D678H: Insafe+ Carbon LoRa

Technical Guide

02/03/21

www.nexelec.fr

NEXELEC – SAS au capital de 420.000 euros
518 790 449 RCS AIX – Code NAF 7112 B – N° TVA FR 54 518 790 449
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1.Presentation

1.1   Introduction to the product

Carbon dioxide detector and indoor air quality monitor

INSAFE+ Carbon is a new generation carbon dioxide detector that also includes a temperature and humidity sensor. INSAFE+ Carbon is not simply a CO2 sensor. Thanks to its « Edge Computing » architecture and its IZIAIR embedded algorithm, INSAFE+ Carbon calculates an indoor air quality index to help you take appropriate actions.

INSAFE+ Carbon is also a connected physical button that you can program with two different actions (short or long press) and an intuitive light feedback.

It is an ideal product for connected homes, residential or tertiary buildings and public establishments (schools, nurseries, leisure centers, retirement homes, etc.).

Product benefits:
> 3-in-1 carbon dioxide detector, Indoor Air Quality monitor and push button
> IZIAIR Indoor Air Quality Indicator
> Wireless sensor for easy and fast installation
> 10-year battery life for the product and wireless connection
> Elegantly designed detector

Applications:
> Control of indoor air quality in residential premises and public places
> Control of HVAC system
> Maintenance optimization
> Improvement of building energy efficiency
> Development of new services: home care assistance, well-being, heating cost savings, etc.

Basic functions:

> Measurement of CO_2, temperature and humidity every 10 minutes

> Programmable push button

> Air quality measurement and instant display with indicator lights:

Green: Optimal air quality

Orange: Moderate air quality

Red: Poor air quality

Advanced features:

> Reconfigurable Product via NFC with NFC Configuration Tool application

> IZIAIR indoor air quality index (5 levels)

> Residual battery life

> Functional self-test (every 10 min.)

> Optimized message transmission: alert management on thresholds, keepalive, datalogging, etc.

1.2   Product scheme

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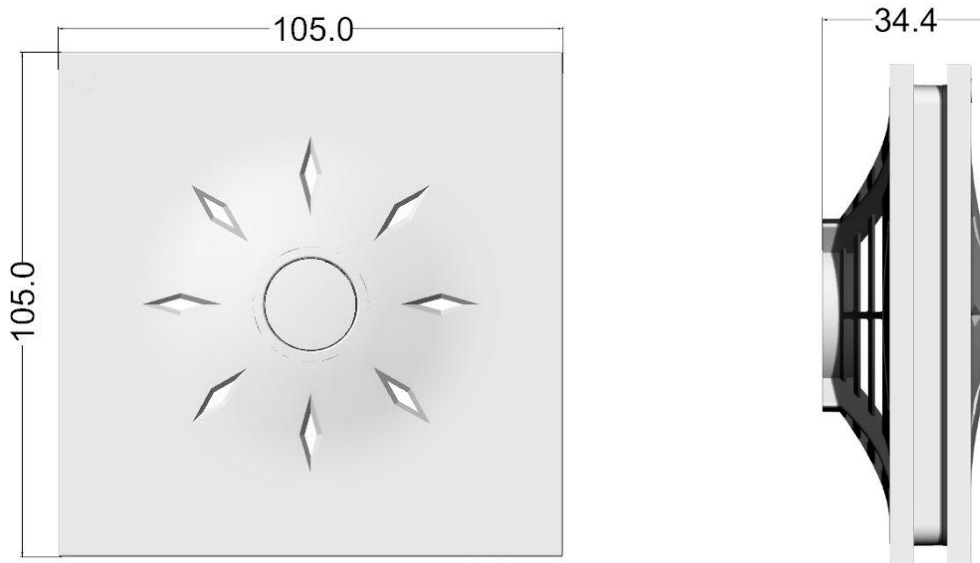
1.3 Detailed specifications

Product terms of use

> Indoor household environment

> Temperature: 0°C to + 50°C

> Relative humidity: from 0 to 95% RH (non-condensing)

Sensors and measurements:

		CO2	Temperature	Humidity
Accuracy	Typical		±0.3 °C	±2 %RH
	Max	±50 ppm +/- 3% of the value	±0.4 °C	±3 %RH
Resolution		20 ppm	0.2 °C	0.5 %RH
Measuring range		0 – 5000 ppm	0 – 50 °C	0 – 100 %RH
Measuring period		10 min	10 min	10 min

Certifications

The product is compatible with the following directives and standards:

Directives

-Radio Equipment Directive (RED) 2014/53/EU
-2011/65/EU (RoHS) Directive

Standards :

-EN 62368-1
-EN 301 489-1 V2.2.0
-EN 301 489-3 V2.1.1
-EN 300 220-2 V3.2.1
-EN 62479 : 2010

2.Installation

2.1   Installation locations

Recommended locations in a domestic or tertiary environment

It is recommended to install the detector:

- Less than 1 meter above the ground if the detector is placed on an item of furniture or a shelf (using the mobile mounting base delivered with the detector)
- Less than 1.5 meters above the ground if the detector is wall mounted (attached with screws and wall plugs)

In order to obtain accurate and reliable data, we suggest you follow recommended locations.
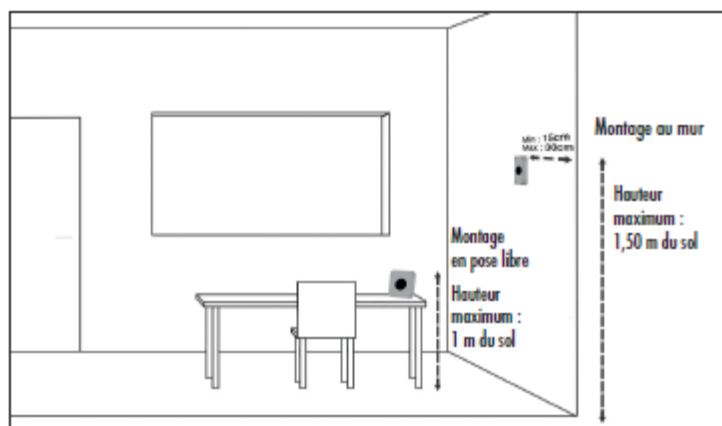
Locations to avoid

Do not install the indoor air quality monitor:

- Less than 30 cm from the ceiling

- Outdoors

- In a location where the temperature is less than 10°C or more than 50°C

- In a location where humidity levels is more than 95% (bathroom, kitchen, laundry room, etc.)

- In a dusty or dirty location (garage, workshop, etc.)

- Less than 1 m from doors and windows, heating, cooling or air vents

- In a narrow area where the detector could be damaged

- In a contained location (e.g. in a cupboard or behind a curtain)

- In a location where the detector could be blocked (e.g. by furniture)

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2.2 Description of mountings
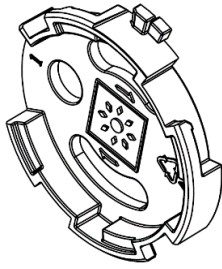
Mounting base for wall-mounted   *Mobile mounting base for standalone mounting*
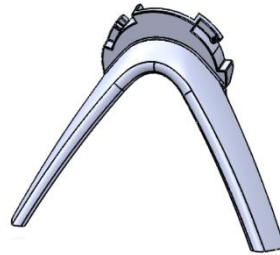
2.3 Mounting and bracket

Attaching the detector to a wall

Use the mounting base and the screws and wall plugs provided with the detector.
The product can also be mounted using the adhesive attachments.
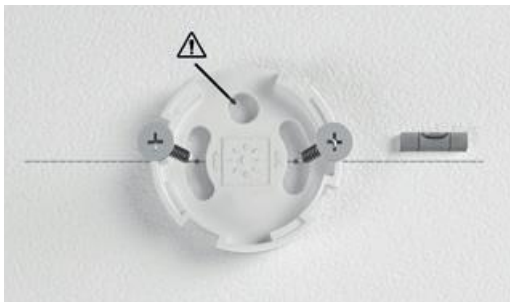
Comply with the following procedure:

> Select an appropriate location to secure the detector to the wall

> Remove the mounting base from the detector

> Mark the preferred location of screw holes on the wall using a pencil. The drawing inside the base

shows the final position of the detector when attached. (3)

> Insert the nylon wall plugs provided and screw on the mounting base (4)

> Place your detector on the mounting base and then rotate a quarter turn to the right to secure.

You should hear a «click», indicating that your detector is secured in its mounting base (5)

> Check that your detector is securely fitted to the wall

Standalone mounting

Use the mobile mounting base supplied with the detector.
Comply with the following procedure:
> Place the detector on an item of furniture or a shelf, less than 1 meter above the ground, to prevent any damage if the detector accidentally falls.
> Place your mobile mounting base on the back of the detector and then rotate a quarter turn to the right to secure. You should hear a «click», indicating that your detector is secured in its mobile mounting base.

2.4 Activation and commissioning process

Activation

To commission your monitor, activate the single-use switch (1)

Initial commissioning

The orange LED will blink during the join process (max 25 seconds). The green LED will remain ON during the initializing period (maximum 1 minute) if the process has been successful, in red otherwise.
If the initial commissioning failed, the product will automatically retry once. In case of failure, the product will then follow the commissioning strategy described below (Refer to Commissioning strategy in case of initial failure).
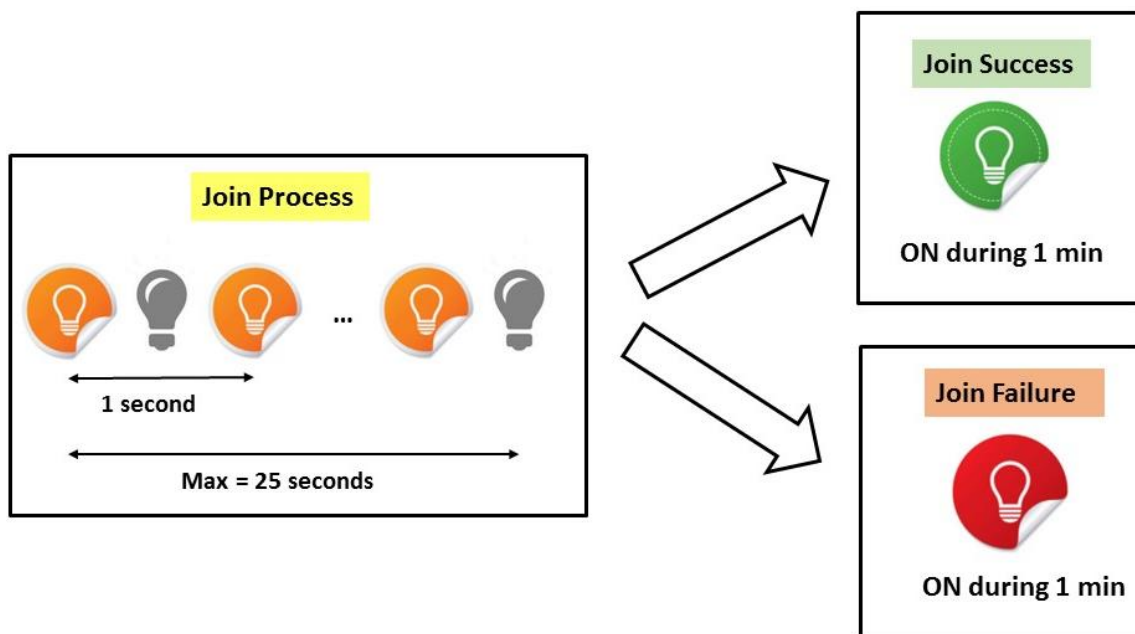
Product configuration and coverage analysis process

If the commissioning process is successful, the product will send its configuration (refer to section 5.11 Product configuration: general functions and 5.10 Product configuration: functions relative to CO2), its status (refer to section 5.5 Product status) and 9 keepalive frames with about 10 seconds between each frame. This process intends to provide enough data for radio coverage analysis.

Commissioning strategy in case of initial failure

If the initial commissioning process failed, the product will automatically try to join the network with an increasing period between each try:

1st retry will occur 20 minutes after initial commissioning.
2nd retry will occur 40 minutes after 1st try.
3rd retry will occur 80 minutes after 2nd try.
….
In case of failure, the product will then try to join the network every 24h.

Schedule a recommissioning

You can schedule a join request. The typical use case is when you want to switch from a server to another. This function is available through downlink command. A confirmation message is sent to confirm the activation of the scheduling (Product status message, join request pending bit).

3.Air quality LED indicators

INSAFE+ Carbon measures temperature, relative humidity and carbon dioxide (CO_2) levels every 10 minutes.
The CO_2 level, produced naturally through breathing, is a good indicator of containment level.
INSAFE+ Carbon calculates an index that assesses the quality of air renewal.

LED	Flashing Period (sec)	CO_2 level* (ppm)	Indoor Air Quality	Analysis and recommended actions
🔴	3	> 1700	Bad The air renewal is too low	The concentration of carbon dioxide is too high. Ventilate the room right now and check the ventilation systems to improve indoor air quality
🟠	3	1000 – 1700	Poor The air renewal is low	The concentration of carbon dioxide is high. Ventilate the room to improve indoor air quality
🟢	600	< 1000	Excellent Optimal conditions	Measurements are good, indoor air quality seems ideal!

*: ±100 ppm hysteresis is applied on the CO2 level to avoid regular switch between levels. These CO2 levels can be reconfigured (See section 5.13 Reconfiguration via downlink message).

Note: The orange LED, indicating a poor air quality, can be deactivated via downlink message or via NFC.

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4.Programmable push button

INSAFE+ Carbon has a programmable push button that enables to launch scenarios (heating, ventilation, presence, etc.) when the product is integrated into a connected ecosystem.

After a **short press** (< 1 second), led corresponding to the last indoor air quality is ON during 3 seconds (refer to table above for details on led indicators). A message is sent containing the type of button press and generating the triggering of appropriate actions (see section 5.6 Button press).

After a **long press** (> 2 second), red-orange-green LED flashes to indicate that the press has been considered. A full measurement is done (CO_2 + temperature + humidity) and sent (see section 5.4 Real Time Data).

A **multiple press (3 times)** generates an OTAA join request. No message of « Button press » type is sent.

A **multiple press (6 times)** generates a recalibration of the CO_2 sensor (See section 9.1 Recalibration of CO_2 sensor). No message of « Button press » type is sent.

5.Description of payload

5.1   General description

Insafe+ Carbon is a configurable product to measure CO_2, temperature, humidity and to analyze indoor air quality. Insafe+ Carbon includes advanced features such as real time measurement, datalogging, alert management, etc.

In order to optimize battery life, management of messages and subscriber fees on network, the functions can be activated, deactivated and configured.

ID Message	Details of the function	Transmission of message	Can be deactivated	Configurable
0	Weekly analysis	Periodic	Yes	TBD
1	Daily analysis	Periodic	Yes	TBD
2	Real time data	On event	Yes	Yes
3	Product status	On event	No	No
4	Button press	On event	Yes	No
5	Datalog Data	Periodic	Yes	Yes
6	Temperature Alerts	On event	Yes	Yes
7	CO_2 Alerts	On event	Yes	Yes
8	Product Configuration CO_2 functions	On event	No	No
9	Product Configuration General functions	On event	No	No
10	Keepalive	Periodic	Yes	Yes

5.2   Weekly analysis

This function will be implemented and documented later.

5.3   Daily analysis

This function will be implemented and documented later.

5.4   Real Time Data

The product measures and sends a message containing environmental data every 10 minutes. You can deactivate the automatic sending of a message when data have not changed. The evolution criterium, called delta, can be configured independently on the 3 values measured (CO_2, temperature, humidity) via NFC application (see section 6 NFC) or downlink.

Example 1:

The table below shows the evolution of the 3 measured values and the associated sending of message according to a configured delta.

	CO2	Temperature	Humidity	
Configured delta	150 ppm	0.5°C	5% RH	
Measurement #				Message sending
1	**500**	**20.0**	**45.4**	Yes (1st measurement)
2	550	20.4	44.2	No
3	575	**20.6**	43.4	Yes
4	650	20.7	42.0	No
5	**780**	20.8	41.4	Yes

Example 2:

The chart below compares the evolution of the measured CO2 level VS the level actually transmitted by the product.

The maximum deviation between these two curves is defined by the value of the product configured « delta », here 150ppm. In this example, such a delta value enables to follow the CO_2 progress with a low margin of error while decreasing by almost 60% the number of messages sent.

CO2 measured	CO2 transmitted
400	**400**
400	
450	
400	
460	
500	
600	**600**
700	
800	**800**
950	**950**
1200	**1200**
1300	
1500	**1500**
1750	**1750**
1700	
1650	
1700	
1750	
1600	**1600**
1500	
1300	**1300**
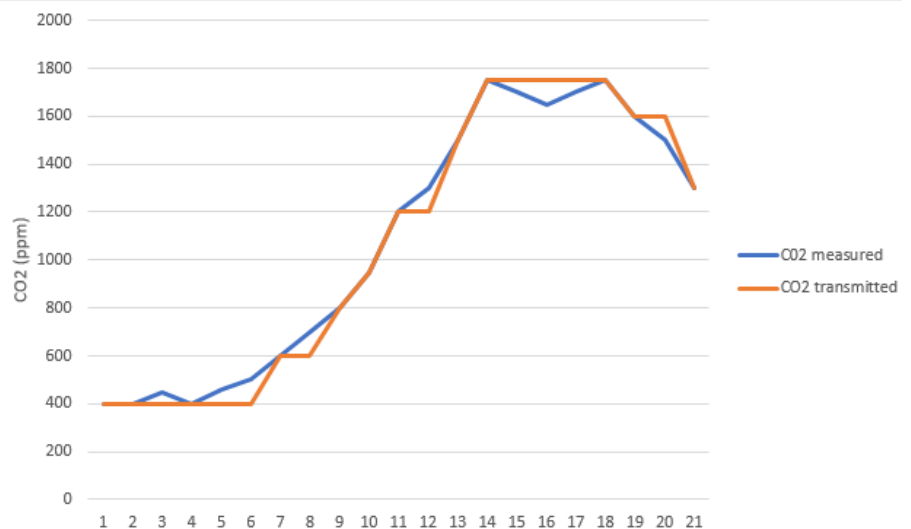
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Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Product Type	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Real-Time Data	0x2		
8	8	DB1.7 DB1.0	CO2 level	CO_2 level (linear), increment = 20ppm	0 - 250	0-5000	ppm
					255	Error	
16	8	DB2.7 DB2.0	Temperature	Temperature (linear), increment = 0,2°C	0-250	0-50°C	°C
					255	Error	
24	8	DB3.7 DB3.0	Relative Humidity	Relative humidity (linear), increment = 0.5%RH	0-200	0-100	% RH
					255	Error	
32	3	DB4.7 DB4.5	IAQ_GLOBAL	IZIAIR global air quality index	0: Excellent 1: Good 2: Fair 3: Poor 4: Bad 5…6: Reserved 7: Error		
35	4	DB4.4 DB4.1	IAQ_SRC	IZIAIR Data source	0:All 1:Drought Index 2:Mold Index 3:Mite Index 4:CO 5:CO2 … 15:Error		
39	3	DB4.0 DB5.6	IAQ_CO2	CO2 Air Quality	0: Excellent 1: Good 2: Fair 3: Poor 4: Bad 5…6: Reserved 7: Error		
42	3	DB5.5 DB5.3	IAQ_DRY	Drought Index Air Quality	0: Excellent 1: Good 2: Fair 3: Poor 4: Bad 5…6: Reserved 7: Error		
45	3	DB5.2 DB5.0	IAQ_MOULD	Mold Index Air Quality	0: Excellent 1: Good 2: Fair 3: Poor 4: Bad		

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					5…6: Reserved 7: Error
48	3	DB6.7 DB6.5	IAQ_DM	Mite Index Air Quality	0: Excellent 1: Good 2: Fair 3: Poor 4: Bad 5…6: Reserved 7: Error
51	2	DB6.4 DB6.3	HCI	Hygrothermal comfort Index	0: Good 1: Fair 2: Poor 3: Error
53	3	DB6.2 DB6.0	Frame index	Frame Index is a loop counter to check if a frame has been lost	0–7

Example :

Raw Frame : 726a75508b0000

Decoded Frame :

- Product Type: 0x7 → Insafe+ Carbon LoRa
- Message Type: 0x2 → Real Time Data
- CO_2 Level: 0x6a → 2120 ppm
- Temperature: 0x75 → 23.4°C
- Relative Humidity: 0x50 → 40 %RH
- IZIAIR Index: 0x4 → Bad
- IZIAIR Source: 0x5 → CO2
- IAQ C02 : 0x4 → Bad
- IAQ DRY : 0x0 → Excellent
- IAQ_MOULD : 0x0 → Excellent
- IAQ DM : 0x0 → Excellent
- HCI : 0x0 → Good
- Frame index : 0x0 → Frame n°0

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5.5   Product status

This message is sent every 7 days or when one of this information changes:

- Battery level indication is defined using 4 levels:

  o   High level: More than 40% remaining battery capacity

  o   Medium level: 10-40% remaining battery capacity

  o   Low level: 5-10% remaining battery capacity

  o   Critical level: Less than 5% remaining battery capacity

- Product Hardware status (HW)
- Level of CO_2 auto-calibration
- Product activation time-counter
- Join request pending status

Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Product Information	0x3		
8	2	DB1.7 DB1.6	Battery level	Battery level	0: High 1: Medium 2: Low 3: Critical		
10	1	DB1.5	Product HW status	Status of HW	0: Hardware OK 1: Hardware fault 0: HW working correctly 1: HW fault detected ?		
11	3	DB1.4 DB1.2	Frame index	Frame Index is a loop counter to check if a frame has been lost	0–7		
14	1	DB1.1	Pending Join	Join request scheduled	0: No join request scheduled 1: Join request scheduled		
15	1	DB1.0	Not Used	Not Used	Not Used		
16	8	DB2.7 DB2.0	Product activation time-counter	Cumulative duration of product activation	0 - 250	0 - 250	month
					255	Error	
24	8	DB3.7 DB3.0	CO2 autocalibration value	See section Recalibration of CO2 sensor	0 - 250	0-5000	ppm
					255	Error	

32	6	DB4.7 DB4.2	Product date	Year (since 2000)	0–63	0-63	Year
38	4	DB4.1 DB5.6	Product date	Month	1-12	1-12	Month
42	5	DB5.5 DB5.1	Product date	Day	1-31	1-31	Day
47	5	DB5.0 DB6.4	Product date	Hour	0-23	0-23	Hour
52	6	DB6.3 DB7.6	Product date	Minute	0-59	0-59	Minute
58	6	DB7.5 DB7.0	Not Used	Not Used	Not Used		

Example :

Raw frame : 73000A124d28fb40

- Type of product: 0x7 → Insafe+ Carbon LoRa
- Type of message: 0x3 → Product Information
- Battery level: 0x0 → High
- Product HW status: 0x0 → OK
- Frame index : 0x0 → Frame n°0
- Pending Join : 0x0 → No join request scheduled
- Product activation time-counter: 0x0A → 10-month cumulative activation
- CO2 auto-calibration value: 0x12 → 360 ppm
- Product date:
- Year: 0x13 → 2019
- Month: 0x4 → Avril
- Day: 0x14 → 20
- Hour: 0x0F → 15h
- Minute : 0x2D → 45 minutes

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5.6 Button press

If this function has been activated, (see section 6 NFC) a message is sent at each:

-Short button press
-Long button press

Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Button press	0x4		
8	3	DB1.7 DB1.5	Button press	Type of button press	0: short press		
					1: Reserved for Nexelec		
					2: Reserved for Nexelec		
					3: Reserved for Nexelec		
					4..7: Reserved		
11	3	DB1.4 DB1.2	Frame index	Frame Index is a loop counter to check if a frame has been lost	0–7		
14	2	DB1.1 DB1.0	Not Used	Not Used	Not Used		

Example :

Raw frame : 7400

Decoded frame :

-Type of product: 0x7 → Insafe+ Carbon LoRa
-Type of message: 0x4 → Button press
-Type of button press: 0x0 → Short press
-Frame index : 0x0 → Frame n°0

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5.7 Datalog data

The Datalog function enables to gather 3 measurements into a single message. You can set up the period between the measurements (10 / 30 / 60 minutes) via the NFC application (see section 6 NFC).

Data are sent in the following format:

The oldest data are referred to [n-2], then [n-1]. The data [n] correspond to current data.

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Message datalog	0x5		
8	8	DB1.7 DB1.0	CO_2 Concentration [n-2]	Concentration CO_2 (linear), increment = 20ppm	0 - 250	0 - 5000	ppm
					255	Error	
16	8	DB2.7 DB2.0	Temperature [n-2]	Temperature (linear), increment = 0,2°C	0-250	0°C / +50°C	°C
					255	Error	
24	8	DB3.7 DB3.0	Relative Humidity [n-2]	Relative Humidity (linear), increment = 0.5%RH	0-200	0-100	% RH
					255	Error	
32	8	DB4.7 DB4.0	CO_2 Concentration [n-1]	CO_2 Concentration (linear), increment = 20ppm	0 - 250	0 - 5000	ppm
					255	Error	
40	8	DB5.7 DB5.0	Temperature [n-1]	Temperature (linear), increment = 0,2°C	0-250	0°C / +50°C	°C
					255	Error	
48	8	DB6.7 DB6.0	Relative Humidity [n-1]	Relative Humidity (linear), increment = 0.5%RH	0-200	0-100	% RH
					255	Error	
56	8	DB7.7 DB7.0	CO_2 Concentration [n]	CO_2 Concentration (linear), increment = 20ppm	0 - 250	0 - 5000	ppm
					255	Error	
64	8	DB8.7 DB8.0	Temperature [n]	Temperature (linear), increment = 0,2°C	0-250	0°C / +50°C	°C
					255	Error	
72	8	DB9.7 DB9.0	Relative Humidity [n]	Relative Humidity (linear), increment = 0.5%RH	0-200	0-100	% RH
					255	Error	

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80	4	DB10.7 DB10.4	Time between the measurements	Time with 10 minute increments between the measurement n and n+1	0 - 15	0–150	min
84	3	DB10.3 DB10.1	Frame index	Frame Index is a loop counter to check if a frame has been lost	0–7		
87	1	DB10.0	Not Used	Not Used	Not Used		

Example:

Raw Frame: 751a674d186a4c196f4a6e

Decoded frame:

- Type of product: 0x7 → Insafe+ Carbon LoRa
- Type of message: 0x5 → Datalog message
- CO_2 Concentration [n-2] : 0x1A → 520 ppm
- Temperature [n-2] :0x67 → 20.6°C
- Relative Humidity [n-2] : 0x4D → 38.5 %RH
- CO_2 Concentration [n-1]: 0x18 → 480 ppm
- Temperature [n-1]:0x6A → 21.2°C
- Relative Humidity [n-1] : 0x4C → 38.0 %RH
- CO_2 Concentration [n]: 0x19 → 500 ppm
- Temperature [n] :0x6F → 22.2°C
- Relative Humidity [n] : 0x4A → 37.0 %RH
- Time between the measurements: 0x6 → 60 minutes
- Frame index : 0x7 → Frame n°7

5.8 Temperature alerts

This function enables to send a message when the temperature reaches one of the two configurable alert thresholds (see section 6 NFC). A hysteresis (typical value of 0.5°C) is applied below each threshold to avoid too many messages.

An activation message is sent when the temperature measured is higher than the threshold set.
A deactivation message is sent when the temperature measured dropped by 0.5°C below the threshold set.
At the start-up product phase, a message is sent with thresholds (activation / deactivation) current state.

Example of operation:
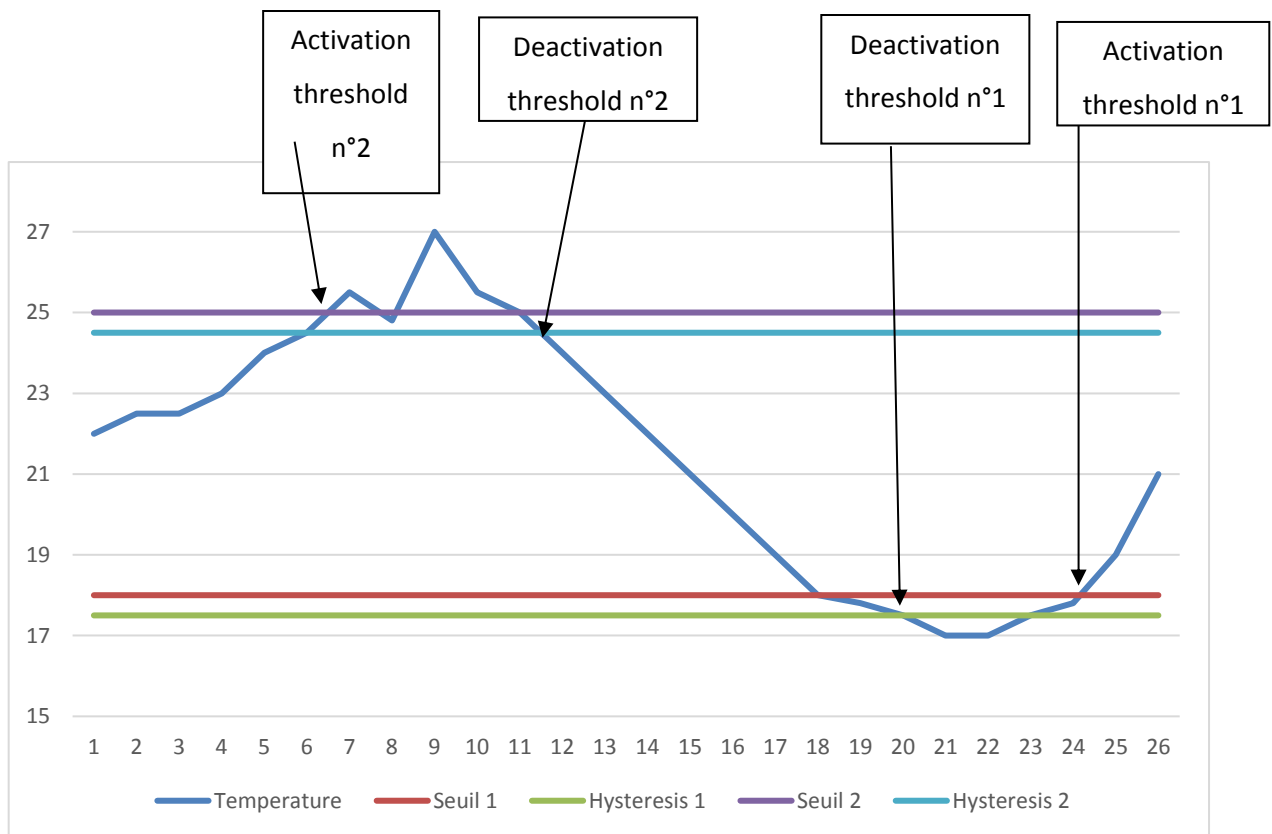
Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Temperature alert	0x6		

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					0-250	0°C / +50°C	°C
8	8	DB1.7 DB1.0	Temperature	Temperature (linear), increment = 0.2°C			
					255	Error	
16	1	DB2.7	T_TH1	Temperature threshold n°1	0: threshold 1 not reached 1: threshold 1 reached		
17	1	DB2.6	T_TH2	Temperature threshold n°2	0: threshold 2 not reached 1: threshold 2 reached		
18	3	DB2.5 DB2.3	Frame index	Frame Index is a loop counter to check if a frame has been lost	0–7		
21	3	DB2.2 DB2.0	Not Used	Not Used	Not Used		

Raw Frame: 7673c0

Decoded frame:

- Type of product: 0x7 → Insafe+ Carbon LoRa
- Type of message: 0x6 → Temperature alert
- Temperature :0x73 → 23.0°C
- T_TH1: threshold 1 reached
- T_TH2: threshold 2 reached
- Frame index : 0x0 → Frame n°0

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5.9   CO2 Alerts

This function enables to send a message when the CO2 concentration reaches one of the two configurable alert thresholds (1000 and 1700ppm by default). A hysteresis (±100ppm) is applied above and below each threshold to avoid too many messages.

An activation message is sent when the concentration measured is 100 ppm higher than the threshold set. A deactivation message is sent when the concentration measured dropped by more than 100 ppm below the threshold set.

At the start-up product phase, a message is sent with thresholds (activation / deactivation) current status.

Example of operation:

Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	CO2 Alerts	0x7		
8	8	DB1.7 DB1.0	CO2 Concentration	CO2 Concentration (linear), increment = 20ppm	0 - 250	0 - 5000	ppm
					255: Error		
16	3	DB2.7 DB2.5	Frame index	Frame Index is a loop counter to check if a frame has been lost	0–7		
19	1	DB2.4	CO2 threshold 1	CO2 threshold 1 (1000 ppm)	0: threshold 1 not reached 1: threshold 1 reached		
20	1	DB2.3	CO2 threshold 2	CO2 threshold 2 (1700 ppm)	0: threshold 2 not reached 1: threshold 2 reached		
21	3	DB2.2 DB2.0	Not used	Not used	Not used		

Raw Frame: 773710

Decoded frame:

-Type of product: 0x7 → Insafe+ Carbon LoRa
-Type of message: 0x7 → CO2 Alert
-CO2 Concentration: 0x37 → 1100 ppm
-Frame index : 0x0 → Frame n°0
-CO2 threshold 1: threshold 1 reached
-CO2 threshold 2: threshold 2 not reached

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5.10 Product configuration: functions relative to CO2

At the start-up product phase or during each reconfiguration, a message is sent to indicate the configuration of the product.

Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Product Configuration (CO2)	0x8		
8	8	DB1.7 DB1.0	CO2 threshold 1	CO2 Concentration (linear), increment = 20ppm	0 - 250	0 - 5000	ppm
					255	Error	
16	8	DB2.7 DB2.0	CO2 threshold 2	CO2 Concentration (linear), increment = 20ppm	0 - 250	0 - 5000	ppm
					255	Error	
24	6	DB3.7 DB3.2	Smart Period 1	Start time of the period (30-minute increment)	0-47	0h00 – 23h30	Hours
30	6	DB3.1 DB4.4	Smart Period 1	Duration of the period (30-minute increment)	0-48	0 – 24	Hours
36	6	DB4.3 DB5.6	Smart Period 2	Start time of the period (30-minute increment)	0-47	0h00 – 23h30	Hours
42	6	DB5.5 DB5.0	Smart Period 2	Duration of the period (30-minute increment)	0-48	0 – 24	Hours
48	1	DB6.7	Smart Period 1	Active?	0: Non-active; 1: Active		
49	1	DB6.6	Smart Period 1	Active on Monday?	0: Non-active; 1: Active		
50	1	DB6.5	Smart Period 1	Active on Tuesday?	0: Non-active; 1: Active		
51	1	DB6.4	Smart Period 1	Active on Wednesday?	0: Non-active; 1: Active		
52	1	DB6.3	Smart Period 1	Active on Thursday?	0: Non-active; 1: Active		
53	1	DB6.2	Smart Period 1	Active on Friday?	0: Non-active; 1: Active		
54	1	DB6.1	Smart Period 1	Active on Saturday?	0: Non-active; 1: Active		
55	1	DB6.0	Smart Period 1	Active on Sunday?	0: Non-active; 1: Active		
56	1	DB7.7	Smart Period 2	Active?	0: Non-active; 1: Active		
57	1	DB7.6	Smart Period 2	Active on Monday?	0: Non-active; 1: Active		
58	1	DB7.5	Smart Period 2	Active on Tuesday?	0: Non-active; 1: Active		
59	1	DB7.4	Smart Period 2	Active on Wednesday?	0: Non-active; 1: Active		
60	1	DB7.3	Smart Period 2	Active on Thursday?	0: Non-active; 1: Active		
61	1	DB7.2	Smart Period 2	Active on Friday?	0: Non-active; 1: Active		
62	1	DB7.1	Smart Period 2	Active on Saturday?	0: Non-active; 1: Active		
63	1	DB7.0	Smart Period 2	Active on Sunday?	0: Non-active; 1: Active		

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| 64 | 8 | DB8.7 DB8.0 | Altitude | Altitude (used for measurement compensation), increment = 50m | 0 - 200 | 0 - 10000 | m |

5.11 Product configuration: general functions

At the start-up product phase or during each reconfiguration, a message is sent to indicate the configuration of the product.

Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Product general Configuration	0x9		
8	1	DB1.7	IQA LED	Activate LED function?	0: Non-active; 1: Active		
9	1	DB1.6	Button Notif.	Notification active button press?	0: Non-active; 1: Active		
10	1	DB1.5	Real Time Data	Active Real Time Data ?	0: Non-active; 1: Active		
11	1	DB1.4	Datalog	Active datalog function?	0: Non-active; 1: Active		
12	1	DB1.3	Temperature Alerts	Active temperature alerts ?	0: Non-active; 1: Active		
13	1	DB1.2	CO2 Alerts	Active CO2 alerts?	0: Non-active; 1: Active		
14	1	DB1.1	Keepalive	Active Keepalive function	0: Non-active; 1: Active		
15	1	DB1.0	Orange LED	Orange LED activated?	0: Non-active; 1: Active		
16	8	DB2.7 DB2.0	Meas. Period	Period between two measurements (CO2, temperature, humidity)	0 - 250 / 255	0 - 250 / Error	min.
24	8	DB3.7 DB3.0	Datalog decimation	Datalog decimation factor (keep only 1 measurement among x)	0 - 255	0 - 255	NA
32	8	DB4.7 DB4.0	threshold n°1 Temperature alert	Temperature (linear), increment = 0.2°C	0-250 / 255	0°C +50°C / Error	°C
40	8	DB5.7 DB5.0		Temperature (linear), increment = 0.2°C	0-250	0°C +50°C	°C

25

Offset	Size	Bit-range	Data	Description	Valid Range	Scale	Unit
			threshold n°2 Temperature alert		255	Error	
48	8	DB6.7 DB6.0	Delta_Temp	Temperature Delta generating the transmission of a «real time» message	0-250	0°C +25°C	°C
					255	Error	
56	8	DB7.7 DB7.0	Delta_Hum	Humidity Delta generating the transmission of a «real time» message	0-200	0-100	% RH
					255	Error	
64	8	DB8.7 DB8.0	Delta_CO2	CO2 Delta generating the transmission of a «real time» message	0 - 250	0 - 5000	ppm
					255	Error	
72	8	DB9.7 DB9.0	Keepalive	Keepalive Period (h)	0 - 250	0 - 250	hours
80	8	DB10.7 DB10.0	SW Version	Software version of the product	0 - 255	0 - 255	-
88	2	DB11.7 DB11.6	NFC status	Status of NFC configuration interface	0: Discoverable 1: Not discoverable 2..3: RFU		
90	6	DB11.5 DB11.0	Not used	Not used	-	-	-

5.12 Keepalive

This message is sent by the product on a regular basis to check its correct functioning. The sending period of this message is configurable (see section 6 NFC).

Data are sent in the following format:

Offset	Size (bit)	Bit-range	Data	Description	Valid Range	Scale	Unit
0	4	DB0.7 DB0.4	Type of product	Insafe+ Carbon LoRa	0x7		
4	4	DB0.3 DB0.0	Type of message	Keepalive Message	0xA		

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5.13 Reconfiguration via downlink message

Product can be reconfigured via downlink message in response to any uplink message. The downlink message must be sent on port 0x56.

Reconfiguration acknowledgement

After reconfiguration, the product will send a message with its updated configuration (5.11 Product configuration: general functions and 5.10 Product configuration: functions relative to CO2).

Downlink message structure

First byte is the header: 0x55.

Then the following bytes can be used to reconfigure the product with respect to the format: Command ID and DATA.

Note: Downlink functionalities will certainly progress in the future. To ensure backwards-compatibility, Nexelec recommends sending the IDs from the lowest to the highest value.

ID	Data length (byte)	Range	Scale	Description
0x00	-	-	-	No change, can be used for padding (Sigfox for example)
0x01	0	-	-	Ask for general configuration of the product (message Configuration of product functions)
0x02	0	-	-	Ask for CO2 configuration of the product message Configuration: functions relative to CO2
0x03	1	0 / 1	0 : disabled 1 : enabled	LED enable
0x04	1	0 / 1	0 : disabled 1 : enabled	Button enable
0x05	1	0 / 1	0 : disabled 1 : enabled	Real Time Value enable
0x06	1	0 / 1	0 : disabled 1 : enabled	Datalog enable
0x07	1	0 / 1	0 : disabled 1 : enabled	Temperature Alert enable
0x08	1	0 / 1	0 : disabled 1 : enabled	CO2 Alert enable
0x09	1	0 / 1	0 : disabled 1 : enabled	Keepalive enable
0x0A	1	0 / 1	0 : disabled 1 : enabled	NFC interface enable
0x0B	1	1 - 9	1 – 9	Datalog decimation factor
0x0C	2	0 - 500	0 – 50°C	Temperature alert: Threshold 1 Temperature by step of 0.1°C
0x0D	2	0 - 500	0 – 50°C	Temperature alert: Threshold 2 Temperature by step of 0.1°C

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0x0E	1	0 - 99	0 – 9.9°C	Temperature Delta generating the transmission of a «real time» message
0x0F	1	0 - 19	0 – 9.5%RH	Humidity Delta generating the transmission of a «real time» message
0x10	1	0 - 250	0 – 5000ppm	CO_2 Delta generating the transmission of a «real time» message
0x11	1	1 – 99	1 – 99h	Keepalive period (hours)
0x12	1	0 - 250	0 – 5000ppm	CO_2 Threshold 1 for Indoor Air Quality LED indicators and CO_2 Alert CO_2 by step of 20 ppm
0x13	1	0 - 250	0 – 5000ppm	CO_2 Threshold 2 for Indoor Air Quality LED indicators and CO_2 Alert CO_2 by step of 20 ppm
0x14	3	See description below		Smart Period n°1 config
	Byte 0.7 MSB	0 / 1	0 : disabled 1 : enabled	Smart period On/Off
	Byte 0.6	0 / 1	0 : disabled 1 : enabled	Monday On / Off
	Byte 0.5	0 / 1	0 : disabled 1 : enabled	Tuesday On / Off
	Byte 0.4	0 / 1	0 : disabled 1 : enabled	Wednesday On / Off
	Byte 0.3	0 / 1	0 : disabled 1 : enabled	Thursday On / Off
	Byte 0.2	0 / 1	0 : disabled 1 : enabled	Friday On / Off
	Byte 0.1	0 / 1	0 : disabled 1 : enabled	Saturday On / Off
	Byte 0.0 LSB	0 / 1	0 : disabled 1 : enabled	Sunday On / Off
	Byte 1	0 – 47	0 – 23h30	Starting time of the period in 30 minutes step
	Byte 2	0 - 48	0 – 24h	Duration of the period in 30 minutes step
0x15	3	Same as above		Smart Period n°2 config
0x16	1	0 - 250	0 – 1000m	Altitude (used for CO_2 level correction)
0x17[1]	6	See description below		RTC configuration (product will reboot after configuration)
	Byte 0	0 - 100	2000 – 2100	year, starting from 2000 (value = 0)
	Byte 1	1 – 12	1 – 12	month, starting from January (value = 1)
	Byte 2	1 - 31	1 – 31	day of the month
	Byte 3	0 – 23	0 – 23	Hours
	Byte 4	0 – 59	0 – 59	Minutes
	Byte 5	0 - 59	0 - 59	Seconds
0x18[1]	2	See description below		Relative clock configuration (product will reboot after configuration)
	Byte 0	0 / 1	0: Backward time slot increasing 1: Forward time slot increasing	Backward/forward RTC time slot increasing
	Byte 1	0 - 250	0 – 250 minutes	Number of minutes to add/remove to the current RTC date

…				Reserved
0x1C	2	1 - 1008	10 – 10080 minutes	Schedule a join request in x minutes
…				Reserved
0x27	1	0 / 1	0: Orange Led working 1: Orange Led deactivated	Orange Led deactivation
…				Reserved
0xFF				Reserved

<u>Note 1</u>: product will reboot after configuration

Examples

Example 1:

- Activate Real time values
- Delta temperature = 0.5°C
- Delta Humidity = 9.5%RH

<u>Frame structure, from LSB to MSB:</u>

Byte	Value	Info
0	0x55	Header for 1- message reconfiguration
1	0x05	ID Real time value enable
2	0x01	Value to enable real time message
3	0x0E	ID for delta temperature
4	0x05	Value for 0.5°C
5	0x0F	ID for delta humidity
6	0x13	Value for 9.5%RH

Example 2:

- Activate Smart Period n°1:
  - o Monday, Tuesday, Thursday, Friday
  - o From 8.30am to 4.30pm (duration = 8 hours)

<u>Frame structure, from LSB to MSB:</u>

| Byte	Value	Info
0	0x55	Header for 1- message reconfiguration
1	0x14	ID Smart Period n°1
2	0xEC	Select the appropriate days and enable function
3	0x11	Starting time (8.30am = 17 steps of 30 minutes)
4	0x10	Duration (8 hours = 16 steps of 30 minutes)

6. NFC configuration

The NFC interface can be deactivated via downlink message. By this way, the NFC memory is no more discoverable and placing the product in the face of the product has no effect. A deactivation of the NFC memory avoids a reconfiguration of the product once deployed.

After being deactivated, the NFC interface can be re-activated again via downlink message.

6.1   NFC antenna location

In the face of the product, place the "do not paint" icon at the top left (standard position when mounting the product in accordance with the instructions given previously).

« Do not paint » icon
(landmark)

NFC Antenna
Place the Smartphone here
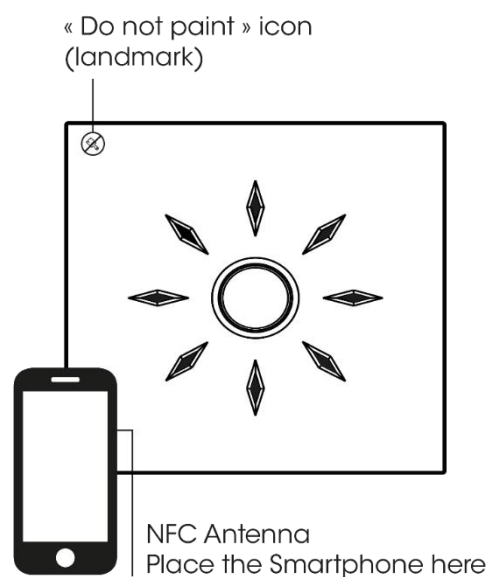
6.2   Presentation of the application

The « Nexelec Config Tool » product reconfiguration application is available in Android for devices (mobile, tablet) equipped with NFC interface.

Nexelec Config Tool
NEXELEC R&D
Outils

DÉSINSTALLER   OUVRIR

6.3   Presentation of reconfigurable data

Product:

Insafe+Carbon Sigfox ▾

Button 〇 ❓

LED 〇 ❓

Real Time Values 〇 ❓

Delta CO2: 0 ppm

Delta Temperature: 0.5 °C

Delta Humidity: 5.0 %RH

Datalog 〇 ❓

Time Period: —————●— 60 mins
10   30   60

Temperature Alert 〇 ❓

Temperature threshold 1: 18.0 °C

Temperature threshold 2: 23.0 °C

Temperature hysteresis: 0.5 °C

CO2 Alert 〇 ❓

Smart Periods 1 〇 ❓

M T W T F S S

Starting time: **07 : 00** ⏲

Ending time: **12 : 00** ⏲

Smart Periods 2 〇 ❓

M T W T F S S

Starting time: **14 : 00** ⏲

Ending time: **20 : 00** ⏲

Altitude Compensation 〇 ❓

Altitude: 100 m

Keepalive 〇 ❓

Keepalive: ———●——— 24 hours
6   12   24

Button: The product can send a message during a short press and another message during a long press on the middle button (see section Button press)

LED : The LED flashes to indicate the measured CO2 level (see section "Air quality LED indicators").

Real Time values: The product measures the data every 10 minutes. If the measure has changed to a value higher than the set delta, a message will be sent. Entering 0 in one of the fields enable to force the transmission of a message at each measure. (See section 5.4 Real Time Data).

Datalog: The product measures CO2, temperature and humidity every 10 / 30 / 60 minutes and sends a message every 3 measurements (30 / 90 / 180 minutes). See section 5.7 Datalog Data.

Temperature Alerts: Set up here the message sending threshold – temperature alert type (See section 0

CO2 alerts: the product sends a message if CO2 thresholds are exceeded (See section 0 CO2 Alerts)

Smart period: The LED display and the sending of messages can be disabled during some periods to increase the product autonomy. Set up the active periods in the application.

Note 1: Set up also the product clock in the « Product Info » tab (Tab "Product Info" → Sync. Date)
Note 2: The product does not take into account the time change (winter/summer). Increase the time slot by 1 hour (forward and backward) to avoid the loss of data)

Altitude: Indicate here the installation altitude of the product. This setting allows to compensate the altitude effect on the CO_2 measurement.
Note: an altitude difference of 500 m leads to an error of about 5% on the CO_2 measurement.

Keepalive: The product sends a message on a regular basis to check its correct functioning (see section 5.12 Keepalive)

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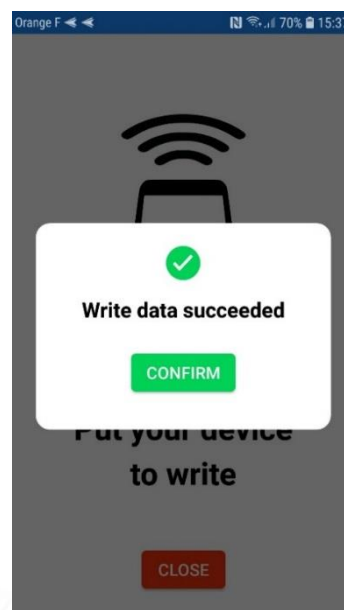
## 6.4 Reconfiguration process

To reconfigure your product:

1) In the Sensor Tab, press on « Read » then bring the product close to the phone.
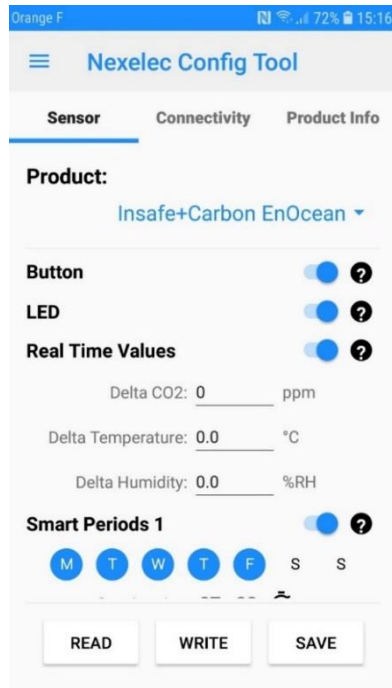
2) Change the configuration of your product (See section 6.3 Presentation of reconfigurable data)
3) Press on « Write » then bring the product close to the phone. Do not remove it before the operation is completed.

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In the case of a writing error (moving phone during transfer for example), the following message is displayed:
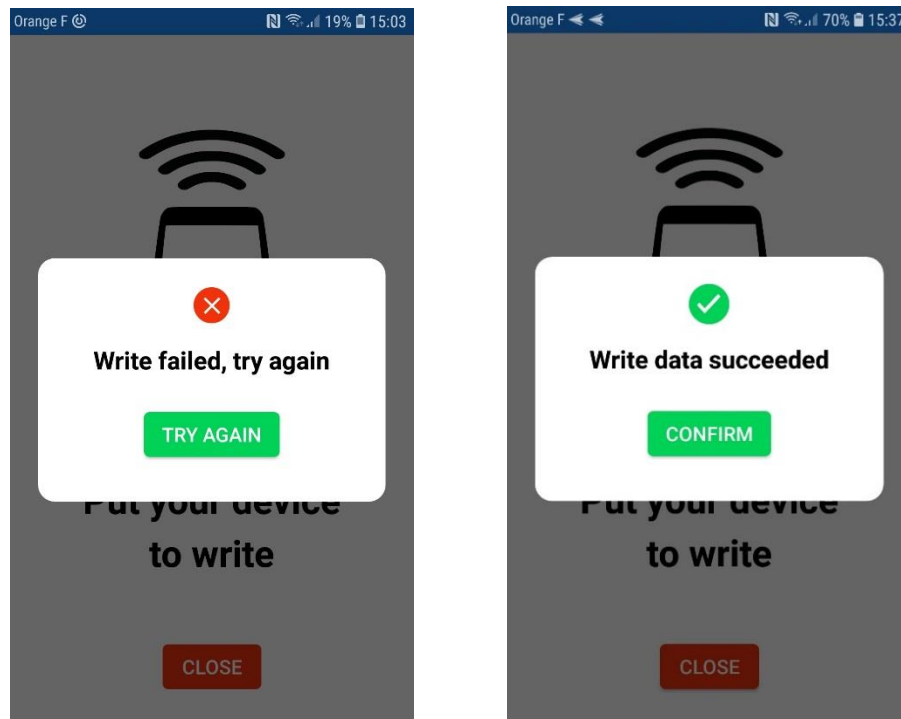
Error screen during the writingScreen indicating a successful writing

Select « try again » and bring the product close to the phone again.

Warning: if the process is quit while the product is not configurated properly, the product can be permanently damaged. Do not stop the process before a successful writing has been confirmed.

4) Your product will automatically update its configuration

6.5   Standard configuration

When the product is delivered, the standard configuration is the following:

Function	Status
Button	Activated
LED	Activated with following parameters: CO2 threshold 1: 1000 ppm CO2 threshold 2: 1700 ppm
Real time data	Activated with following parameters: Delta CO2: 250ppm Delta Temperature: 1.0°C Delta Humidity: 5.0%RH
Datalog	Deactivated
Temperature alert	Deactivated
CO2 alert	Deactivated
Smart Periods	Deactivated
Altitude compensation	Activated with following parameters: Altitude: 100m
Keepalive	Activated with following parameters: Period: 24h

Using this standard configuration, the product will have 7 years estimated lifetime (see section Product autonomy for more information).

7.Product autonomy

The product is powered by a non-chargeable and non-replaceable battery. When the battery is empty, the product must be replaced. The product autonomy depends on the LED switch-on time that indicates air quality (see section 3 Air quality LED indicators). The more the LED will be switched-on, the lower the autonomy. The product autonomy also depends on the number of messages sent. The table below helps you evaluate the number of messages sent based on the functions that have been activated in the product:

Function	Average number of messages sent per day
Product Status	0.15
Keepalive 6h	4
Keepalive 12h	2
Keepalive 24h	1
Datalog 10min	48
Datalog 30min	16
Datalog 60min	8
Real-time data	The product measures environmental data every 10 minutes. If the value (T °, CO2 or humidity) has changed significantly, a message will be sent. The number of messages depends on the product environment (see note 1)
Temperature alert	The product sends a message each time the temperature reaches a defined threshold. The number of messages depends on the product environment (see note 1)
CO2 alert	The product sends a message each time the CO2 level reaches a defined threshold (with a hysteresis of 100 ppm). The number of messages depends on the product environment (see note 1)

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Note 1: These functions depend on environmental conditions. The table below gives an example of the number of messages in office conditions.

Function	Number of messages per day
Real time data Temperature delta : 0.5°C CO2 delta : 150 ppm Humidity delta: 5% RH	25
Real time data Delta Température : 1.0°C Delta CO2 : 250 ppm Delta Humidité : 5% RH	10
Temperature Alerts	4
CO2 Alerts	4

In LoRa, the network can define parameters like datarate and output power to optimize the device battery power consumption (See Adaptative Data Rate description in LoRaWan specification).

Two tables are built to show the best case and the worst case depending on the network:
- Best case: Output power = 2dBm, Spreading factor: SF7
- Worst case: Output power = 14dBm, Spreading factor: SF12

The tables below show the product autonomy according to two criteria:
- LED switch-on time that indicates air quality
- Number of messages sent per day

Number of messages / days	0	10	20	50	100	140
Time spent in degraded air quality (poor / bad) (h/day)	Autonomy (year)					
0	10	10	10	7.5	4.5	3.5
1	10	10	10	7	4.5	3.5
2	10	10	9.5	6.5	4.5	3.5
4	10	9.5	8.5	6	4	3.5
8	8.5	7.5	6.5	5	3.5	3
12	6.5	6	5.5	4.5	3.5	2.5
24	4	4	3.5	3	2.5	2

Autonomy for Insafe+Carbon with SF12, 14dBm output power (Worst case)

Number of messages / days	0	10	20	50	100	140
Time spent in degraded air quality (poor / bad) (h/day)	Autonomy (year)					
0	10	10	10	10	10	10
1	10	10	10	10	10	10
2	10	10	10	10	10	10
4	10	10	10	10	10	10
8	8.5	8.5	8.5	8	8	7.5
12	6.5	6.5	6.5	6.5	6.5	6
24	4	4	4	4	4	4

Autonomy for Insafe+Carbon with SF7, 2dBm output power (Best case)

You can increase the autonomy of your product by switching off the LED function as well as the communications during specific periods of the week (LED functions and/or Smart Period : 6.3 Presentation of reconfigurable data).
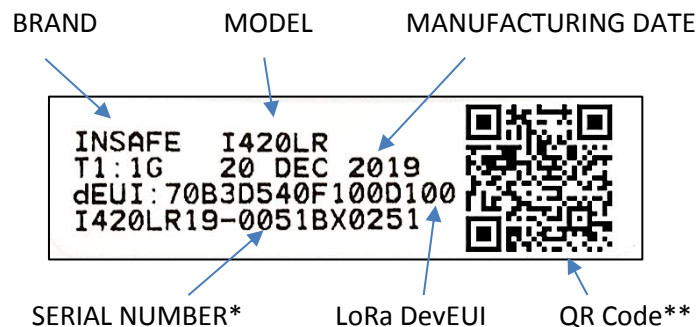
8.Traceability and marking

Three labels and a QR Code are located at the back of the product.

Labels at the back of the product

8.1 Tracking label

This label is placed both at the back of the product and on the packaging.

*Serial number format:

I420LR	19	-	00	51	BX	0251
Model	**Year**		**Reserved**	**Week of production**	**Batch**	**Number in batch**

**QR Code:

Format: Serial number; Testbench; Date; LoRa DevEUI
Example: I420LR19-0051BX0251;1G;201219;70B3D540F100D100

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8.2 LoRaWAN QR Code

A QRCode compatible with the LoRa Alliance standard (LoRaWAN® Device Identification QR Code) is placed both at the back center of the product and on the packaging.

<u>Example :</u>

Device Schema version: D0
AppEUI: 70B3D540F5A8B680
DevEUI: 70B3D540F3519458
Owner Token: FFFF0420
Serial number: SI420LR21-05050DF0088

9.Maintenance and failures

9.1 Recalibration of CO2 sensor

Why calibrate the product?

The measurement of CO_2 level is performed through an infrared sensor technology (NDIR: non-dispersive infrared). This optical technology has a drift that the product automatically compensates by using an ABS (Automatic Baseline Correction) method. This allows to cast off maintenance and to maintain performances throughout the lifetime of the product.

This method is efficient and reliable in an usual environment, where the CO2 rate reaches its minimum level (400ppm) for a few hours (at night for premises, in the day in a bedroom).

Steps to follow

The calibration is automatically performed every 8 days. You can also do a manual calibration.
To do this:

> Place the product outdoors or close to an open window

> Position your product for at least 2 minutes in this environment

> Press the product middle button 6 times within 3 seconds

The green LED lights up during the entire product calibration process (for about 8 seconds). Once the LED is off, the recalibration is over.

9.2   Clock setting

The product has a clock allowing the operation of the Smart Period. This clock drifts very slightly (about 5 minutes/year) in domestic conditions (20-25°C).

Product clock must be configured via downlink (See 5.13 Reconfiguration via downlink message) or using « Nexelec Config Tool » application (See "Reconfiguration via NFC" section of this documentation for general information on NFC) :

>Launch "Nexelec Config Tool" NFC application

>Select "Product Info" tab and then press on « Sync. Date »

>Bring the product closer to synchronize the phone clock

>The product automatically restarts and takes into account this new clock.

10. Revision History and product batch number

10.1   Technical guide changelog

Document revision	Details	Date
A	Created	10/05/2019
B		26/08/2019
C	Add information about standard configuration Add information about battery levels Update product behaviour following long press on button	24/10/2019
D	Add information relative to product autonomy	12/11/2019
E	Add information on Activation and commissioning process Update information on temperature and humidity accuracy	27/02/2020
F	Add information about tracking label	11/03/2020
G	Update power consumption (LED change) Add reconfiguration via downlink commands	31/08/2020
H	Add new functions: - Activation/Deactivation of NFC interface - Indoor air quality indicators: activation/deactivation of orange LED (Poor level) - Relative clock configuration - Configuration of CO2 thresholds (for LED indicators and CO2 alerts)	02/03/2021

NEXELEC – SAS au capital de 420.000 euros
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10.2 Associated product batch number

Use the table below to know the functionalities implemented in your product. To understand better the serial number format, refer to section Tracking label.

Technical guide revision	Product Code	Revision starting from serial number
A..F	/	I420LRxx-xxxxAAxxxx
G	/	I420LRxx-xxxxCCxxxx
H	00	I420LRxx-00xxCOxxxx
H	05	I420LRxx-05xxDPxxxx