In the home page are present:

- The mac address alias (eg. PS-17397)
- Sensor id number (eg. 65432)
- The status (free or occupied)
- And if it's active or Not Active (the big dot, green or white)

and 6 buttons for:

- Change the sensor
- Force a Keep Alive message from sensor
- Calibrate the sensor
- Open the Configuration Menu to see the actual config and to change parameters
- Switch sensor from LoRa WAN to LoRa Pro (not enabled for US/Canada)
- Update the sensor's firmware via BLE

!!! IMPORTANT !!!

When Parking Sensors App is connected to a sensor, sensor can't communicate in LoRa Wan, because it's possible to use one connection per time only.

7. CERTIFICATIONS

7.1. Conformity

The Smart Parking Ecoh US complies with Title 47 Part 15 subpart B of the FCC rules and regulations for Radio Frequency Devices – Unintentional Radiators (2019).

This device contains the following BLE transmitter module:

- **FCC ID: S9NBNRGM2SA**

  This BLE module with embedded stack and profile has been qualified in accordance with SIG qualification rules:
  - Declaration ID: D043965
  - Qualified design ID: 121363
  - Product type: End Product
  - Core spec version: 5.0
  - Product description: BLE v5.0 module

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 operatio.

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

FCC ID: 2AUT7ECOH-915

7.2. Note to users

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

—Reorient or relocate the receiving antenna.

—Increase the separation between the equipment and receiver.

—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

—Consult the dealer or an experienced radio/TV technician for help.