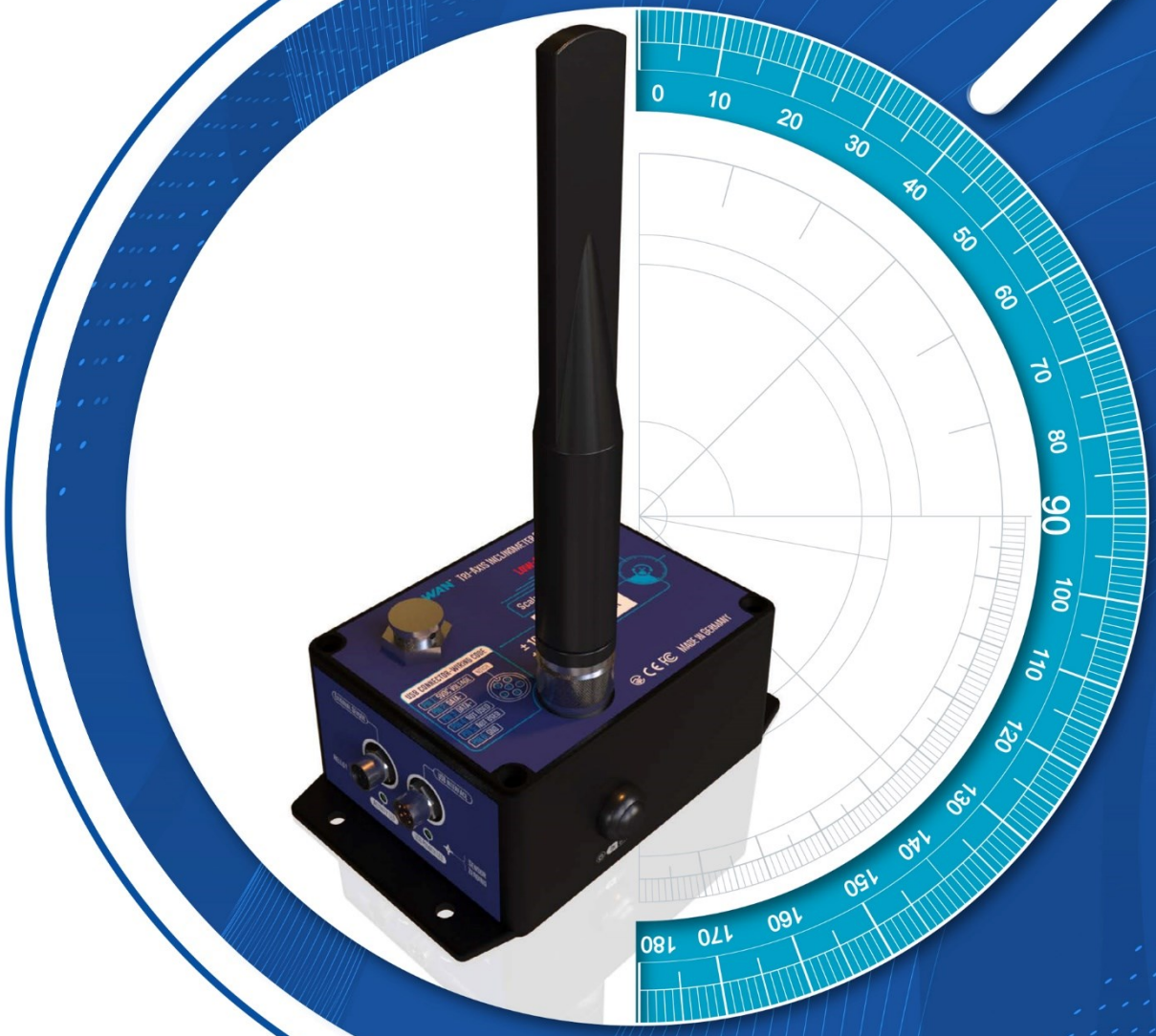
TRIAXIAL INCLINOMETER SENSOR

UG-ENG-SATEVIS-ALPHA-INC



LoRaWAN™

SATEVIS

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Reader n°2	M. Grueman, Sales Engineer	✓	

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1.0	12/10/2023	S. Abadi	• First version of the document
1.1	23/04/2024	S. Abadi	• USB Wiring code updated • Example with TTN added
1.2	16.06.2024	S. Abadi	• Added Uplinks/Downlinks examples

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Such changes will, nevertheless be incorporated into new editions of this document.

Contents

1 ACRONYMS AND ABBREVIATIONS

AES	Advanced Encryption Standard
AMRR	Alarm Monitoring Refresh Rate
CA	Critical Alarm
EUI	Extended Unique Identifier
LLC	Logical Link Control
LNS	LoraWan® Network Server
MA	Minor Alarm
MAC	Media Access Control
PER	Packet error rate
RF	Radio Frequency
RSSI	Radio Signal Strength Indicator
SA	Severe Alarm
SNR	Signal Noise Ratio
THOLD	Threshold
TTI	The Things Industries
TTN	The Things Network
WSN	Wireless sensor Network

1.1 VISUAL SYMBOLS DEFINITION

Tip or Information : Provides advice and suggestions that may be useful when installing Satevis™ sensors

Caution– Alerts the user with important information about Satevis® sensors, if this information is not followed, the equipment /software may fail or malfunction.

Danger – This information MUST be followed if not you may damage the equipment permanently or bodily injury may occur.

2 DOCUMENT ORGANISATION

Satevis® Alpha-Inc product description	• Satevis® Alpha-inc sensor series presentation : Overview, Unpacking and Accessories Description
Device Registration on your LNS	• Details the device Registration on TTN LNS and CommonSense® LNS , connectivity with Lorawan® Gateway
Device configuration and status check for field operator	• Details Hello and Sensor Zeroing functions
Uplinks and Downlinks Messages description	• Details all Uplinks and Downlinks messages with LNS
Satevis™ sensor installation on the field	• Follow our recommendation for a better sensor deployment on the field

3 SATEVIS® ALPHA-INC SENSOR SERIES DESCRIPTION

- ✓ *It is highly recommended to read all the user guide related to Satevis® software & equipment before getting start your Satevis® device.*
- ✓ *Use only accessories supplied by Beanair sensors (batteries, power supply unit, and antenna). Use of other materials may damage the Satevis® device;*
- ✓ *Only Beanair Sensors is qualified to make changes on the Satevis® device*
- ✓ *Don't try to remove the adhesive label on the product; it contains important information such as the EUID and product version;*

3.1 DIFFERENCE BETWEEN SATEVIS™ ALPHA-INC AND SATEVIS™ ALPHA-IINC KOMPAKT

Satevis™ Alpha-Inc sensor series is designed for Structural Health monitoring (SHM), Condition Maintenance Monitoring (CMS) and Test and Measurement.

Features differences between Satevis™ Alpha-Inc and Satevis™ Alpha-Inc Kompakt are explained here:

Features	Alpha-Inc	Alpha-Inc Kompakt
Tx Radio Power	+14Dbm or +22dBm	+14 dBm
Mounting base	Screw and Magnetic	Screw Mounting
Battery	3 x C Size Cell 6.5Ah in Series	1x D Size Cell 19Ah
Casing size (without antenna)	151 x 130 x55 mm	115 x90 x55 mm
Weight	950 g	700g

Satevis™ Alpha-INC

Satevis™ Alpha-INC KOMPAKT

Please consult the product datasheets for more information about main features:

- **Satevis™ Alpha-Inc datasheet**: click here
- **Satevis™ Alpha-Inc Kompakt datasheet** : click here

3.2 REGIONAL PARAMETERS

Make sure the REGION configured on your Satevis® sensor is matching the Antenna Frequency:

Region	Frequency Plan	Common Name	Antenna (Marking)	Antenna GAIN
Europe	863-870 MHz	EU868	ALFA 868	2dBi or 5dBi
INDIA	865-867 MHz	IN865	ALFA 868	2dBi or 5dBi
North America	902-928 MHz	US915	ALFA 915	2dBi or 5dBi
ASIA	920-923 MHz	AS923	ALFA 915	2dBi or 5dBi
AUSTRALIA	915-928 MHz	AU915	ALFA 915	2dBi or 5dBi
SOUTH-KOREA	920-923 MHz	KR920	ALFA 915	2dBi or 5dBi
RUSSIA	864-870 MHz	RU864	ALFA 868	2dBi or 5dBi

The following frequency plan are not available on Satevis® device: China 779-787 MHz, Europe 433 MHz, China 470-510 MHz.

Region Parameters can be configured with your Satevis® Link software, **for more information : click here**

3.3 UNPACKING YOUR SATEVIS® DEVICE

In addition to the Satevis® device you will find inside the packet a list of accessories.

- ✓ *Battery (1 D-Size Cell 19Ah with it's battery remover strap) or Battery Pack*
- ✓ *USB to M8-6pin cable adapter, 2 meters length*
- ✓ *1 x Magnet*
- ✓ *4 x screws and Locknuts*
- ✓ *2 x M8 Plastic cap*
- ✓ *1 N-Type Antenna 2dBi or 5dBi*
- ✓ *1 button shield protection*

3.3.1 Lithium-Thionyl Primary Cell (or non-rechargeable battery)

Satevis® Alpha-Inc	Satevis® Alpha-Inc
1x Primary Cell Pack – 3 x C Size Cell in series (3S1P configuration) with Shunt Diode protection Capacity 6.5Ah for each cell	1 x D-Size Primary Cell – Capacity 19Ah, Voltage 3.6VDC

Primary cell pack (only for Satevis™ Alpha INC) should come with a shunt diode for each individual primary cell. With the shunt diode, a damaged cell does not experience current drive through it internally from any remaining cells in the string, thus it does not heat up and possibly overheat or reverse voltage. the risks of battery explosion. Satevis™ Alpha INC KOMPAKT is not concerned by this protection as it uses only 1 primary Cell.

Satevis™ device works with non rechargeable primary cell, please don not try to recharge it , you will explode the battery.

3.3.2 USB to M8 Cable

Main Functions:

- ✓ *USB power supply (it doesn't recharge the primary cell) +5VDC*
- ✓ *Connection to Satevis® Link software;*
- ✓ *Firmware Upgrade from STCubeProgrammer software*

The cable comes on the first side a M8-6 Pins (A-Coding) standard plug that is used for connecting the USB cable to the Satevis® Alpha-Inc and on the second side a USB connector to be inserted to your PC.

Figure 1 : M8 to USB cable (2 meters Length)

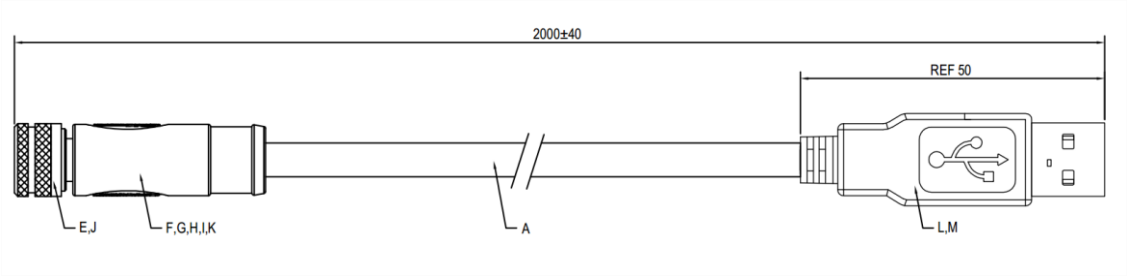


Figure 2: M8 to USB Cable

3.3.3 Lorawan® Antenna

The choice of antenna is very important, the Antennas provided with our sensors were tested and qualified for Long Range applications.

If you decide to use other kind of Antenna make its compatibility with Lorawan® frequency plan.

Self-amalgamating tape helps to protect your antenna connection against corrosion and keeps a good connection between N-Type Antenna and Socket. It can be purchased from electronic components reseller.

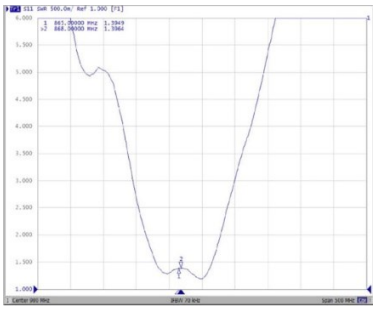
3.3.3.1 Antenna Specifications

Parameter	SATEVIS-ANT-868-2DBI	SATEVIS-ANT-868-5DBI	SATEVIS-ANT-915-2DBI	SATEVIS-ANT-915-5DBI
Frequency Range	863-870 MHz	863-870 MHz	902-928 MHz	902-928 MHz
Gain	2 dBi	5 dBi	2 dBi	5 dBi
VSWR	≤ 2.0			
Radiation Pattern	Omni			
Impedance	50 Ω			
Connector	N male			
Dimensions	⌀22 x 64 mm	⌀22 x 180 mm	⌀22 x 64 mm	⌀22 x 180 mm
Weight	43 g	82 g	43 g	82 g
Temperature	-40 °C to 85 °C			
Humidity	95% @ 25 °C			

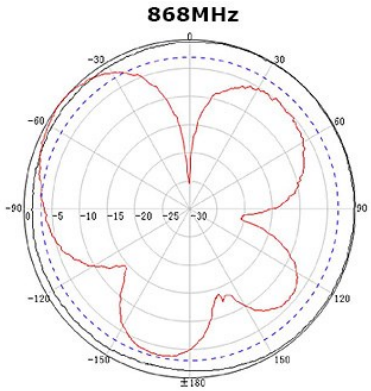
Make sure the selected Region code (configurable from Satevis® Link software) is compatible with your Antenna Frequency, otherwise your sensor will not work properly.

Please consult Satevis® Link Quickstart for more information : click here

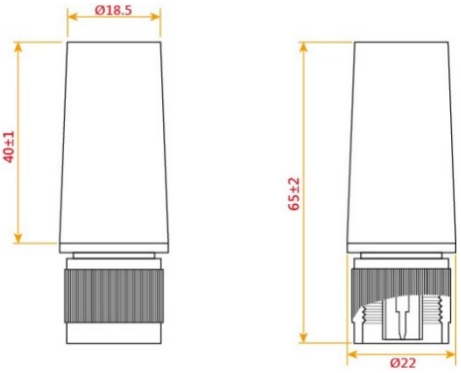
3.3.3.2 SATEVIS-ANT-868-2DBI : 868MHZ / 2dBi gain



VSWR

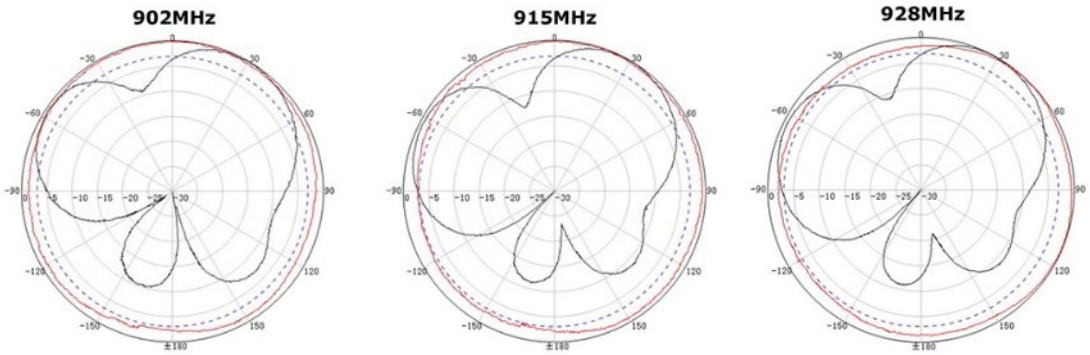


Radiation Pattern

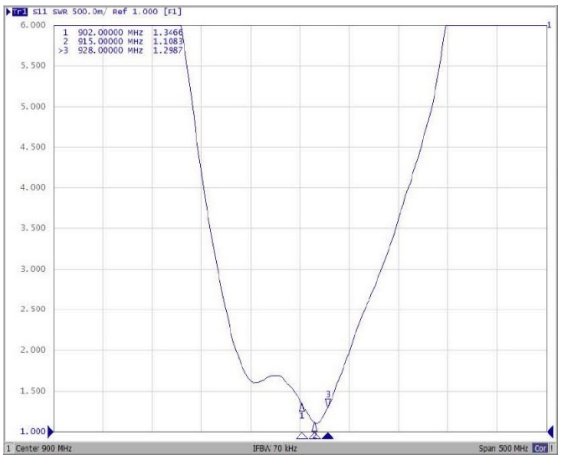


Mechanical Drawing

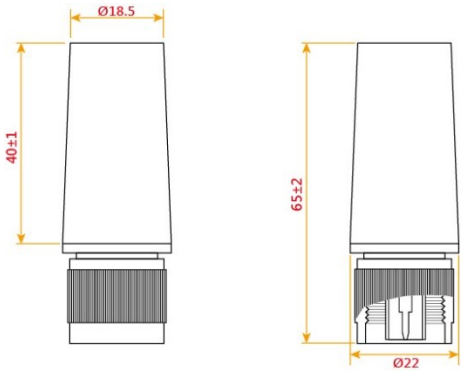
3.3.3.3 SATEVIS-ANT-915-2DBI : 915MHZ / 2dBi gain



Radiation Pattern

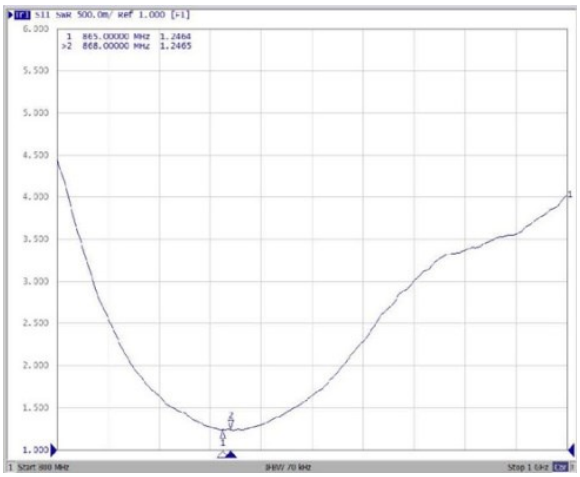


SWR

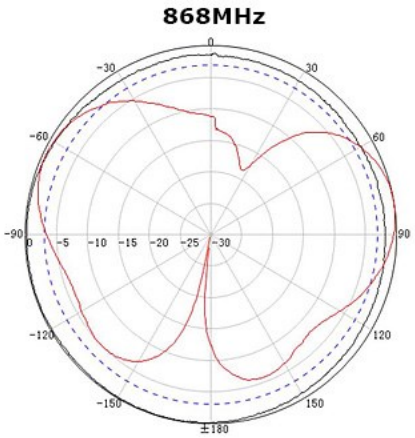


Mechanical Drawing

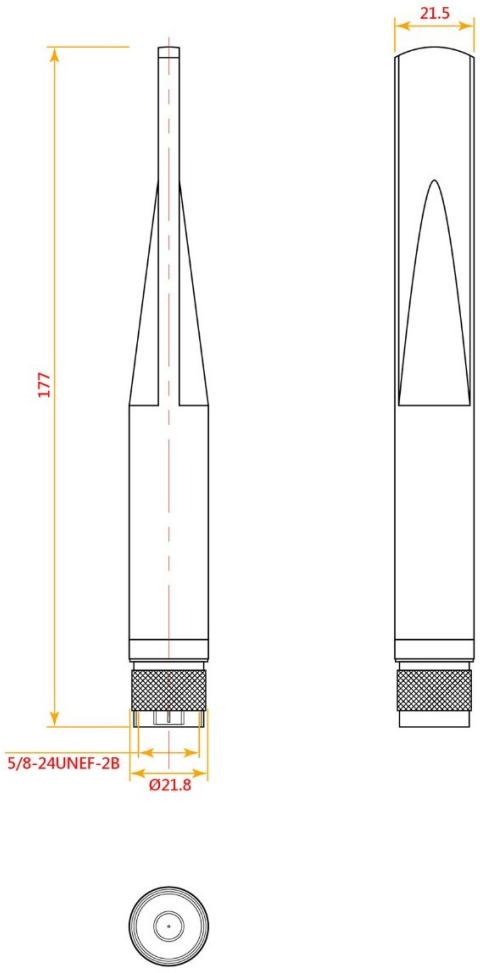
3.3.3.4 SATEVIS-ANT-868-5DBI : 868MHZ / 5dBi gain



VSWR

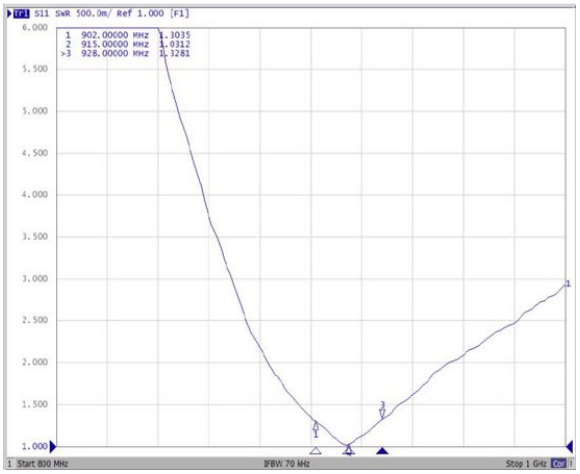


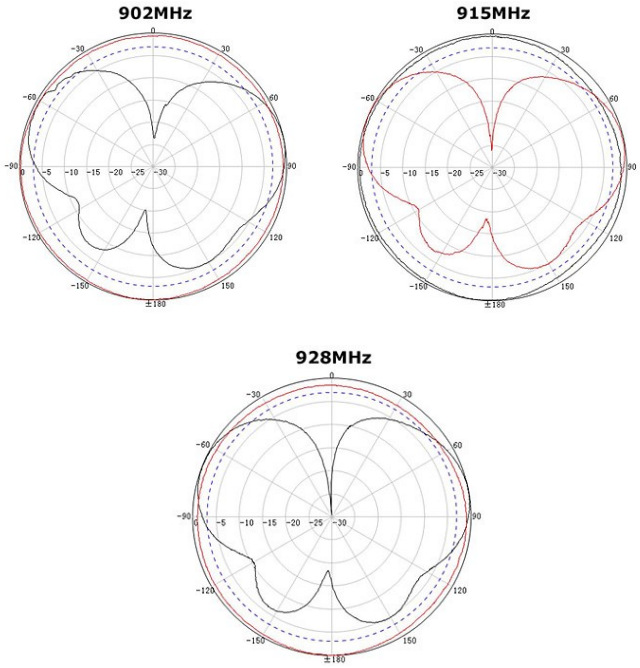
Radiation Pattern



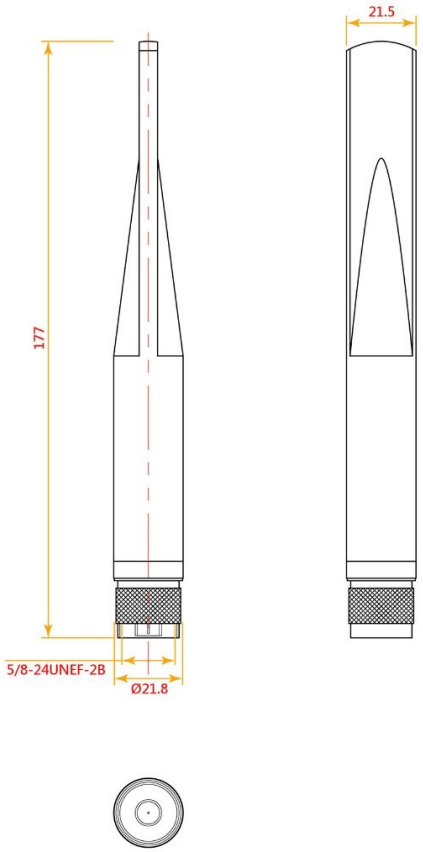
Mechanical Drawing

3.3.3.5 SATEVIS-ANT-915-5DBI : 915MHZ / 5dBi gain





VSWR **Radiation Pattern**



Mechanical Drawing

3.3.4 Magnet for Sensor Zeroing and Hello Message

Both Hello and Sensor Zeroing functions are activated with a Magnet (provided with your sensor). All what you have to do is to hold the magnet close to one of the two white circles as shown on the next picture:

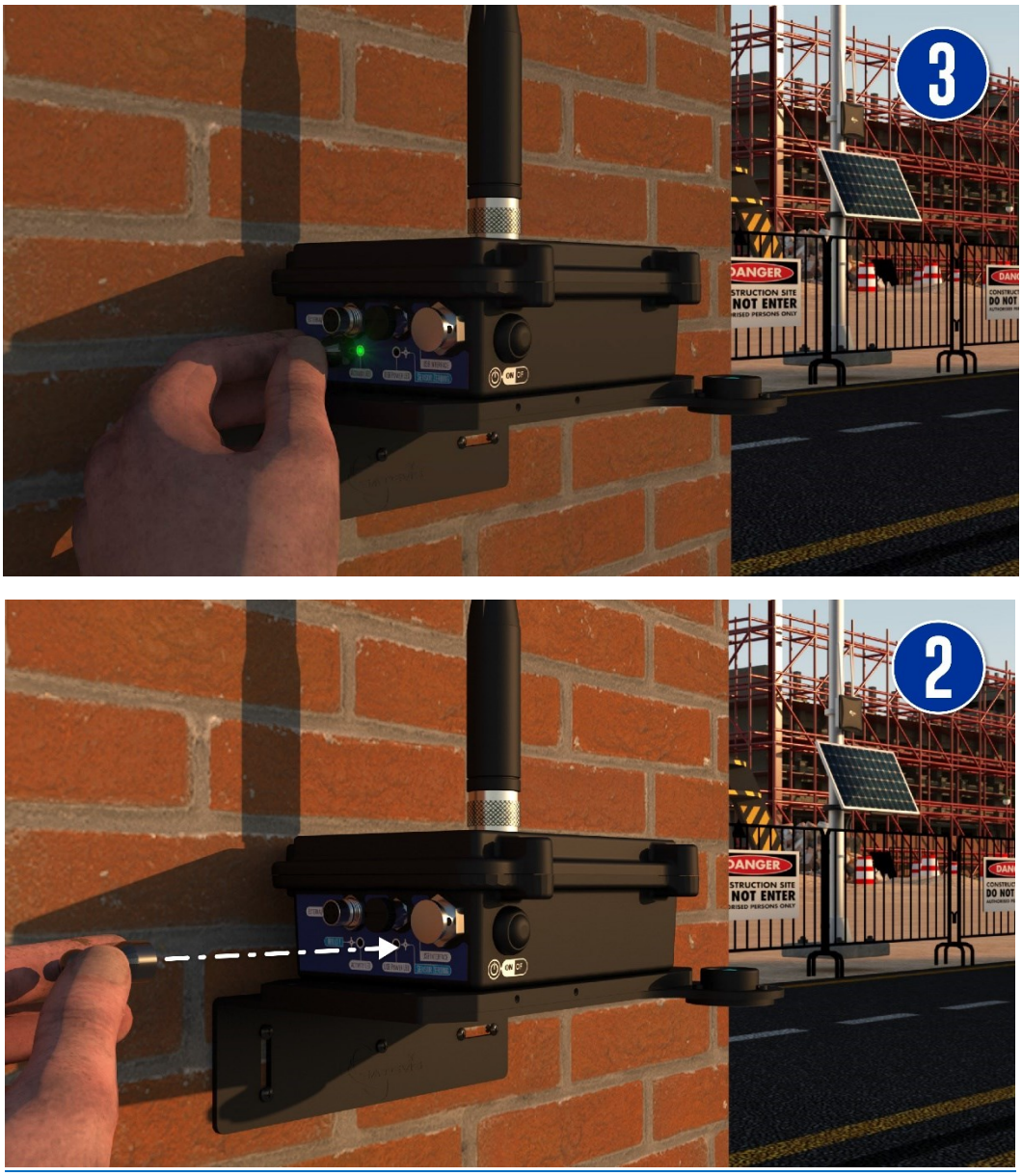


Figure 3 : Sensor zeroing and Hello Labels

Magnet Hold duration:

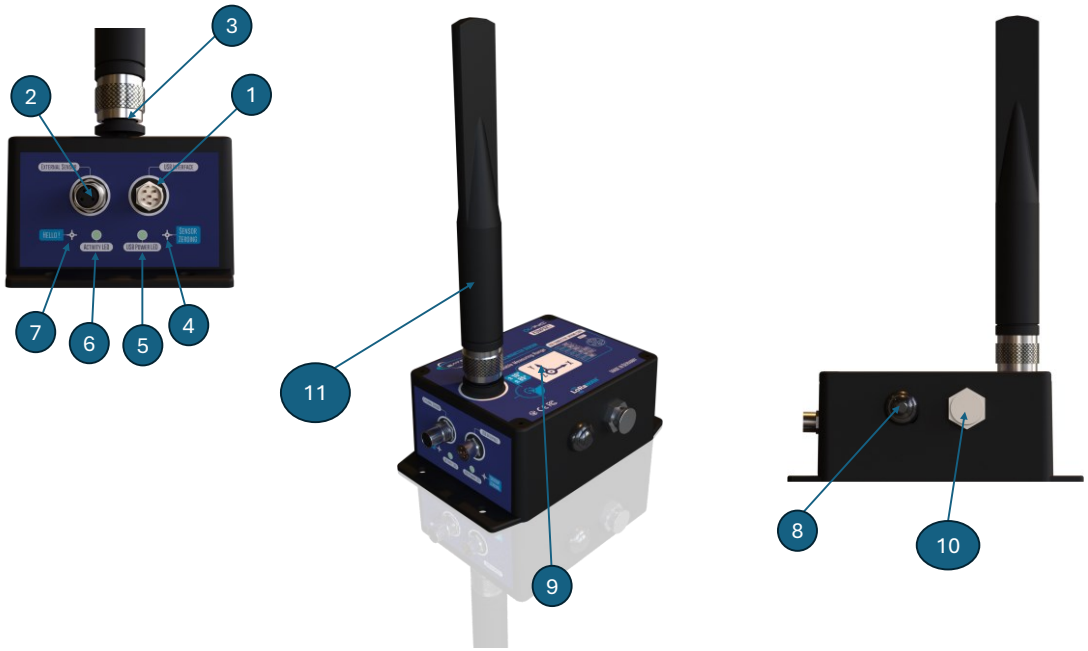
- **Sensor Zeroing :** Hold Duration 10s then Activity LED blinks in **Blue Color**
- **Hello Message**: Hold Duration 10s then Activity LED blinks in **Green Color**

3.3.5 Screws and Locknut

Satevis® device is delivered with 4 screws + 4 Locknuts you can use to mount your Satevis device.

Figure 4: Screws and Locknut

3.4 PRODUCT OVERVIEW



3.4.1 Casing description

Number	Function	Description
1	M8-6 Pins male Contacts Socket (USB 2.0 and DC Power Supply)	***Two functions:*** ***USB Communication and 5VDC* power supply. The socket sealing is maintained with a screw cap.** ***In the case If the USB connector is not used, M8 cap should be screwed back to keep the device waterproof;***
2	M8-4 Pins female contacts socket for External sensors	M8-4Pins Connector for digital sensors compatible with Satevis®. Please consult our website for more information about all external sensors possibility.
3	Antenna Socket	N-Type Female Antenna Socket.

		Before to power ON, always make sure your antenna is screwed correctly on your Satevis® device.
4	"Sensor Zeroing " non-contact button	"**Sensor Zeroing**" non-contact button restores the factory settings on the Satevis® Alpha-Inc Point the pole of the Neodymium magnet that was provided with your Satevis® Alpha-Inc towards the "Sensor Zeroing" label circle. Hold Duration 10s until Activity LED blinks in **Blue Color**
5	USB POWER LED	✓ If your device is powered from USB Power, this LED will turn to **GREEN for 2s**
6	"Activity LED"	Bi-color **GREEN** / **Blue LED** showing Sensor Activity Cf. table below for led description
7	"Hello " non-contact button	"**Hello**" non-contact button generates Hello Request on the Satevis® Alpha-Inc Point the pole of the Neodymium magnet that was provided with your Satevis® Alpha-Inc towards the "Hello" label circle. **Hold Duration 10s** until Activity LED blinks in **Green Color**
8	ON/OFF Push Button	ON/OFF Latching Push Button, the device power on when the button is inserted. Allows to power up/power off the Satevis® Alpha-Inc ON/OFF Push button
9	Satevis® Alpha-Inc product version label	Displays Inclinometer sensor measurement Axis X/Y/Z , and USB socket wiring code.
10	Breathing Vent	Pressure and moisture protection vent, make sure this vent is not obstructed after installation.
11	N-Type Antenna	Four different versions of Antenna are provided : • 2dBi - 868 MHZ or 915 MHZ • 5 dBi - 868 MHZ or 915 MHZ

		Check the Antenna section for more information about Antenna specifications.

3.4.2 Label with QR Code

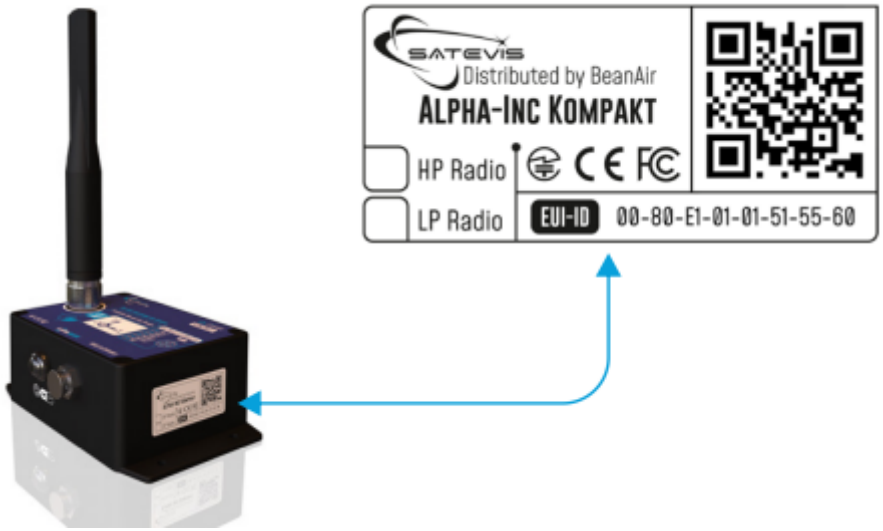


Figure 5 : Label with QR Code

The label with QR code contains the following Info:

- Device EUI
- Product certifications : FCC/CE/Giteki
- High Power or Low Power Radio

By scanning the QR Code , you can get the Device EUI.

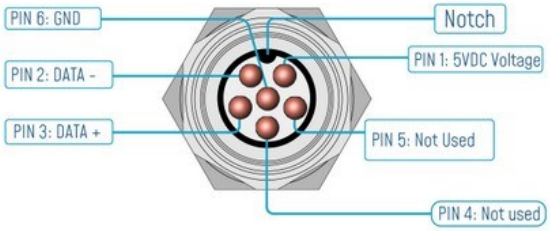
3.4.3 LEDs description

Operating status	Activity LED
Satevis® Alpha-Inc **is powered off**	**Green LED** : ON during 1s
Satevis® Alpha-Inc is switching ON	**Green LED** : ON during 1s ***BLUE LED***: Blinking during 5s, user has uploaded wrong firmware version
Hello Request is done	**Green LED** is on during 1s
Sensor Zeroing is done	**BLUE LED** is on during 1s
Connection to STCubeProgrammer	**Green LED** is on

3.4.4 M8-6 Pins wiring code for USB Communication and External Power

Satevis® device is designed with reverse polarity protection on USB Power supply, however we highly recommend you to respect the wiring code if you decide to bring your own cable.

M8 6pin Socket (MALE, A-CODING)- Pin assignation



Interface Name	M8 Pin assignation
5VDC Voltage	PIN 1
DATA -	PIN 2
DATA +	PIN 3
Not used	PIN 4
Not Used	PIN 5
GND	PIN 6

M8 6pin Plug (FEMALE, A-CODING)- Pin assignation

M8-6Pins Plug

Interface Name	5VDC Voltage	USB DATA -	USB DATA +	Not used	Not Used	GND
M8 Pin assignation	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6
Wire Color (A-coding)	BROWN	WHITE	GREY	BLUE	GREEN	PINK

3.4.5 Mechanical drawing

Satevis® Alpha-Inc comes with an *IP67* rating without corrosion protection. We suggest to use external cable grease if you decide to install Satevis® sensor in a marine environment with high turbulence,

Drawing is available on the following web link: Click here

Mechanical Step file is available on the following weblink: click here

3.4.6 Mounting Guidelines

- ✓ Mounting surfaces need to be clean, free of any residue from epoxies, waxes, paint or other foreign materials.
- ✓ Mounting surface should be flat.
- ✓ The tri-axis Inclinometer allows a mounting on vertical or horizontal direction;

- ✓ The mounting hole must be checked to ensure it is longer than the mounting screw so as to prevent "bottoming out".
- ✓ Use a torque wrench for tightening screws to the manufacturer's specifications. Do not use electric tools as their frequencies may damage the sensor.
- ✓ Avoid shock and vibration during measurement, as these could corrupt the measurement results.
- ✓ If the device is powered from USB: secure the cable using clamps, o-rings, tape or other materials most suited to the application. Ensure that you have sufficient slack to allow for free movement of the sensor.
- ✓ Inspect mounting holes and remove any debris, burrs or other foreign materials.

3.4.7 Mechanical Mounting Options

The following table summarize all mounting options available on Satevis® device:

Model	Satevis® Alpha-Inc	Satevis® Alpha-Inc Kompakt
Screw Mounting	YES	YES
Magnetic Mounting	YES	Magnetic base should be purchased separately **ref:** SATEVIS-MAGNETIC-BASE
Angle Bracket	Angle Bracket can be purchased separately, **ref.:** SATEVIS-ANGLE-BRACKET	

- For Monitoring a vertical structure or a pole, we recommend you to use an angle bracket.
- For Monitoring a metal structure /equipment, we suggest you to use the magnetic base. If you are using the Satevis® Alpha-Inc, the mounting base can be used for both magnetic and screw mounting;

3.4.8 EMI shielding

Satevis® Alpha-Inc casing integrates an EMI Shielding gasket for Harsh Industrial application with High level of Electromagnetic Interference.

This EMI protection is only present on the **Satevis® Alpha-INC , you will not find it on the Satevis® Alpha-Inc Kompakt version.**

3.4.9 USB Power supply

For long term Monitoring on remote site, Satevis® sensor was designed to work with Lithium Thionyl Chloride (LiSoCl2) primary cell as main source of power. However it can be powered from the USB during firmware upgrade or during configuration with Satevis® Link software.

A permanent power from USB can be used.

USB Voltage	*Max current needed by Satevis Alpha Inc*
5VDC	25 mA max with USB Communication
	15 mA max without USB Communication

During the device connection to USB power, the internal primary cell is automatically disconnected from power and there is no risk to damage it.

We don't advice to use a USB Power Bank to power it, as must of power banks are automatically switching off when the current is low 10-20mA. However if you need to use one we recommend to use power bank without automatic switch off from 'Voltaic Systems'.

3.4.10 External Digital Sensor

External Digital Sensor can be added to Satevis® sensor, however you need to upload the right firmware to use it correctly.

The M8-4PINS connector present on the casing allows this connection , but user need to make sure the right firmware is uploaded:

- **Satevis-Alpha-Inc-ONE-TH-VX.X.HEX**
- **Satevis-Alpha-Inc-Kompakt-ONE-TH-VX.X.HEX**

Sensor type	*Description*
Temperature/Humidity sensor	**External Temperature and Humidity sensor** **Sensor specs are available on the following link**

1.1.1 How to extend the battery life

Battery autonomy depends highly on the frequency of data acquisition and transmission.

3.5 SENSOR CALIBRATION

3.5.1 Factory Calibration procedure

The calibration procedure is based on a side-by-side comparison with a reference tilt meter. For better measurement stability, the two tilt meters are mounted on a sinus table.

3.5.2 How often to recalibrate your Satevis® sensors

Depending on the operating environmental conditions, the following table summarize how often user should recalibrate its sensor:

Operating temperature < 40°C	*Operating temperature > 40°C*
6 years	**3 years**
3 years	**2 years**
6 years	**3 years**

Table 1: Satevis® Alpha-Inc *re-calibration*

3.6 FIRMWARE UPGRADE

Firmware Upgrade is done with the M8-USB cable adapter and STCubeProgrammer. On the following Link (Click here) your will find :

- **Satevis®** latest firmware are available on the following link ;
- **STCubeProgrammer** used to program the firmware (should not be confused with Satevis® Link software used to configure LoraWan® Network settings);
- Quickstart on Programming **Satevis®** device is available on the same directory ;

4 REGISTER SATEVIS® SENSOR ON YOUR LNS

4.1 LORAWAN STACK VERSION

Lorawan V1.0.2 REVB Class A is available on Satevis® device, make sure your LoraWan® network server (is compatible with **Lorawan® version 1.0.2).**

For security reasons, only OTAA Activation mode is available. We don't provide BTP Activation mode as it's not secured.

4.2 CHECKLIST

Always Register your Satevis® sensor at your office:

- Your Satevis® device must be connected to your PC with the original USB cable adapter provided with your device
- Satevis® Link software is installed on your PC and connected to your sensor.

All these parameters related to sensor registration are backed up on your Satevis® flash memory and will not be deleted if you switched off.

4.3 LORAWAN® GATEWAY

Satevis® device is working with any kind of Lorawan® Gateway with Packet Forwarder function.

Make sure your gateway is compatible with with **Lorawan® version 1.0.2. REVB**

We suggest you to use Industrial gateway with multiple connections to Internet (WIFI/LAN/4G) for a secured connection.

For small network (up to 25 LoraWan® sensors) or with sensors operating with slow monitoring refresh rate (every 5-10 minutes), you can use a 8-channels Lorawan® gateway.

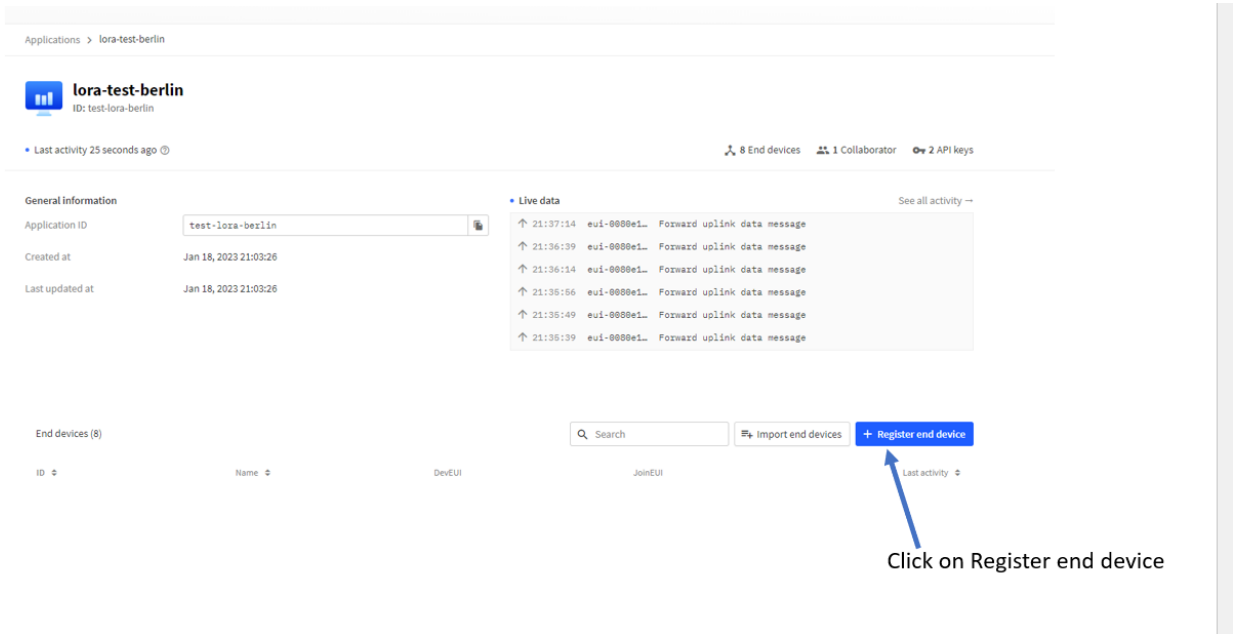
For bigger network or with sensors operating at faster monitoring refresh rate (1-2 minutes), we suggest you to move to a 16-channels Lorawan® gateway , you will avoid network congestion.

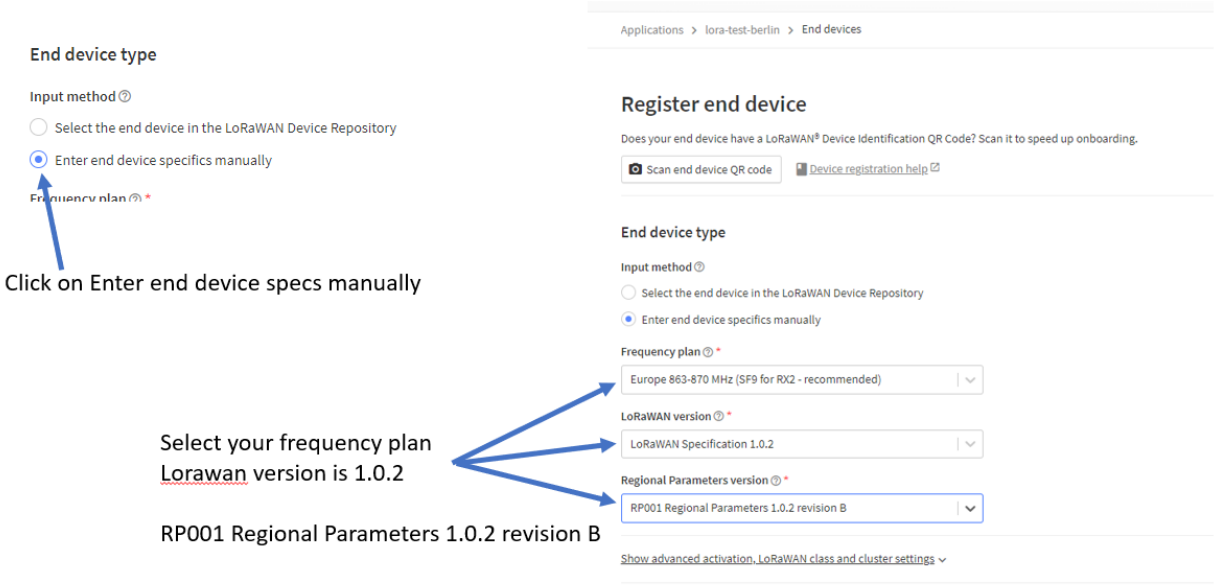
Feel free to contact us if you have any doubt about the compatibility between Satevis® device and your LoraWan® gateway.

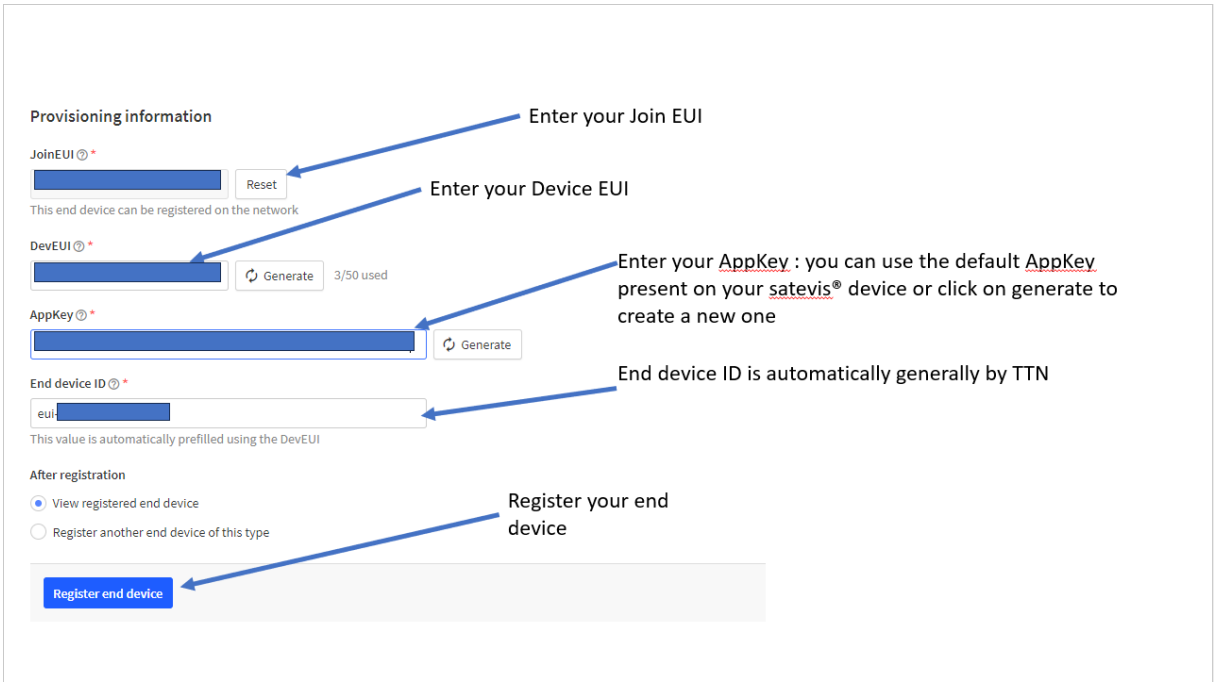
Our LoraWan® Gateway is based on a 8-channels Seeed Studio SenseCAP M2 Gateway.

4.4 REGISTRATION ON THE THINGS NETWORK

If you already have TTN account , you can start to Register your Satevis® device:







Examples of sources codes with TTN are available on the following weblink: TBD

4.5 REGISTRATION ON COMMONSENSE®

Please read our user Manual dedicated to CommonSense®: click here

5 SENSOR CONFIGURATION AND STATUS CHECK FOR FIELD OPERATOR

If field operator is not present to do these operations, both hello and sensor zeroing can be performed remotely on user request (downlink message).

5.1 HELLO FUNCTION

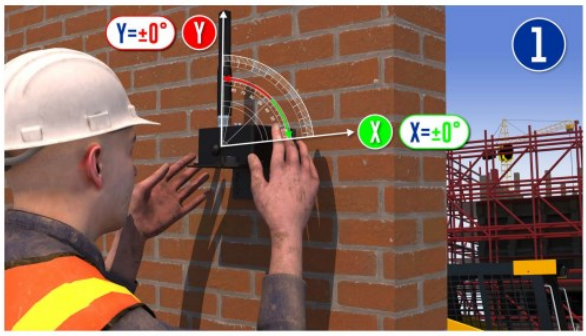
Caption 1: After installing the Alpha-Inc-Kompakt inclinometer, the field operator can check at any moment if the sensor is working properly

Caption 2: By Holding the magnet on the 'Hello!' label for more than 5s, the sensor wakes-up and transmits to the Lorawan network the data measurement followed by the system diagnostic (battery status and network quality)

Caption 3: The Activity Led blinks in green color, confirming that a data measurement is transmitted to the Lorawan network.

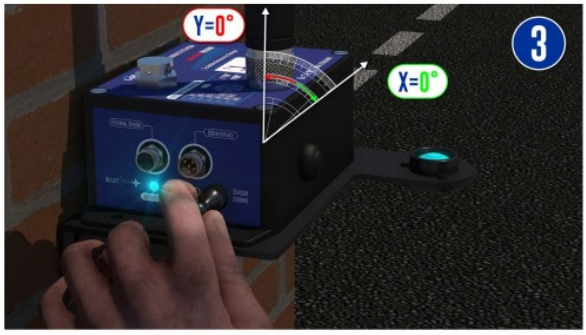
Caption 4: The field operator can check on Satevis® Cloud software (or a third-party cloud software) if his sensor is working properly.

5.2 SENSOR ZEROING



Caption 1: Even if an angle bracket is used, it's sometimes difficult to bring a zero-offset on both X and Y axis (in the case if Z axis is on the same direction than Earth Gravity).. In some cases, the field operator can not spend too much time on this task.

Caption 2: To enable the sensor zeroing function, hold the magnet on 'Sensor Zeroing" Label for more than 20s.



Caption 3: The Activity LED blinks in blue, the sensor zeroing starts on both X and Y axis . When this process is done, the Activity led will blink again in blue color and transmits a data measurement to the Lorawan® network. If the sensor zeroing process is not done correctly (the device is moving) the Activity Led will blink in Red color.

Caption 4: The Sensor-zeroing process can be also done remotely from the cloud software.

6 UPLINKS AND DOWNLINKS MESSAGES DESCRIPTION

Uplink and downlink description are for end-users.

Developers working Satevis® device integration within a LNS, should visit our developpers Portal: Click here

The access to developers Portal is secured , please contact us to get the password.

6.1 DEFINITIONS

LoraWan® messages can be divided into uplink and downlink messages based on the direction they travel.

Uplink messages - Uplink messages are sent by Satevis® device to the LNS relayed by one or many gateways.

Downlink messages - Each downlink message is sent by the LNS to only one end device and is relayed by a single gateway.

All Uplinks are confirmed messages: the LNS transmits a confirmation for each message. This method enables temporary data backup mechanism in the case of transmission failure.

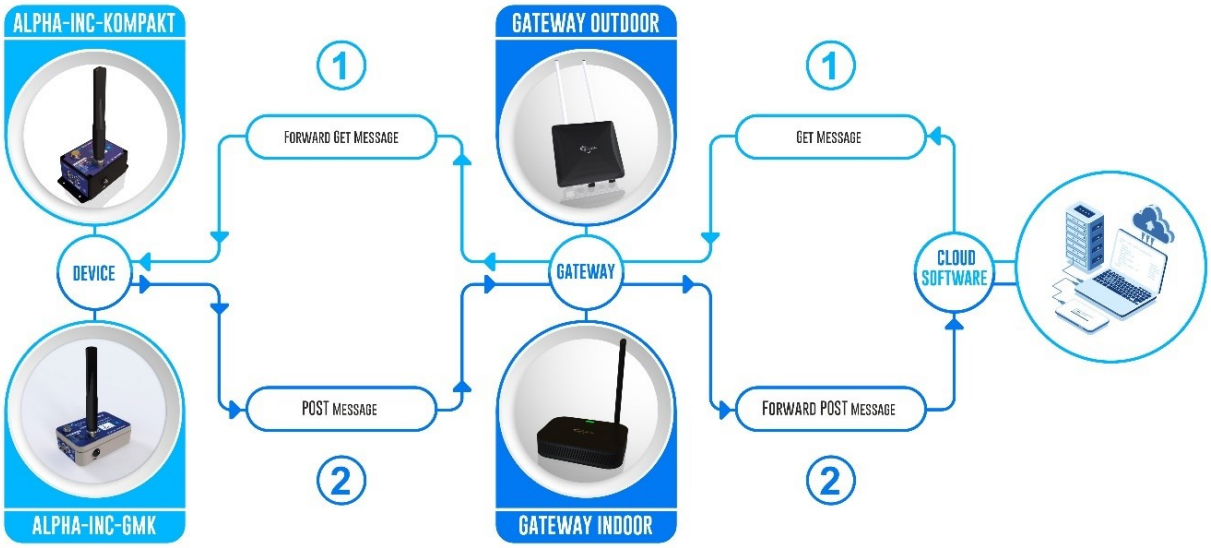
6.2 POST AND GET MESSAGE TRANSFER METHOD

To simplify data exchange , we have implemented a message transfer method inspired from HTTP protocol.

6.2.1 GET request

GET Request is transmitted by the LNS to read Satevis® device status or to get currents settings.

Satevis® device will always answer with a POST message.

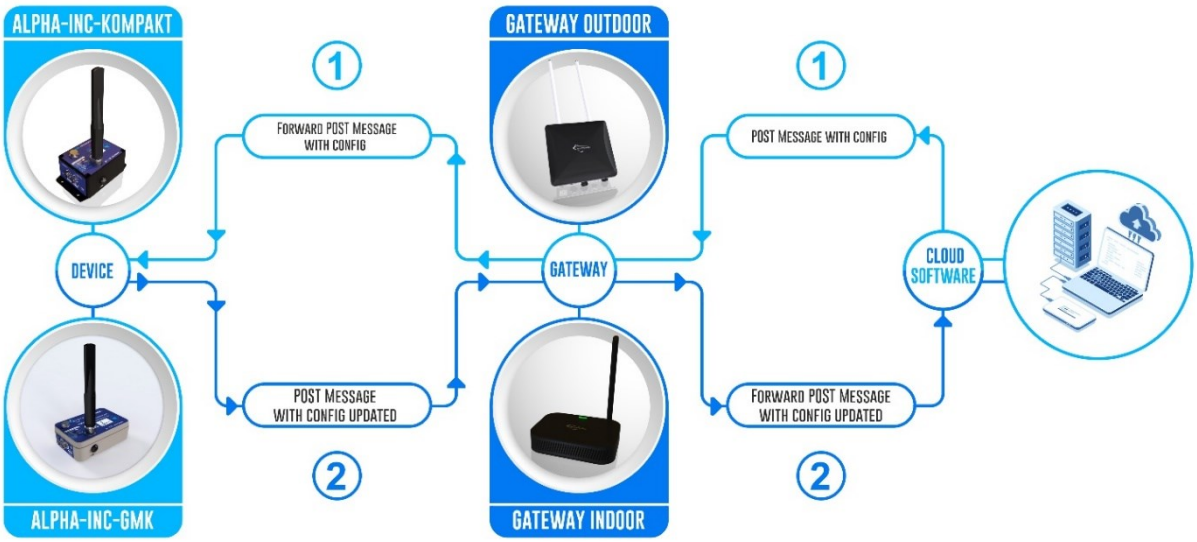


6.2.2 POST Request

POST request can be transmitted by Satevis® device to the LNS, it contains :

- Device profile at Startup,
- Device current configuration;
- System Diagnostic Report
- Data Measurement

When POST request is transmitted by the LNS, it contains new settings (ex: alarms thresholds, new measurement mode.....).



6.3 LIST OF ALL MESSAGES EXCHANGED

The list of all messages exchanges between Satevis® device and the LNS are displayed here:

Field Type
Messages type transmitted by satevis device duing startup
Message Type related to data measurement and diag transmitted frequently (user configurable)
Message Type Posted during Init or on User Request(Push Button)
Message Transmitted during Init or frequently (user configurable)
Remote device config. Transmitted only on GET request from LNS
Datalogger config & status
Error Message
Specific sensor config or Status

Message Type ID	Uplink	Downlink	Short description
Device Main Profile	POST	GET	Fisrt Message Tx at startup - Important to build up Satevis profile on LNS/ cloud software
Sensor Profile	POST	GET	Second Message Tx at Startup- Important to build up Satevis profile on LNS/ cloud software
System Diag Report	POST	GET	Cyclic Diag Report - Refresh rate can be remotely configured (SDRR) System Diag Report can be also transmitted on user request
Slow Monitoring' Message	POST	N.A.	Cyclic Data neasurement transmission , several measurement samples can be encapsulated in the message
Alarm Notification message ('Alarm Monitoring' mode)	POST	N.A.	Alarm notification transmitted in the case if an alarm threshold is reached based on the logical AND/OR alarm notification Rule and Thresholds Values
Hello Data Transmission message	POST	GET	Hello Message transmitted: during startup, on GET request and after Sensor zeroing
Keep Alive Message ('Alarm Monitoring' mode)	POST	N.A.	Keep Alive data transmission in the case if there is no Alarm Threshold reached
LORAWAN Stack Info	POST	GET	LoraWan stack info (For security reasons Lora settings can be only changed from Satevis Link software). Only GET request is available
Monitoring Full Config	POST	POST, GET	All the Timing parameters related to Monitoring mode
Sensor Channel Alarm config	POST	POST, GET	Sensor Channel configuration including alarm thresholds type, and values
Monitoring Mode config	POST	POST, GET	Monitoring Mode configuration. Can be used to START/STOP the Monitoring application
System Diag Settings	POST	POST, GET	System diag refresh rate configuration
Hardware Reset Request	POST	POST	Remote Request to RESET Satevis device
LoraWan RejoinFrequ config	POST	GET, POST	Configuration related to LoraWan Rejoin cycle
Clock Source config	POST	GET, POST	Configuration related to clock source. Currently only LNS Clock source is available
Sensor calib. Config	POST	GET	Date of calibration for all the sensor channels
DataLogger Config	POST	POST, GET	Datalogger settings
DataLogger Status	POST	GET	Provides datalogger status
Sensor Zeroing config	POST	POST, GET	Enable/Disable sensor zeroing
Sensor Zeroing Results	POST	GET	Transmits offsets values on Inclinometer sensor
Inclino sensor config	POST	POST, GET	Inclinometer sensor range config
IR Temp config	POST	POST, GET	IR Temperature sensor config

6.4 DURING DEVICE STARTUP PROCESS

At device startup , these first messages are transmitted automatically to the cloud software:

- **Main Profile:** contains the Satevis® Device ID, all the versions ID (Hardware, Firmware, LoraWan® Stack), Lorawan® Settings and all the timing parameters related to the different monitoring modes
- **Sensor Profile:** contains all the sensor channels profile connected to Satevis® Device, this will allow the user to create a database on the cloud software containing the Sensor Type, Conversion Method to the physical unit

Satevis® device will receive a clock synchronization message from LNS on PORT 202.

When Profile Information is transmitted, Satevis® device starts to send Hello Message followed by System Diag Report, informing the user about the device status.

Clock synchronization is a critical function used on data timestamping and alarm management. Make sure your LNS (LoraWan® Network Server) integrates Clock synchronization on PORT 202, popular and recent LNS integrate this service and doesn't need specific development on your side.

For more information about Clock synchronization, please read Lora Alliance Spec : click here

6.5 DURING MONITORING PERIOD

Satevis® device transmits frequently the following message:

- Measurement data : Slow Monitoring Mode or Alarm Monitoring Mode
- System Diagnostic report: Battery status, Voltage, Internal Temperature

Information related to Network Quality (SNR, RSSI) are available on each Uplink message

6.5.1 System Diagnostic Report

System Diagnostic report is transmitted on a duty cycle which can be changed by the user.

Diagnostic Information	*Description*	*Values*
Power Source	Displays from which power source the device is operating	• USB Power • Primary Cell Pack (1 or multiple cells)
Battery Power Status	Displays battery Power status. If the Battery displays Standby Low battery, it needs to be changed.	• Battery saver mode : battery is working properly with optimized power saver mode • Battery is powered OFF By user • Battery not present : disconnected by user • Standby Low Battery
Battery Voltage	Displays battery Voltage	Battery voltage in Volts
Battery level status	Displays battery level status	• Battery level is very low • Battery level is low • Battery level is medium • Battery level is good • Battery level is very good
Battery Diagnostic	Displays Battery diag	• Battery Good • UnderVoltage : Battery Voltage too low for normal operation, must be changed ; • Overvoltage : High Battery Voltage, further actions should be taken • Info Battery Not available (case of battery power switched off or No Battery Available)
Internal Temperature	Internal Temperature sensor located close to Inclinometer sensor for temperature compensation and internal monitoring	Value in °C
Datalogger Status	Currently Datalogger function is not available	Different status are available: • Datalogger enabled • Datalogger stopped • Datalogger Formatted ready to be used • Datalogger Full, datalogger stopped • Datalogger flash failure

		• Datalogger Busy Download
Datalogger Memory used	Currently datalogger	% datalogger memory used

Currently datalogger function is not available. Planned for Q4-2024. As LoraWan® is not designed for fast data transmission, datalogs can be downloaded from Satevis® Link software by using the USB adapter.

6.5.2 Monitoring Mode (Data Acquisition & Transmission)

Two types of Monitoring modes are available:

- **Slow Monitoring Mode** for an ultra-low power operation
- **Alarm Monitoring Mode** for Alarm tracking

6.5.3 Slow monitoring Mode

Slow Monitoring mode is suitable for an ultra low power operation on your Satevis® device.

6.5.3.1 User-settings

Two user-settings are available:

- **Monitoring Refresh Rate (Acronym: MRR, Unit : seconds):** Measurement data is performed on a duty cycle, it starts with a Minimum value of 20s and maximum Value 86400s;
- **Max Number of Data samples (MAX_DATA_SAMPLES) in a message:** Defines max number of data samples contained in a message;

The message containing data measurement is transmitted to the LNS when the Maximum number of data samples have been reached.

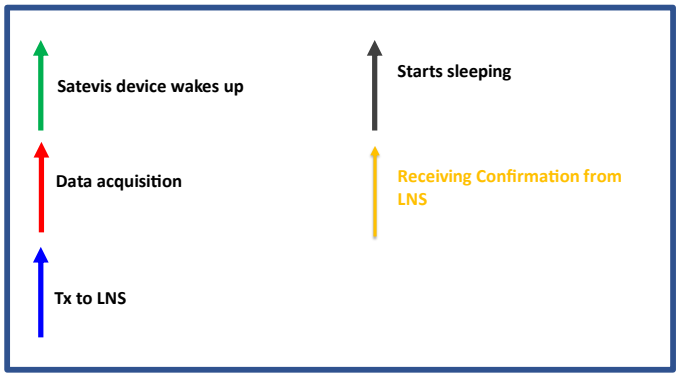
Example : if MRR = 20s, MAX_DATA_SAMPLES = 8 , every 160s, a buffer message containing 8 samples measurement data is transmitted to the LNS

Why sending a message containing several samples ?

This will allow to limit data transmission (and therefore optimize battery power consumption) and avoid a network congestion in the case of high network density.

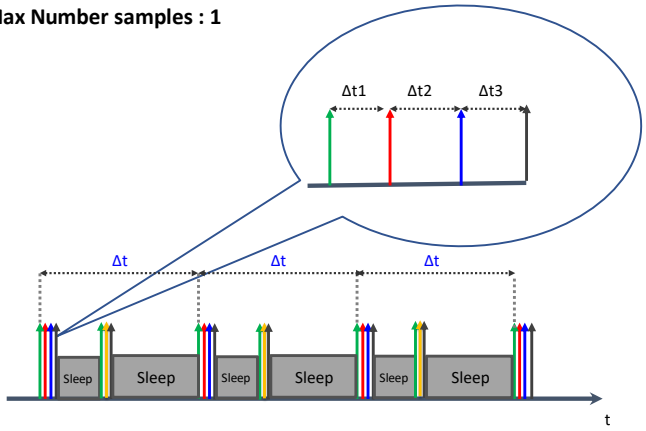
6.5.3.2 Device operation : case of 1 data sample in a message

Captions



Slow Monitoring Mode

Max Number samples : 1



In Slow Monitoring Mode Satevis® device operates as follow:

Step 1 : A Data acquisition is performed on a Monitoring Refresh rate (MRR) and timestamped. In this case the Max Number of Data Samples is 1 sample in a buffer, the Data Acquisition is immediately transmitted;

Step 2: The device wakes-up to check the confirmation message (or Acknowledgment) from the LNS

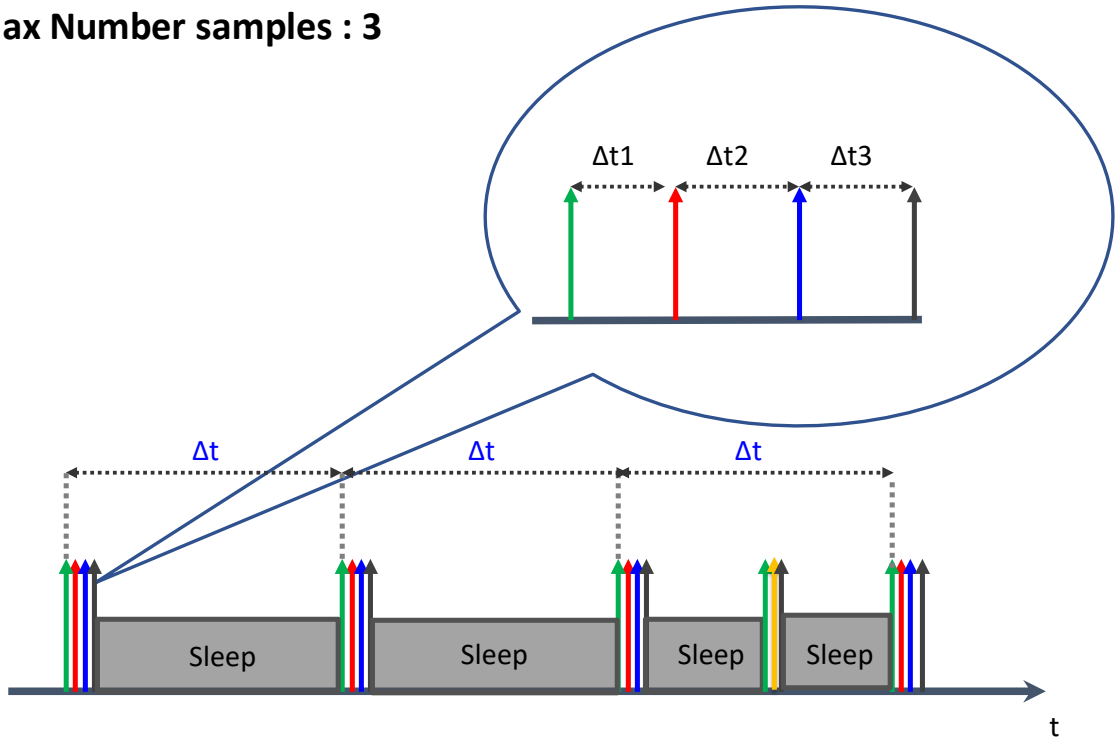
Step 4: Depending on System diagnostic Refresh Rate, System Diagnostic report is transmitted 20 seconds after the Data Acquisition,

Step 5: Satevis® device goes to sleep (if “sleep” power mode is enabled)

6.5.3.3 Device operation : case of 3 data samples in a buffer

Slow Monitoring Mode

Max Number samples : 3



6.5.4 Alarm Monitoring

In Alarm Monitoring Mode, Satevis® device transmits an Alarm notification if an Alarm Threshold is reached.

In the case of no Alarm presence, the device transmits a Keep Alive notification to keep the user informed about the Monitoring status.

The keep alive message frame contains : max, min , average values and latest measurement calculated during the keep alive period.

Three level of Alarm notifications can be transmitted to the LNS: **Minor Alarm (MA), Severe Alarm (SA), Critical Alarm (CA).**

6.5.4.1 User-settings

Several settings are available for an accurate alarm configuration:

- When an Alarm Threshold is reached, data acquisition can be accelerated for a real-time Alarm Tracking (**AMRR - Alarm Monitoring Refresh Rate**)
- If an Alarm Threshold is not reached, data acquisition is refreshed frequently (**Monitoring Refresh Rate - MRR**) and a Keep alive message is transmitted on a duty cycle (**Keep alive refresh rate -KARR**)
- Logical 'OR' or 'AND' combination can be generated for Alarm Notification
- For each sensor channel:
    - Alarms can be enabled/disabled;
    - Three levels of Alarms Thresholds can be configured: **Minor Alarm (MA), Severe Alarm (SA), Critical Alarm (CA);**
    - Low, Mixed or High Alarms Thresholds can be configured;

6.5.4.2 Alarms thresholds configuration

For all sensor channels, three different types of Alarm Threshold crossing are available:

- **Low Alarm Threshold** : Triggers an alarm when a data measurement is falling
- **High Alarm Threshold** : Triggers an alarm when a data measurement is rising
- **Mixed Alarm Thresholds :** Triggers an alarm when data measurement is outside a band of 'No Alarm Zone'

Three levels of alarms thresholds are available allowing users to redirect the alarm notification to different emails or to activate a relay:

- **Minor level:** Lowest level of alarm,
- **Severe level:** Medium level of alarm notification
- **Critical level:** Critical level , field intervention is requested

	Low Alarm Threshold	*High Alarm Threshold*
Alarms thresholds Level	MA (Minor Alarm) > SA (Severe Alarm) > CA (Critical Alarm)	MA (Minor Alarm) < SA (Severe Alarm) < CA (Critical Alarm)
Example for Temperature Sensor	MA = -5°C , SA = -7°C, CA = -10°C MA notification is transmitted to LNS, if temperature goes below -5°C. SA notification is transmitted to LNS, if temperature goes below -7°C CA notification is transmitted is temperature goes below = -10°C See Figure 6	CA = +30°C , SA = +34°C, MA = +36°C Alert level notification is transmitted to LNS, if temperature goes higher than +30°C. Action level notification is transmitted to LNS, if temperature goes higher than +34°C. Alarm level notification is transmitted to LNS, if temperature goes higher than +36°C. See Figure 7
Example for Humidity Sensor	MA = 45%RH , SA = 35%RH, CA = 30%RH MA notification is transmitted to LNS, if humidity goes below 45%RH. SA notification is transmitted to LNS, if humidity goes below 35%RH. CA notification is transmitted to LNS, if humidity goes below 30%RH.	CA = 85%RH, SA = 80%RH, MA = 70%RH MA notification is transmitted to LNS, if humidity goes higher than 70%RH SA notification is transmitted to LNS, if temperature goes higher than 80%RH CA notification is transmitted to LNS, if temperature goes higher than 85%RH
Example for Inclination Sensor	MA = +5°Angle , SA = +3°Angle, CA = -6°Angle MA notification is transmitted to LNS, if inclination goes below +5°Angle	CA = +3°Angle, SA = +4°Angle, Alert = +6°Angle MA notification is transmitted to LNS, if inclination goes higher than +3°Angle

	SA notification is transmitted to LNS, if humidity goes below +3°Angle CA notification is transmitted to LNS, if humidity goes below -6°Angle	SA notification is transmitted to LNS, if temperature goes higher than +4°Angle CA notification is transmitted to LNS, if temperature goes higher than 85%RH

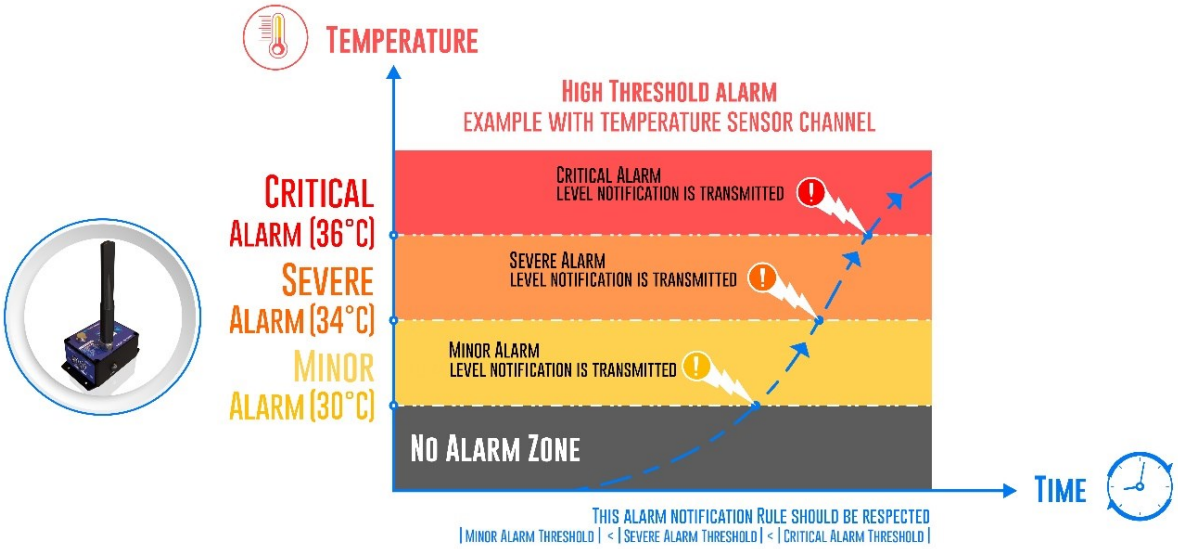


Figure 6 : Example of High Threshold Alarm on external Temperature sensor

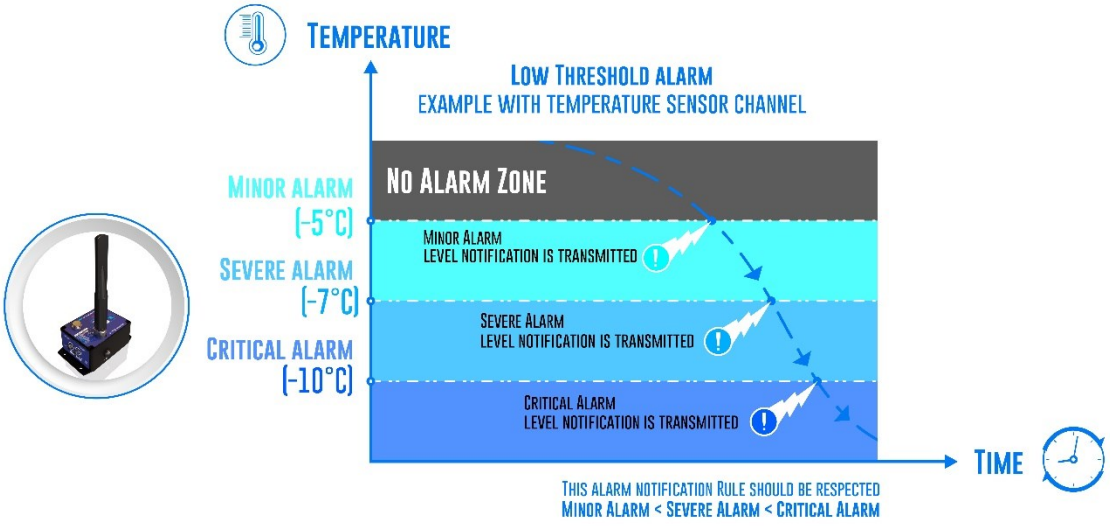
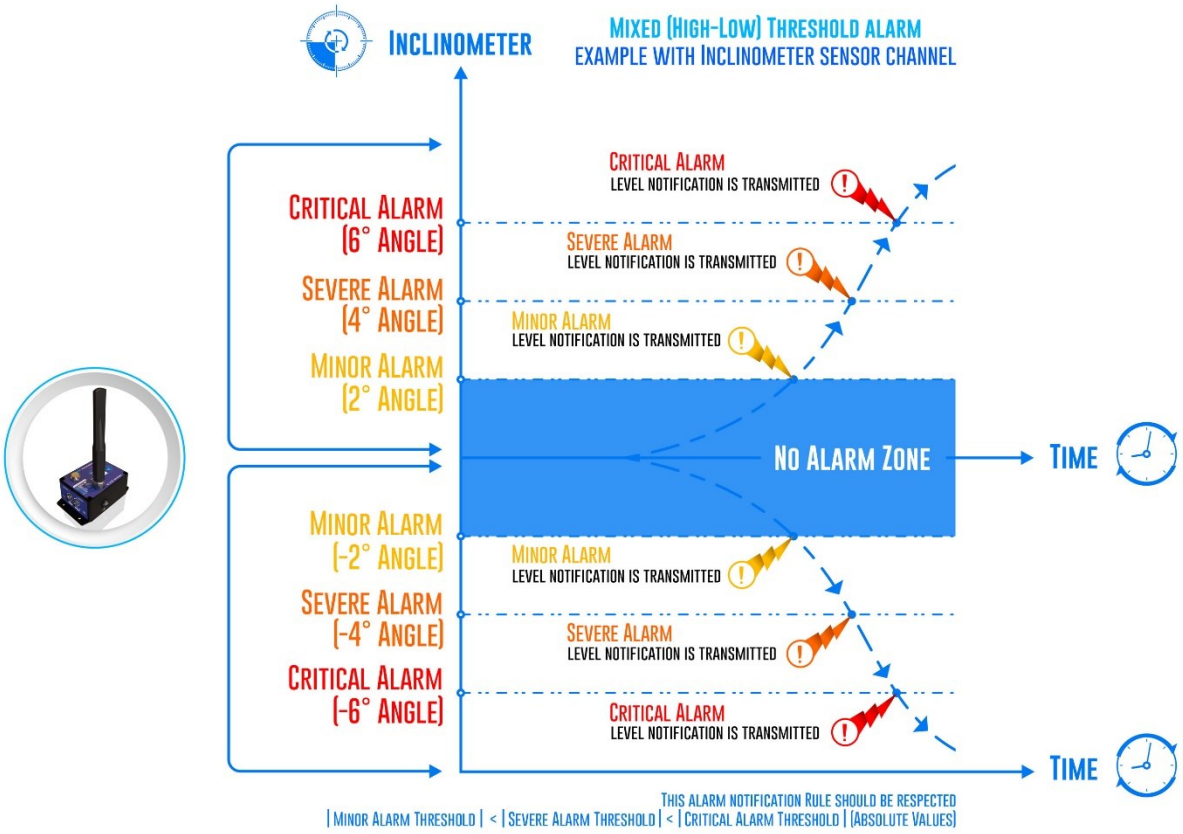


Figure 7 : Example of Low Threshold Alarm on external Temperature sensor

Mixed High-Low can be used for sensors used to track a structure/equipment moving to one direction and the opposite.



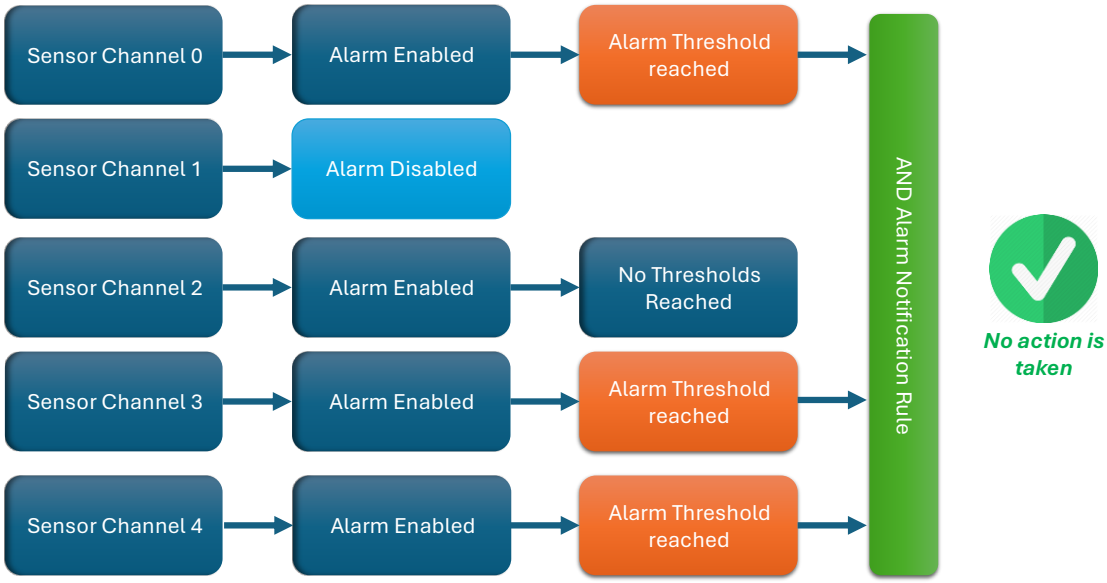
6.5.4.3 Alarm Notification Rule

Two alarms notifications rules are present:

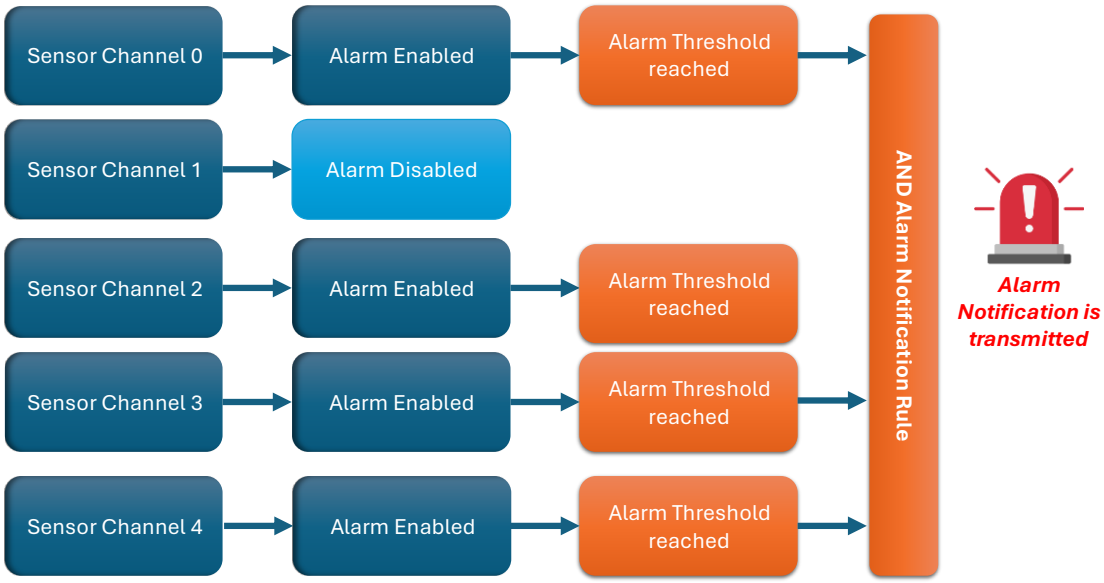
- **Logical 'OR' Alarm Notification :** Alarm notification is transmitted to cloud software if an Alarm Threshold is reached on one of the sensor channel (Alarm Notification should be enabled on the sensor channel)

- **Logical 'AND' Alarm Notification** : Alarm notification is transmitted to cloud software if an Alarm Threshold is reached **on all the sensor channels at the same time** (Alarm Notification should be enabled on the sensor channel)

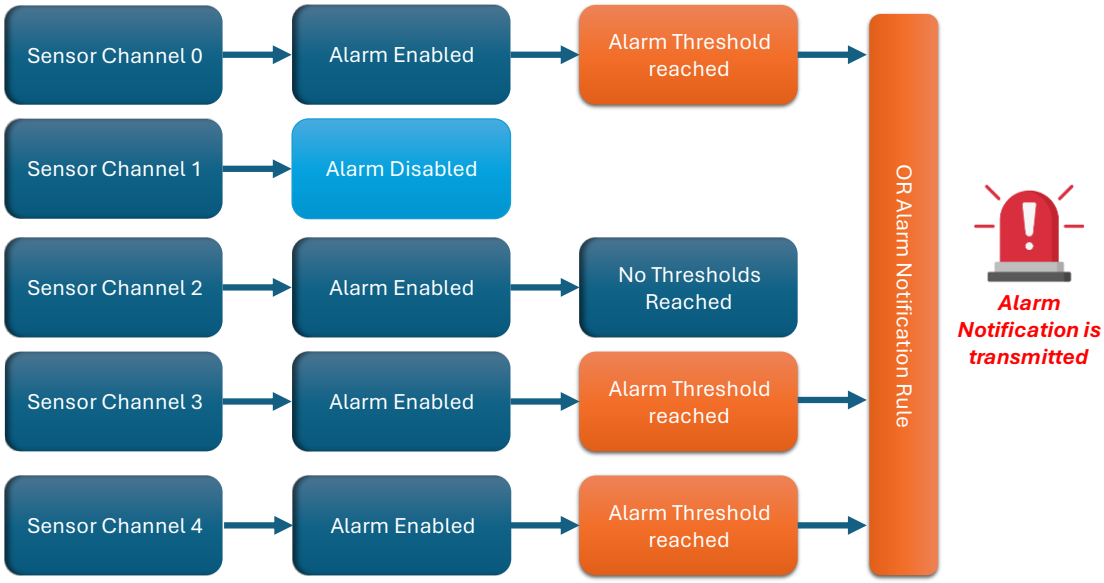
Example with AND Rule: No Alarm notification is transmitted to LNS as on Sensor Channel 2 , no Alarm Thresholds was reached.



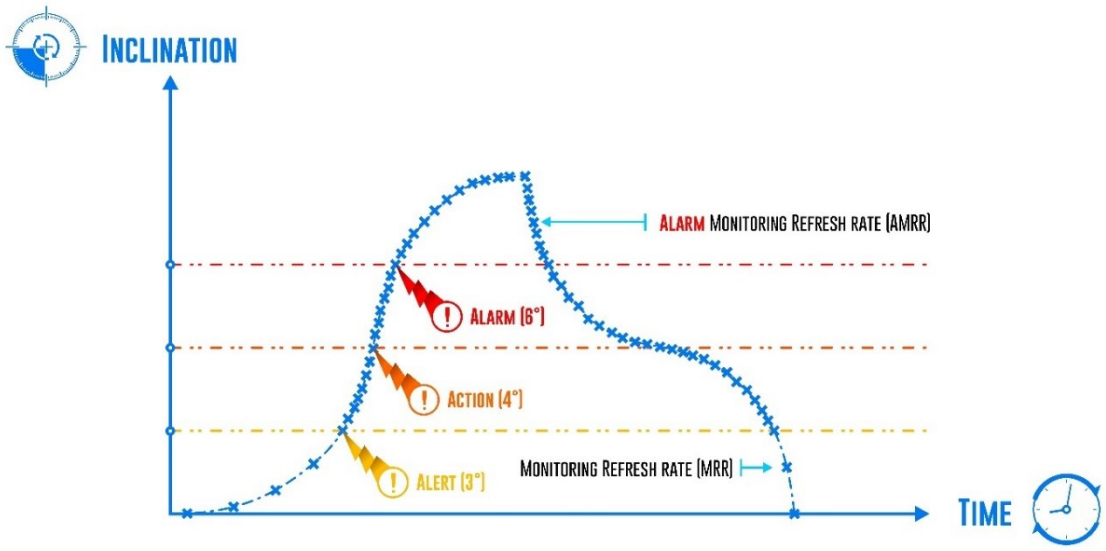
Example 2 with AND Rule : An alarm notification is transmitted to the LNS as all the sensor channels reached an Alarm Threshold.



Example 3 with OR Rule : An alarm notification is transmitted to the LNS as an Alarm Threshold was reached on one of the sensor channel.



6.5.4.4 Device operation



On this example , inclination sensor channels comes with the following configuration:

- Alarms Thresholds are configured with Minor Alarm = 3°, Severe Alarm = 4° , Critical Alarm = 6°

- High Threshold alarm is configured with OR Alarm Notification Rule
- Alarm Monitoring Refresh Rate (AMRR) is configured with 40s, Monitoring refresh Rate is configured with 2 minutes
- Keep Alive refresh rate is configured with 10 minutes

6.5.5 STOP Monitoring Mode

Stop Monitoring mode can not be considered as a data acquisition mode, Satevis® device stops data acquisition and transmission.

To avoid irrelevant alarms transmissions, use this mode during your sensor deployment and configuration on the field .

6.5.6 All the Timings parameters

Timing setting	*Acronym*	*Unit*	*Minimum*	*Maximum*	*Default Factory Settings*
Monitoring Refresh Rate	MRR	seconds	20s	86400s	300s
Alarm Monitoring Refresh Rate	AMRR	seconds	20s	86400s	60s
Keep Alive Refresh Rate (KARR)	KARR	seconds	20s	86400s	300s
System Diagnostic Refresh Rate	SDRR	seconds	60s	86400s	600s

All the Timing restrictions (min, max values, multiple values) are directly managed by Satevis® device:

- **System Diagnostic Refresh rate (SDRR)** must be a multiple of **Monitoring Refresh Rate** (MRR);
- **Alarm Monitoring Refresh Rate (AMRR)** must be lower than **Monitoring Refresh Rate** (MRR);
- **Keep Alive Refresh Rate (KARR)** must be a multiple of **Monitoring Refresh Rate** (MRR);

6.6 OTHER SETTINGS ACCESSIBLE FROM YOUR LNS

Settings	*Description*
Lorawan® Re-Join frequency	Re-Join frequency in the case of disconnection with the LNS. Satevis® device initiate a re-join process only in the case in the connection with the LNS is lost. To not decrease the battery lifetime, Rejoin Frequency can be configured between 1h to 255h.
Inclinometer sensor config	**Inclinometer measuring range can be configured between different values:** • **Static Range ±10deg** : measuring range is limited to ±10deg, provides best precision ±0.01° • **Static range ±85deg**: measuring range is limited to ±85deg, offers higher range with ±0.02° precision • **Automatic ± 10°:** sensor starts with lower range ± 10° and moves to higher range ± 85°: if the structure is moving with high inclination > ± 10° (Example: vertical/Folding Bridge, Vessel) • **Automatic range ± 85°:** sensor starts with High Range ± 85° and moves to lower range ± 10° if the structure is moving with low inclination
Hardware Reset	**Request to Reset remotely the sensor**
Sensor Zeroing	**Request to Initiate sensor zeroing**
Hello Request	**Request to Initiate Hello Message**
Sensor calibration status	**Request sensor channels calibration status**

7 SATEVIS™ SENSOR INSTALLATION ON THE FIELD

7.1 CHECKING NETWORK QUALITY

Network quality comes with two important values :

- **RSSI (Radio Signal Strength Indicator):** RSSI (Received Signal Strength Indicator) is a relative measurement that helps you determine if the received signal is strong enough to get a good wireless connection from the transmitter. Since LoRaWAN supports bi-directional communication, RSSI is an important measurement for both gateways and end devices. RSSI is measured in dBm and its value is a negative form. The closer the RSSI value is to zero, the received signal is stronger.

- **SNR (Signal Noise Ratio):** SNR (Signal-to-Noise Ratio), often written as S/N, is the ratio of the received signal power to the noise floor. SNR is commonly used to determine the quality of the received signal. If the RSSI is above the noise floor the receiver can easily demodulate the signal.

If the RSSI is below the noise floor, it is impossible to demodulate the signal. However, LoRa can demodulate signals that are below the noise floor.

From practical experiments:

- **If SNR approaches the limit specified for the spreading factor then the packet reception will start to fail. For SF8, the SNR limit is -10dBm. SNR a very good indication of approaching reception failure.**

- **Under very good reception conditions, with strong signals, SNR is not a good indicator of signal quality and RSSI should be considered;**

Both SNR and RSSI are provided by your LoraWan® Gateway to your LNS.

7.2 LID OPENING/CLOSING

We suggest you to open/close your casing lid in a dry environment (office), you will avoid to bring Humidity inside the casing.

The Lid can be opened to change the primary cell or the battery pack, there is no user-function inside the casing. Avoid to remove the shield PCB

For easier device installation, ON/OFF switch and non-contact are located outside the casing.

7.3 ANTENNA MOUNTING

Avoid to screw forcibly the antenna on the casing, you will damage the connections.

1. Start to slowly screw the antenna on the anti-clockwise direction until you hear a click , you make sure both Antenna socket and antenna threads flanks are matching;
2. You can start to screw the antenna on the clock-wise direction ;

Use the self-amalgamating tape provided with your device, you will protect your antenna connection against corrosion.

7.4 BREATHING VENT

The main function of the vent is to keep:

- same air pressure between inside/outside the casing
- moisture outside the casing.

Avoid to obstruct the VENT, otherwise the Vent can not breathe.

7.5 MARINE ENVIRONMENT

To avoid casing oxidation in Marine environment (Salin water) , use cable grease around the connectors and junction.

Example of reference : SKU: 6173 from Liqui Moly

7.6 SUN RADIATION

If your sensor is directly exposed to Sun radiation with a rising temperature +60°C , use a Sunshield to protect it. You can use a simple white color plastic cover (like flower pot).

7.7 LIGHTNING PROTECTION

If Satevis® device is installed on a mast, lightning protection on Antennas is highly recommended. We suggest to use N-Type/N-Type lightning Arrester which should be grounded to the mast.

The threaded hole

7.8 M8 SOCKETS FOR USB AND DIGITAL SENSOR

If you don't use USB function, or external digital sensors. Don't leave Connectors opened, please bring the M8 caps to protect the sockets.

In the case if these caps are lost, you can easily purchase it on electronic resellers online shops : Mouser/Digikey/RS Component.

7.9 LORAWAN FIELD TESTER

Before to deploy Satevis® sensors on your site, we suggest you to use a Lorawan® field tester.

8 TROUBLESHOOTING

✓ ***Why the Satevis® device LEDS are not activated during data transmission ?***

Even if we have designed a device with Ultra-Low Power LEDS it's still use some power. LEDS are only activated on specific events Power Cycle/Hello Messaging / Sensor zeroing.

If you are not sure if your device is working on site:

- Check Last Data received on your LNS,
- Use Hello function to get the latest sensor status;

✓ ***What should I do if interference is present on the radio channel?***

Check the Frequency Plan available on your Gateway, maybe you are using a Frequency Plan intensively used by other devices.

✓ ***Why the Satevis® device doesn't respond to DownLink Messages (POST messages transmitted by the LNS)?***

- Downlink messages are transmitted only when an Uplink Message is received
- Check if your device is connected to a Lorawan® gateway

✓ ***Why do I have too much noise on my sensor signal ?***

- Check your external power supply quality
- Check if you device is installed properly and there is no vibration. If vibration is present use rubber foam between the sensor and your equipment/structure to decrease the vibration

When the Inclinometer sensor is configured with a measuring range of 10 degree, why I see 10-12degree Angle on the axis pointing to the ground ?

- If your Inclinometer sensors is configured with ±10° measuring range, you will see saturation on the sensor Axis pointing to the gravity. The inclination is extracted from an accelerometer with low measuring range ;
- Our inclinometer is based on a accelerometer with low range, the gravitational force has three vector components, in X, Y & Z directions. Due to gravity, the inclinometer should saturate at 10 degree on the Z axis (Z axis is pointed to the ground).