8931N

Technical Specification

INTRODUCTION

The TE model 8931N wireless vibration sensor combines a triaxial accelerometer, a data collector, and a radio into one compact, battery-operated device that measures both vibration and temperature data. It was designed for harsh environments and some models comply with ATEX certification.

The model 8931N wireless accelerometer uses the LoRaWAN™ communication protocol. It offers a simple, reliable, and secure means of expanding condition-based maintenance into plant areas where the cost to install wired systems is prohibitive, making data available to existing process control and information systems. Additionally, it offers a Bluetooth Low Energy (BLE) interface to allow easy changes to default settings of the sensor

The model 8931N incorporates a piezoelectric accelerometer which offers a wide bandwidth to >15kHz, outstanding measurement resolution and superior long-term stability when compared to designs using MEMS solutions.

The 8931N contains a digital signal processing capability that provides an FFT analysis of the sensed vibration.
The output data describes the center frequency, peak value, bandwidth, and percent of the total spectral content for the eight most significant acceleration peaks in the vibration signal.

Because of this feature, the 8931N directly provides the data most needed to plot trends and monitor changes in the performance and condition of factory machinery.

Contents

1 Operating Modes

The 8931N comes with different modes of operation which are listed below:

1.1 Modes of operation

Operating mode	Description	Condition
Standard	User mode.	None

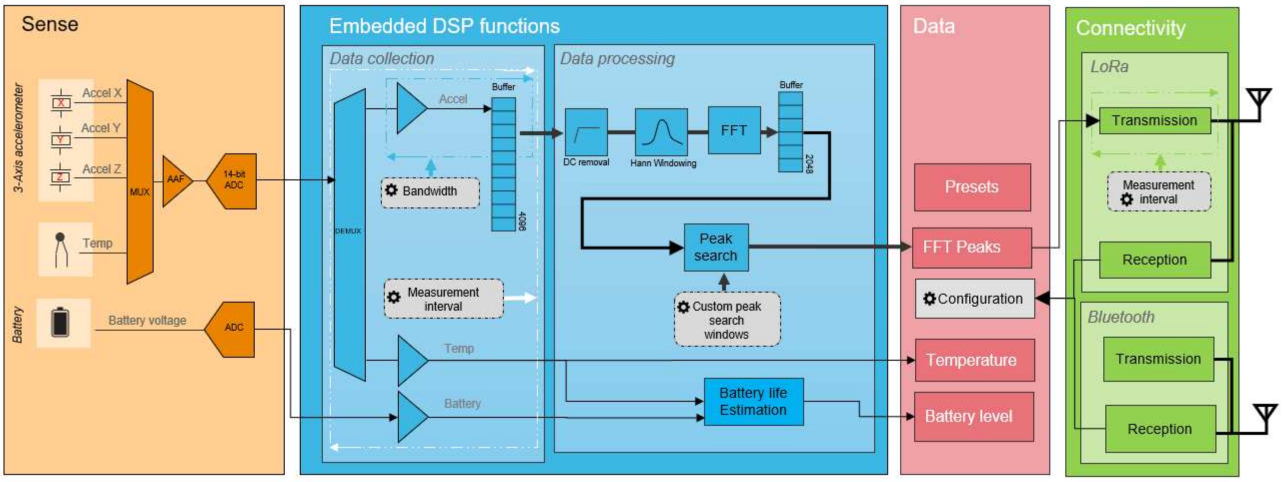
2 Normal Mode Description

The 8931N operates as a smart device. It offers sensing, processing, and wireless communication capabilities.

It embeds smart functions based on FFT computing with a powerful peak detection algorithm. Configurable parameters offer the end user the flexibility needed within the application.

The 8931 N solution consists of sensitive accelerometer and temperature sensor elements combined with a powerful embedded microprocessor.
The device computes sensor readings in a smart way, with the most important peaks in the frequency domain are extracted from the spectrum based on configurable windows of interest.

Finally, the peaks are transmitted over the LoRaWAN network at the programmed interval, split in 3 separate uplinks (1 frame per axis).



2.1 General Description

The product has two BLE modes:

- Advertisement Mode: available time slot to access to Connected mode
- Connected Mode: advanced mode for configuration and special mode. Each advertisement allows the opportunity to user to switch to Connected mode
- LoRaWAN is used to send data to an external network

1. First hour after power on

- **BLE**
  - When the device is powered on, a yellow LED blinks to confirm the proper battery insertion

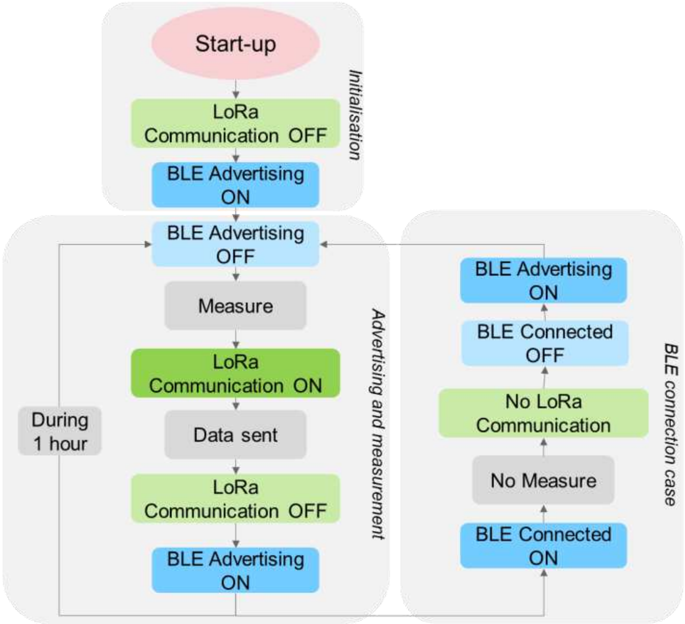
  From the sensor startup and for 1 hours, the device advertises every 1 second. This allows user to configure the product by switching to connected mode. Measurement is performed at measurement interval, but data is not available on advertisement frame
- When beaconing, LoRaWAN communication is disabled and powered off

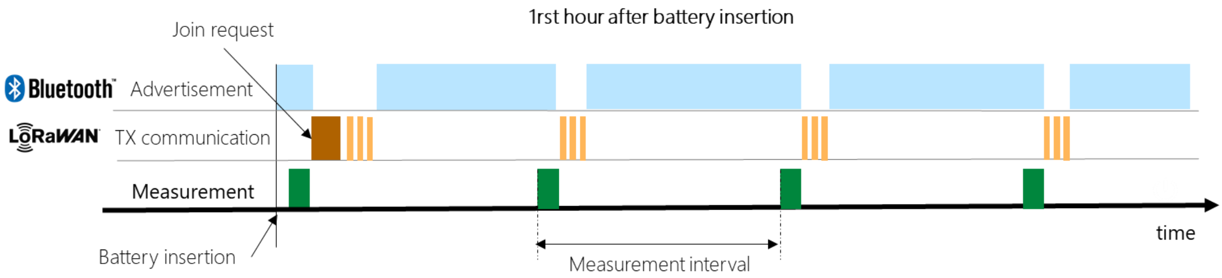
- **LoRaWAN:**
  - When initiating a measurement and a LoRaWAN communication, BLE is disabled. Between BLE advertisement OFF and LoRaWAN communication ON, it takes 4000ms
  - The device performs an initial set of acquisition on the factory default settings. Then it processes the measurements depending on the default parameters
  - The Join Request process allows customer identification and connection to the Lora Network. Procedure is performed as follows:
    - At startup, a request to join the Lora Network (called “Join Request”) is sent from the unit to the Network
    - If Join Request is accepted, a connection is made, and the sensor will begin sending data via upstream links to the Lora network
  - If Join Request procedure fails, the unit tries again for a period of time defined in the LoRaWAN section 2.4.1.

  The Join Request signal from the Lora Radio transmitter is never transmitted simultaneously with an advertising or connection signal from Bluetooth Radio transmitter

- If this LoRaWAN Join Request procedure succeeds, the data is transmitted through 3 uplink messages.
  When initiating LoRaWAN communication, BLE is disabled. Between BLE advertisement OFF and LoRaWAN communication ON it takes 4000ms.
- Once LoRaWAN communication is ended, the system will reactivate BLE. It takes 950ms between Lora communication OFF and BLE communication ON

First hour after battery insertion

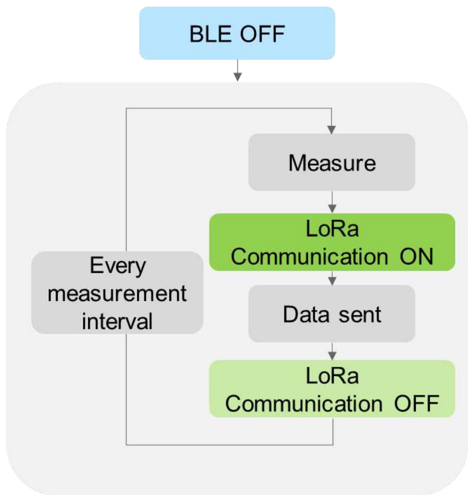


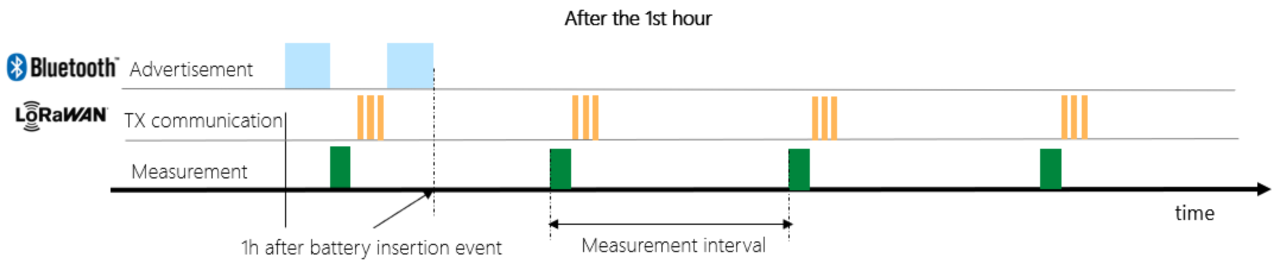


2. 1 hour after power on:

- BLE is disabled.
- The device acquires data from the sensor. The measurements are processed depending on the default parameters
- If this LoRaWAN join procedure is successful, the data is transmitted through 3 uplink messages (separated by 5min)
- Once LoRaWAN communication is ended, system goes into an idle state

After 1 hour

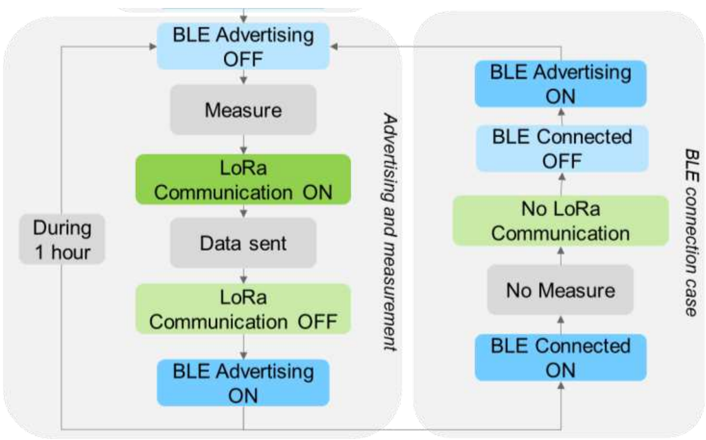


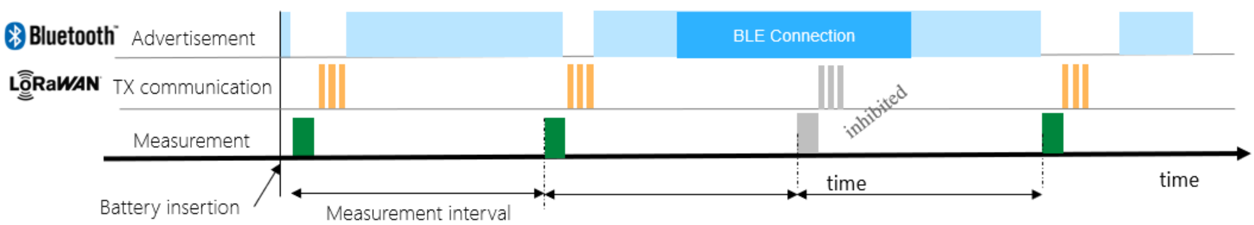


3. BLE Connected Mode

4. If the sensor advertises a central device can initiate a connection and the sensor switches into BLE Connected Mode (peripheral). While a communication is established between the sensor and the central device, measurements and LoRaWAN transmissions are stopped.

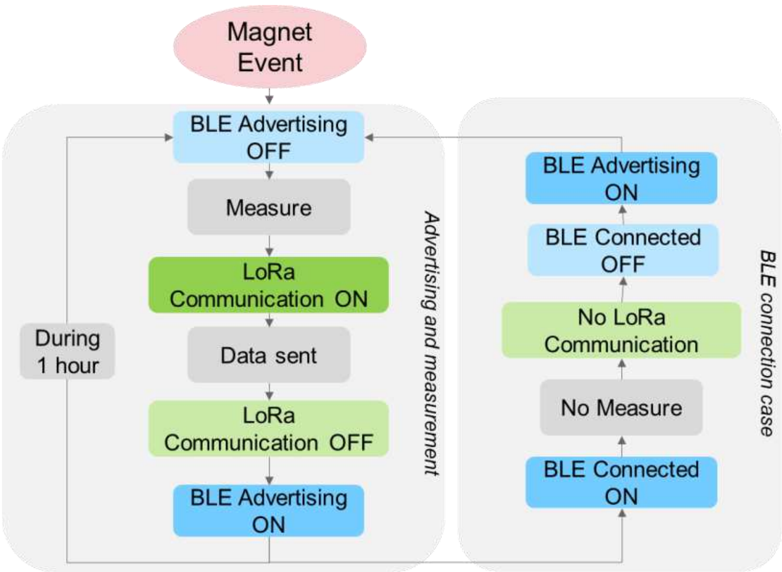
This mode is used to configure the device parameters.

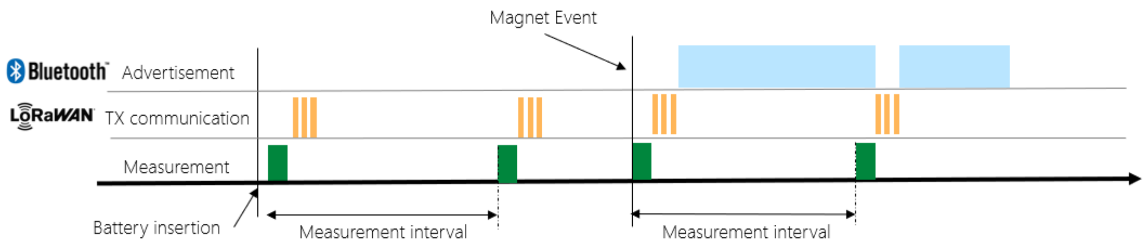


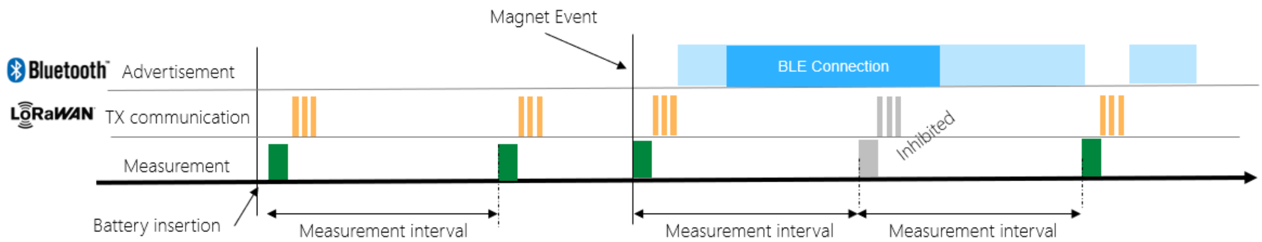


1. Special event:

If the user wants to make an asynchronous data acquisition, or access to BLE connected mode, the magnet can be used. The magnet event will trigger a measurement, send data over LoRaWAN and activate BLE advertisement with an interval of 1 second for the duration of 1 hour.

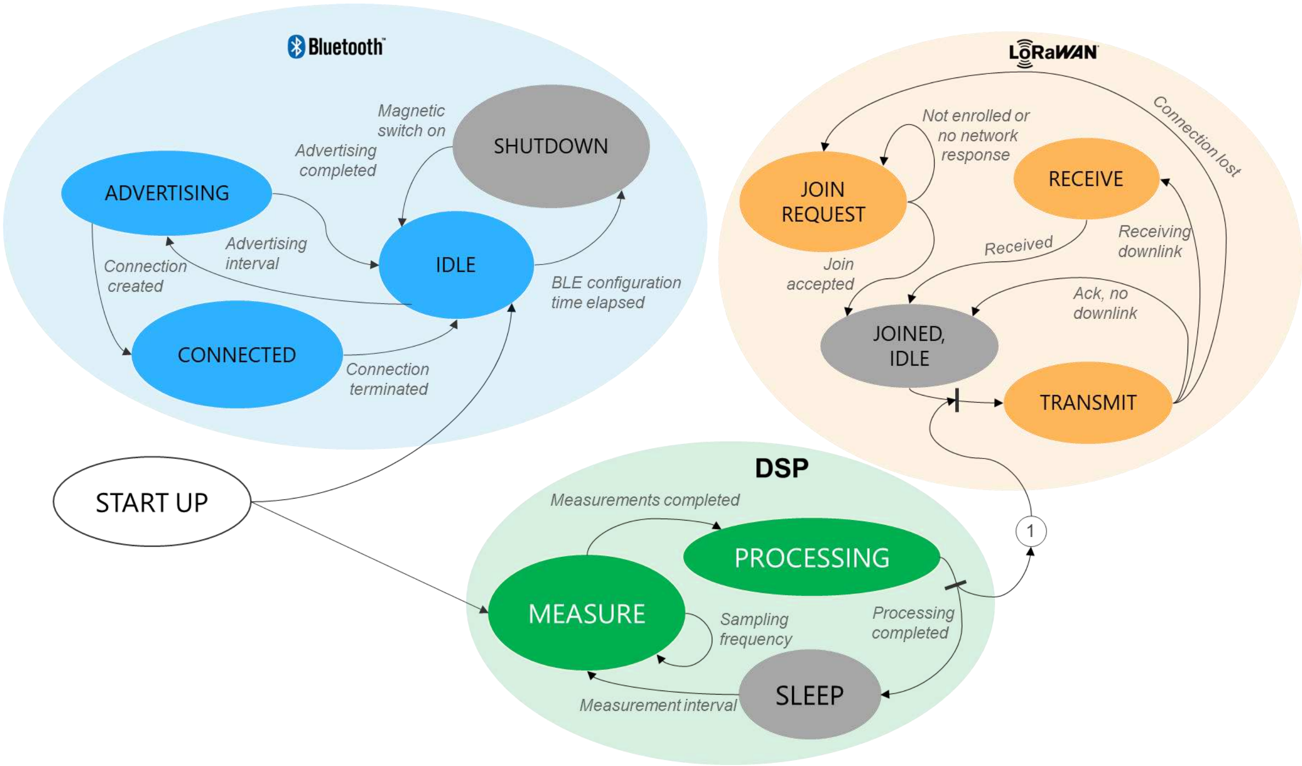

Magnet Event
BLE Advertising OFF
Measure
LoRa Communication ON
Data sent
LoRa Communication OFF
BLE Advertising ON
During 1 hour
Advertising and measurement
BLE Advertising ON
BLE Connected OFF
No LoRa Communication
No Measure
BLE Connected ON
BLE connection case


Magnet Event
Bluetooth Advertisement
LoRaWAN TX communication
Measurement
Battery insertion
Measurement interval
Measurement interval


Magnet Event
Bluetooth Advertisement
BLE Connection
LoRaWAN TX communication
Inhibited
Measurement
Battery insertion
Measurement interval
Measurement interval
Measurement interval

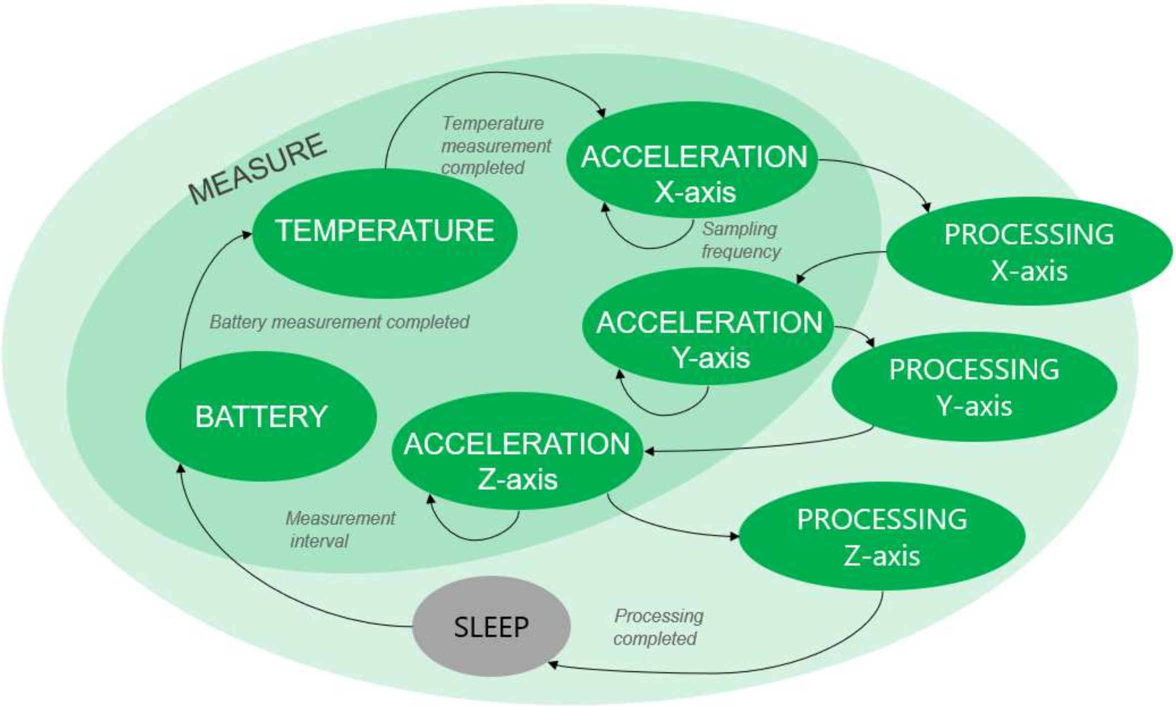
2.2 Mode of Operations

The device operation can be summarized by the following state machine diagram.



2.2.1 Data Collection

Sensor measurements are performed and transmitted at a configurable interval from 15 minutes up to 24 hours. This is driven by the Measurement interval parameter.



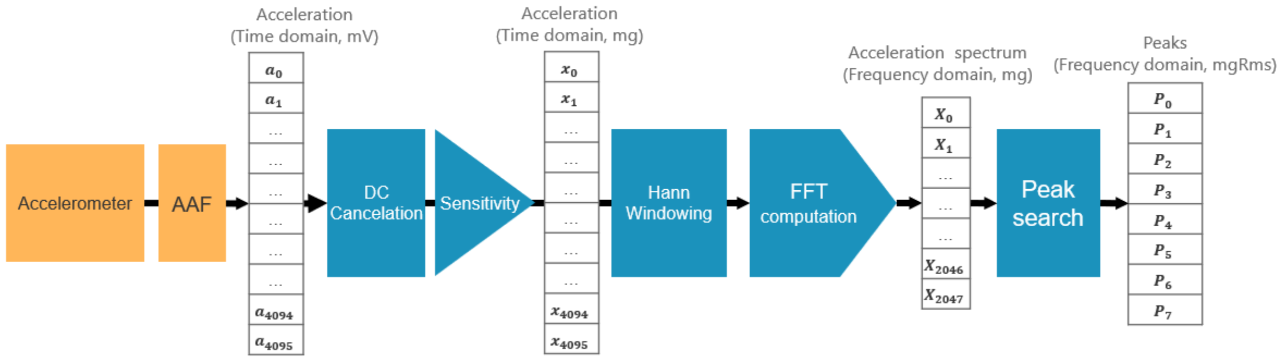
After a wake up of the sensor, the device powers on the sensing element and waits for about 3 seconds to let the accelerometer boot and stabilize its output (warm up).

A measurement consists of reading battery level, temperature, and a set of 4096 acceleration values on 3-axis at a configurable rate.

Data	Unit	Accessibility
Battery level	%	LoRaWAN, BLE
Temperature	°C	LoRaWAN, BLE
Acceleration	mg	None Values are FFT peaks

2.2.1 Data Processing

The data processing signal chain transforms the acceleration raw data into frequency peaks. The same processing is applied for each axis.



Acceleration data is collected at a chosen sampling frequency (f_s = *Bandwidth*2.56*) defined by the *Bandwidth* parameter. Raw data passes through an anti-aliasing filter (5th order Butterworth filter, $f_c = f_s/2$).

Once a set of acceleration reading is measured (4096 points), the microprocessor removes the DC signal (to remove the bias voltage of the sensing element), multiplies the results by the calibration sensitivity (mV/g), applies a Hann window to that signal and converts it into a normalized FFT spectrum. Finally, a peak search algorithm extracts the most significant peaks from the spectrum.

Note that only "peak values" are accessible by the user. Raw data and FFT spectrum are only stored for internal computation and will not be readable.

2.2.2.1 Signal processing

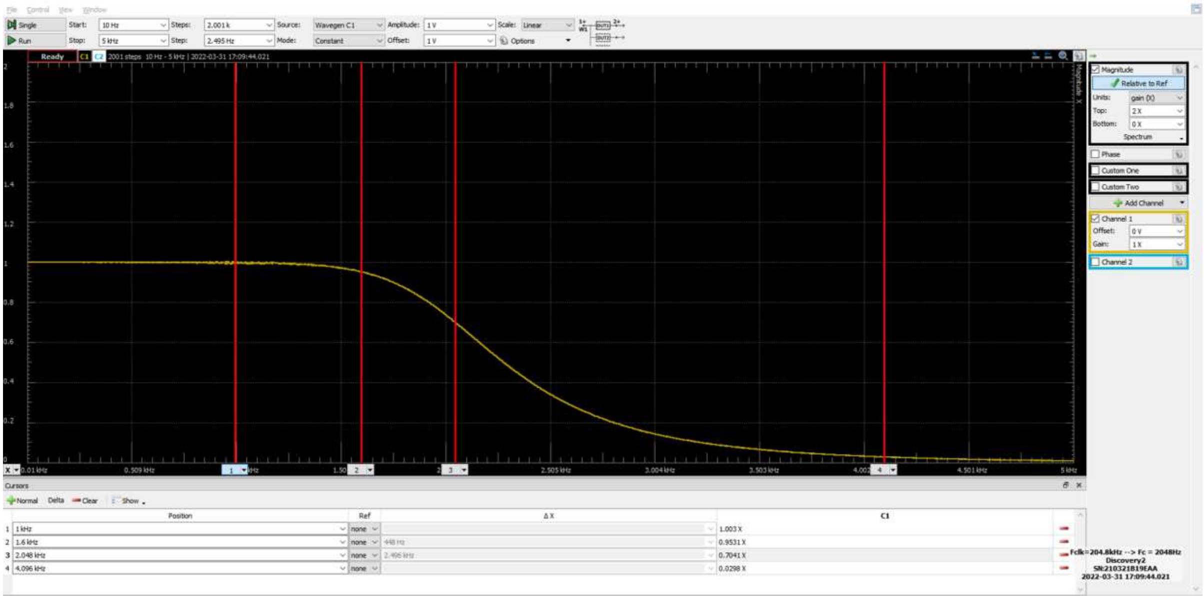
2.2.2.1.1 Acceleration acquisition

BUTTERWORTH FILTERS—MAX7420/MAX7424

Insertion Gain Relative to DC Gain	$f_{IN} = 0.5f_C$	-0.3	0		dB
	$f_{IN} = f_C$	-3.6	-3.0	-2.4	
	$f_{IN} = 3f_C$		-47.5	-43	
	$f_{IN} = 5f_C$		-70	-65	

$$a_n = a(t)(with\ fc\ and\ AAF)$$

See below the bode diagram of the AAF with Fc=2kHz as an example.



2.2.2.1.2 DC cancellation plus sensitivity

$$x_n = \left(a_n - \frac{\sum_{i=0}^{4095} a_i}{4096} \right) / \text{sensitivity}$$

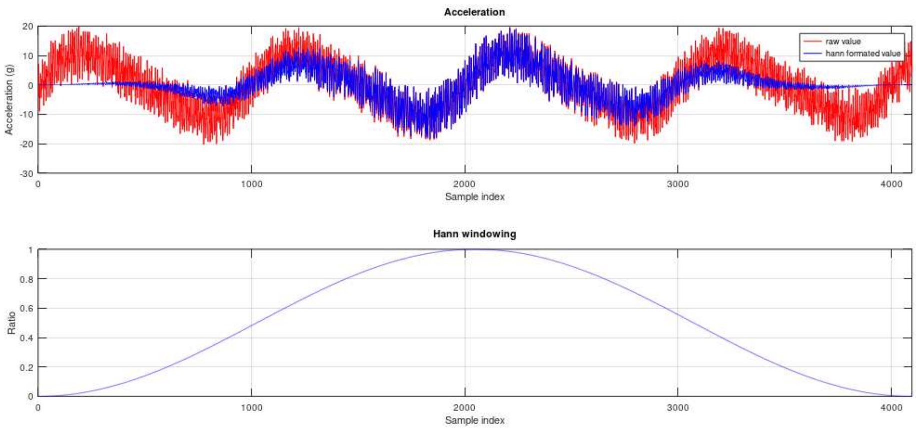
2.2.2.1.3 Hann windowing

The FFT computation comes with a fixed Hann windowing operation. This will spectrally distribute the potential leakage coming from the data collection. This operation multiplies the input time domain buffer (acceleration data) by the Hann function.

The data transformation with the Hann windowing is defined by the following formulas:

$$x_{hann_n} = x_n * \sin^2\left(\frac{\pi * t}{f_{max}}\right)$$

The graph below show the effect of the Hann windowning on a random raw acceleration signal.



2.2.2.1.4 Fast Fourier transform

After having applied the windowing, the time domain values are turned into frequency domain values using an embedded FFT computation.

5. N: number of time domain samples

6. $x_{hann}(t)$: raw data with widowing in the time domain
7. P_k: result of the FFT calculation
8. X_k : normalized magnitude spectrum in frequency domain
9. abs : refers to the complex magnitude $\sqrt{a^2 + (b\ i)^2}$

$$P_k = FFT(x_{(t)})$$

$$X_k = \frac{abs(P_k)}{N/2}, k = 1\ to\ \frac{N}{2} - 1$$

$$X_k = \frac{abs(P_k)}{N}, k = 0$$

2.2.2.1.5 Peak search

Parameters	Formula
Peak index	$Peak_{index}$, index of the bin in the spectrum
Frequency resolution	Δf
Peak frequency	$Peak_{FREQ} = Peak_{index} * \Delta f$
Peak magnitude RMS	$Peak_{RMS} = \sqrt{\frac{8}{3}} * \sqrt{\sum_{i=bin-1}^{bin+1} \frac{X[k]^2}{2}}$
Total Spectrum rms	$Signal_{RMS} = \sqrt{\frac{8}{3}} * \sqrt{\sum_{k=0}^{2047} \frac{X[k]^2}{2}}$

*purple colored text: Hann energy compensation

2.2.2.2 FFT configuration

2.2.2.2.1 Bandwidth mode

The user can define the FFT resolution mode parameter depending on his application. This gives the maximal observable frequency of the 8931N. The 16 admissible values cover a range from 200Hz up to 14.4kHz. High will be the bandwidth lower will be the resolution.

2.2.2.3 Peak search algorithm

The 8931N sensor embeds a peak search algorithm which allows users to find the most significant peaks (in term of magnitude strength) in the frequency domain spectrum.

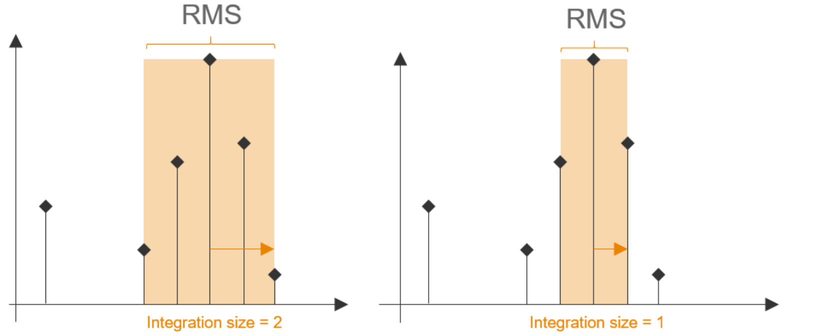
Every peak will be given over BLE (connected mode) or LoRaWAN (uplink message) with the following information.

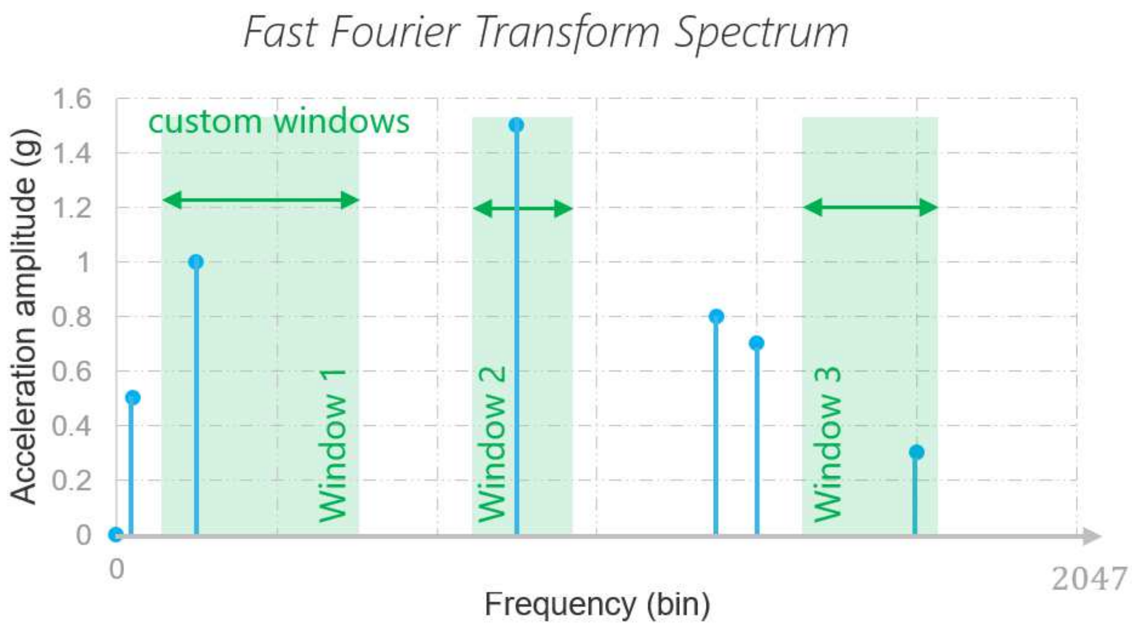
Parameters	Description
Peak bin index	Bin index of the peak. Frequency of the peak (Hz) can be calculated by multiplying thus value by the FFT resolution.
Peak magnitude RMS	Magnitude of the peak in gRMS integrated on the “bin size”

2.2.2.3.1 Search window

By default, there is one window, the peak search looks for the most 8 peaks in the full spectrum (from 0 up to 2047 bin) with an integration size of one.

It is possible to program up to 8 custom windows to define several regions of interest. Advanced parameters include number of peaks per window, integration size of the gRMS calculation.

Window configuration	Description
Peak number	Number of peaks to be found (from 0 up to 63) in the particular window
Integration size	Number of bins around the main bin to be integrated into the RMS peak magnitude. This parameter can be used to filter side lobes and avoid multiple peaks found around the same frequency. A value of 1 bin means the central bin plus 1 bin each side of the main bin. 
Min Frequency	Minimum frequency of the search window in bin index
Max Frequency	Maximum frequency of the search window in bin index

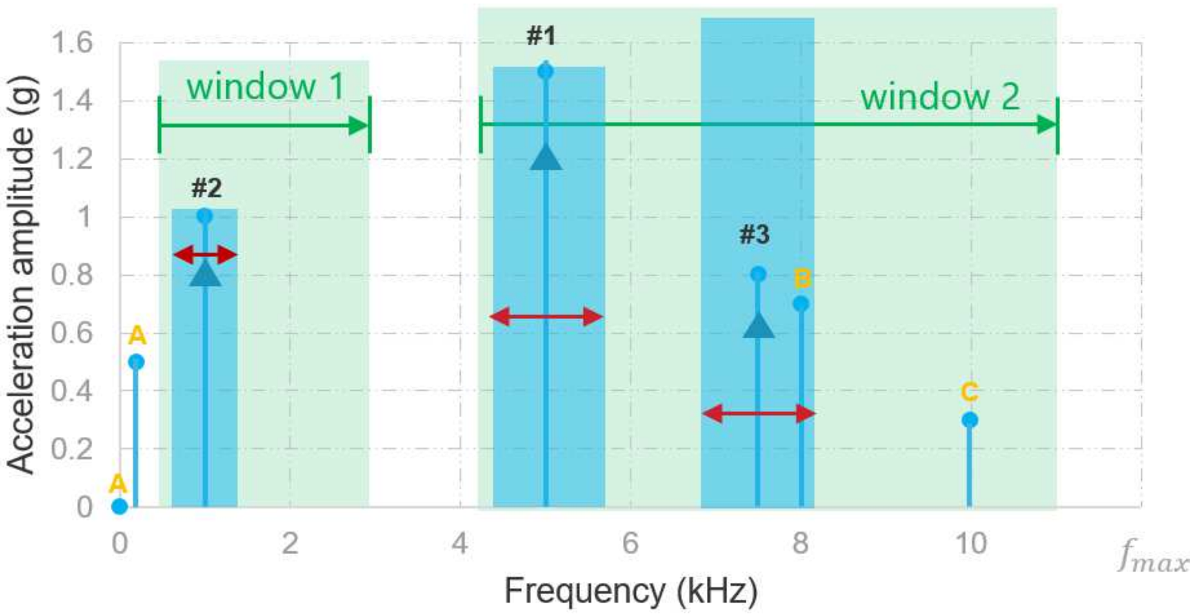


2.2.2.3.2 Example

In example below, the sensor bandwidth is set to 12.8kHz (bin resolution is 8Hz)). Two custom windows have been programmed with the following parameters.

Window index	Parameters
1	Freq: [300 Hz – 3kHz] => [60bin-375bin], Integration size: 5, Nb peak: 1
2	Freq: [4.2 kHz – 11kHz] => [525bin-1375bin], Nb of bins: 3 (150*8=1.2kHz), Nb peak: 2

Legend	Symbol
Frequency min	
Frequency max	
Number of bins	



The peak search gives as result: **#1**, **#2**, **#3**

Other peaks are filtered out from the search for the following reasons:

- All peaks outside the windows (**A**) will be discarded from the peak search results.
- Any peak (**B**) located in the "integration size" area (number of bin) of a stronger one will be included in the RMS output (of peak #3 in that example) but won't show up as a detected peak.
- If the number of peaks for a dedicated window is reached, any new other peak (**C**) inside the window will be ignored.

2.2.3 Presets

If the user does not need to use several configurations in the field (nor rotating mode), this section can be ignored.

The 8931N comes with a specific concept called "Preset". It adds high flexibility configuration for the user and offers various pre-configured modes.

The presets are divided into three different categories:

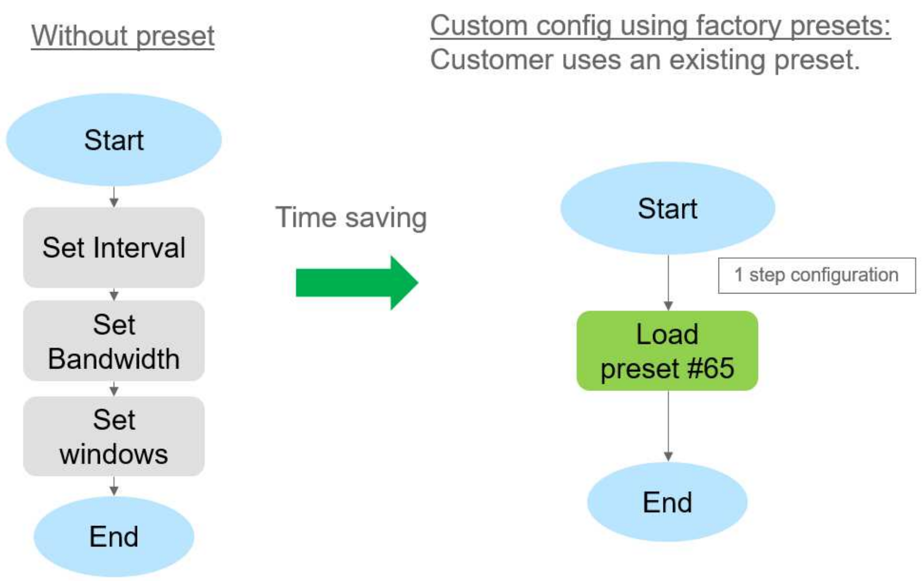
- **User**: editable area which allows the user to create their own configurations. (16 user presets available)
- **Factory predefined**: read only preset which are callable for an easy and fast configuration. (15 factory presets)

2.2.3.1 Preset management

By default, the sensor uses the "User Preset 0". It is possible to switch between 2 presets by activating the preset identifier to be loaded. It can be done anytime in BLE (connected mode) or using the appropriated LoRaWAN downlink.

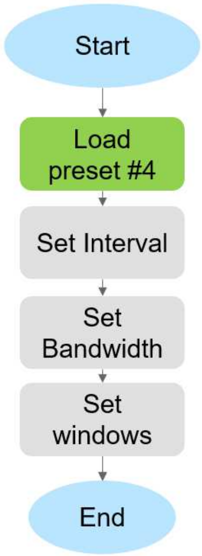
2.2.3.1.1 Calling preset replaces many configurations' steps

Once the preset is loaded, the pre-recorded parameters are applied to the sensor configuration and are instantaneously available.



2.2.3.1.2 Overwrite a user preset

If the selected preset is a user-defined preset, the parameters of the active preset can be modified (and saved) in the usual way (over BLE or LoRaWAN) using the default commands.



2.2.3.1.3 Overwrite a factory preset

If the active preset is a factory predefined one (standard or customer), the write commands will not be considered. The parameters will remain as defined in the preset map and will not be updated.

2.2.3.2 Preset map

By default, the 8931N uses “USR_PR_0” as the active preset.

The map of preset of the sensor is split in 31 blocks (16+15) of an equal size. Each preset stores BW_MODE, MEAS_INTERVAL, and 8 peaks search windows.

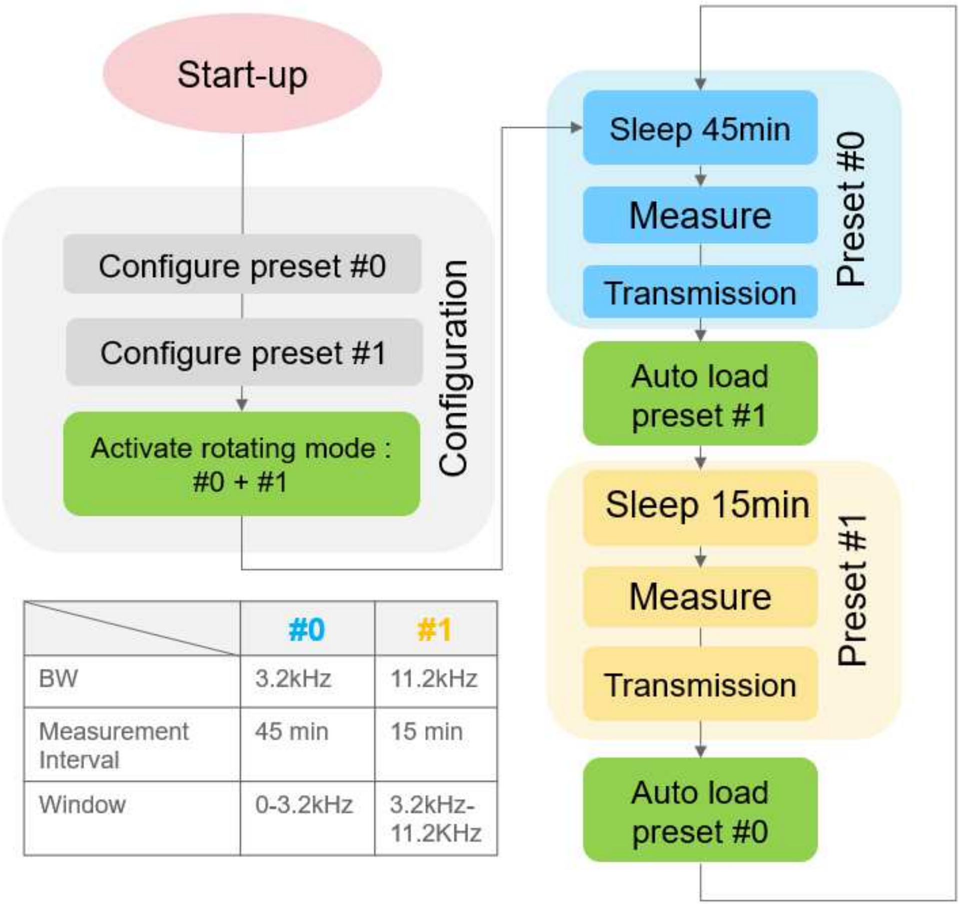
	Preset		DSP		Peak search windows					
Category	NAME	ID	BW_MODE (Hz)	MEAS_INTERVAL	ID	ENABLE	Boundaries		INTEG_SIZE	PEAK_NB
							MIN (Hz)	MAX (Hz)		
User	**USR_PR_0**	0	11 (14.4k)	1 hour	0	True	0 (0)	1599 (14.4k)	1	8
					1	False	-	-	-	-
					2	False	-	-	-	-
					3	False	-	-	-	-
					4	False	-	-	-	-
					5	False	-	-	-	-
					6	False	-	-	-	-
					7	False	-	-	-	-
	USR_PR_1	1	11	1 hour	0	True	0	1599 (14.4k)	1	8
	USR_PR_n	n	…	…	…	…	…	…	…	…
	USR_PR_15	15	11	1 hour	0				1	8
Factory Predefined	8931_Default	64	11 (14.4k)	1 hour	0	True	0 (0)	1599 (14.4k)	1	8
	BW1K6_ULP	65	3 (1.6k)	1 day	0	True	0 (0)	1599 (1.6k)	1	8
	BW4K8_ULP	66	5 (4.8k)	1 day	0	True	0 (0)	1599 (4.8k)	1	8
	BW9K6_ULP	67	8 (9.6k)	1 day	0	True	0 (0)	1599 (9.6k)	1	8
	BW1K6_LP	68	3 (1.6k)	0.5 day	0	True	0 (0)	1599 (1.6k)	1	8
	BW4K8_LP	69	5 (4.8k)	0.5 day	0	True	0 (0)	1599 (4.8k)	1	8
	BW9K6_LP	70	8 (9.6k)	0.5 day	0	True	0 (0)	1599 (9.6k)	1	8
	BW1K6_STD	71	3 (1.6k)	1 hour	0	True	0 (0)	1599 (1.6k)	1	8
	BW4K8_STD	72	5 (4.8k)	1 hour	0	True	0 (0)	1599 (4.8k)	1	8
	BW9K6_STD	73	8 (9.6k)	1 hour	0	True	0 (0)	1599 (9.6k)	1	8
	BW1K6_HR	74	3 (1.6k)	15 min	0	True	0 (0)	1599 (1.6k)	1	8
	BW4K8_HR	75	5 (4.8k)	15 min	0	True	0 (0)	1599 (4.8k)	1	8
	BW9K6_HR	76	8 (9.6k)	15 min	0	True	0 (0)	1599 (9.6k)	1	8
	BW9K6_RTH	77	8 (9.6k)	15 min	0	True	266 (1.6k)	1599 (9.6k)	1	8
	BW1K6_RTL	78	3 (1.6k)	45 min	0	True	0 (0)	1599 (1.6k)	4	8

2.2.4 Self-Rotating Mode

The 8931N implements the “Rotating Mode” feature. This allows the user to run 2 different presets consecutively without external action required. After the execution of a preset, the second preset queued in the mode will be loaded. Once executed it will return the first preset.

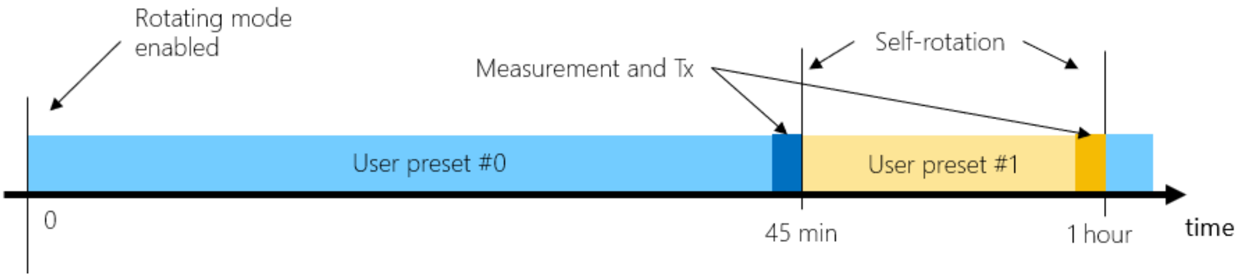
The example below shows how to take advantage of the rotating mode. Here 2 presets are configured with 2 different bandwidth and measurement intervals.

The self-rotating mode automatically switches between #0 and #1 without any external user action required.



	#0	#1
BW	3.2kHz	11.2kHz
Measurement Interval	45 min	15 min
Window	0-3.2kHz	3.2kHz-11.2KHz

In this example, every 1 hour will result in 2 measurements: one with a high frequency band and another (15min later) with a low bandwidth but with a higher resolution.



2.3 User Accessible Configuration/Data

2.3.1 Sensor settings formats

This section describes the format of all accessible sensor settings.

2.3.1.1 Measurement interval

Interval between two measurements. This parameter can be written using a LoRaWAN downlink or in BLE connected mode. This is readable in BLE only.

MEAS_INTERVAL

bit	10	9	8	7	6	5	4	3	2	1	0
field	MEAS_INTERVAL = 15										

- MEAS_INTERVAL: From 15min up to 24h. 1LSB=1min. (Default is 15min)

2.3.1.2 FFT information

Gives/Set the FFT setting of the sensor. This parameter can be written using a LoRaWAN downlink or in BLE connected mode. This is readable in BLE and or transmitted in the LoRaWAN uplink messages. See 2.2.2.1.1.

FFT_INFO

bit	4	3	2	1	0
field	OUTPUT_SEL	BW_MODE = 9			

- BW_MODE: from 0 up to 15. This parameter changes the FFT resolution. Default is 9

BW Mode	FFT resolution (Hz/bin)	Sampling Frequency (Hz)	Bandwidth (Hz)	Acquisition duration (s)
0	0.125	512	200	8
1	0.25	1024	400	4
2	0.5	2048	800	2
3	1	4096	1600	1
4	2	8192	3200	0.5
5	3	12288	4800	0.333333
6	4	16384	6400	0.25
7	5	20480	8000	0.2
8	6	24576	9600	0.166667
9	**7**	**28672**	**11200**	**0.142857**
10	8	32768	12800	0.125
11	9	36864	14400	0.111111
12	10	40960	16000	0.1
13	11	45056	17600	0.090909
14	12	49152	19200	0.083333
15	13	53248	20800	0.076923

- OUTPUT_SEL: velocity or acceleration output selection. Acceleration is only supported in the B-sample

OUTPUT_SEL

0	Acceleration

2.3.1.3 Window configuration

Gives/Set a peak search window. This parameter can be written using a LoRaWAN downlink or in BLE connected mode. This is readable in BLE only. Note that the user can configure and activate up to 8 windows simultaneously.

Windows Id	Default configuration
1	Enabled, 8 peaks, 1bin, 0 to 1600
2	Disabled
3	Disabled
4	Disabled
5	Disabled
6	Disabled
7	Disabled
8	Disabled

WINDOW_CFG_n

<table>
<tr><td>byte</td><td colspan="8">0</td><td>1</td><td>2</td><td>3</td><td colspan="2">4</td><td>5</td></tr>
<tr><td>bit</td><td>7</td><td></td><td></td><td></td><td>3</td><td>2</td><td>1</td><td>0</td><td>(8)</td><td>(8)</td><td colspan="2">(12)</td><td colspan="2">(12)</td></tr>
<tr><td>field</td><td>ENABLE</td><td></td><td></td><td></td><td colspan="4">WIN_ID</td><td>PEAK_CNT</td><td>INTEG_SIZE</td><td colspan="2">FREQ_MIN_BIN</td><td colspan="2">FREQ_MAX_BIN</td></tr>
</table>

- ENABLE: enabled (1) or disable (0) window ID.
- WIN_ID: index of the window to be configured from 1 up to 8.
- PEAK_CNT: from 0 up to 63.
- 0: integrates the RMS on the full window. The peak search is deactivated in that window. As output, the reported peak will be on the center of the window.
- >0: number of peaks to be searched in the current window.

- INTEG_SIZE:
  - >1: takes the RMS of the central peak plus bin around (+/- INTEG_SIZE)
- FREQ_MIN_BIN: Frequency min of search window in bin index. From 0 up to 2047
- FREQ_MAX_BIN: Frequency max of search window in bin index. From 0 up to 2047

Important note: the minimum frequency must be strictly smaller than the maximum frequency.

The bin index can go up to 2047 but the value could overpass the bandwidth. It is recommended to never exceed 1600 bin. Peaks higher than 1600 will be attenuated with a maximum of 30% because of the AAF effect.

2.3.1.4 LoRaWAN percentage of confirmed uplink messages

It is possible to reduce the number of acknowledgements between the LoRaWAN gateway and the device.

LORA_ACK_PER

byte	0							
bit	7	6	5	4	3	2	1	0
field	PERCENTAGE = 100							

- PERCENTAGE: Percentage of LoRaWAN uplink confirmed messages. From 0% up to 100%. Default is 100%
  Important note: Using 0% will prevent the sensor to rejoin LoRaWAN. This value should not be used.

2.3.1.5 Active preset

Gives/Set the active preset of the sensor. This parameter can be overwritten using a LoRaWAN downlink or in BLE connected mode. This is readable in BLE and or transmitted in the LoRaWAN uplink messages (see DEVSTAT).

ACTIVE_PRESET

byte	0							
bit	7	6	5	4	3	2	1	0
field	PRESET_ID_SEL							

- PRESET_ID_SEL: current preset running on the 8931N

2.3.1.6 Rotating mode

Gives/Sets the rotating mode. This parameter can be overwritten using a LoRaWAN downlink or in BLE connected mode. This is readable in BLE only.

Activate and configure the rotating mode.

ROTATION_MODE

Byte	0	1	2
Description	ROT_MODE	ROT_ID_0	(ROT_ID_1)

- ROT_MODE:

ROT_MODE	Rotating mode
0	Disable rotation and load ID_0. ID_1 is optional
1	Enable rotation between ID_0 and ID_1. It starts with ID_0.

- ROT_ID_0: identifier of the 1st preset to be loaded
- ROT_ID_1: identifier of the 2nd preset to be loaded after 1st rotation. If ROT_MODE is disabled, this argument is optional

2.3.2 Data formats

This section describes the format of all accessible data.

2.3.2.3 Device status

Give the latest status of the sensor.

DEVSTAT

byte	0								1							
bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
field	PRESET_ID_SEL								ACC_ERR	TEMP_ERR		ROT_EN	BATT			

- PRESET_ID_SEL: gives the active preset identifier
- ACC_ERR: This bit is set if a device detects an error when reading the acceleration

ACC_ERR	Error condition
0	No error detected
1	Unable to read acceleration

- TEMP_ERR: This bit is set if a device detects an error when reading the temperature

TEMP_ERR	Error condition
0	No error detected
1	Unable to read acceleration

- ROT_EN: This bit tells the user if the rotating mode is enabled

ROT_EN	Rotating mode
0	Disabled
1	Enabled

- BATT: percentage of remaining battery (short value). 1 LSB = 10% ,0xF error code

2.3.2.4 Battery

This is readable in BLE connected mode.

BATTERY

Bit	7	6	5	4	3	2	1	0
field	BATTERY							

- BATTERY: provides remaining battery value in % (from 0 up to 100).

2.3.2.5 Temperature

TEMPERATURE

Bit	7	6	5	4	3	2	1	0
field	TEMPERATURE							

TEMPERATURE: provides the current temperature. In case of temperature error, the value will be set to 0xFF.

$$TEMP_{°C} = TEMP_{LSB} * 0.5 - 40$$

2.3.2.6 Acceleration

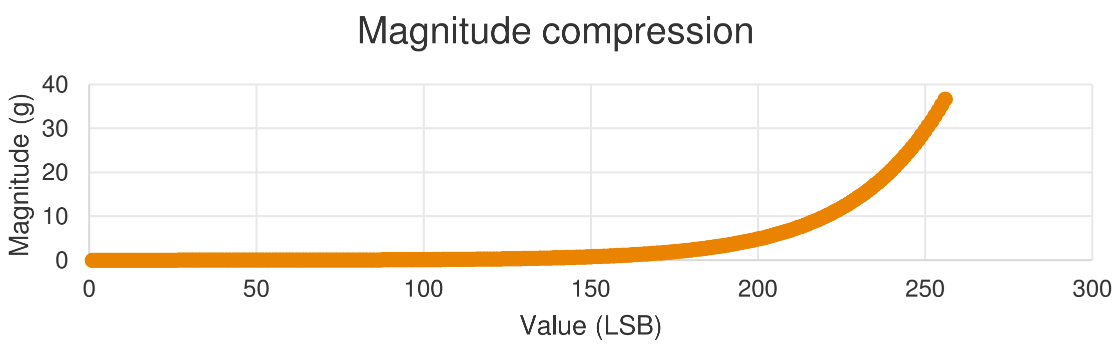
The acceleration is encoded into a single byte format. It could be magnitude gRMS or time domain g depending on the field.

ACC

Bit	7	6	5	4	3	2	1	0
field	MAG_RMS							

- MAG_RMS: gives the current magnitude

$$MAG_{gRMS} = 10^{(MAG_{LSB}*0.3149606-49.0298)/20}$$



2.3.2.5 Axis information

The axis information contains both sleeked axis, number of peaks found and the full spectrum RMS.

AXIS_INFO

byte	0								1							
bit	1	0	5	4	3	2	1	0	7	6	5	4	3	2	1	0
field	AXIS_SEL		PEAK_COUNT						TOT SIGNAL RMS							

- AXIS_SEL:

AXIS_SEL

Value	Axis
0	X
1	Y
2	Z

- PEAK_COUNT: number of FFT peaks. (0 up to 63)
- TOT_SIG_RMS: rms acceleration of the full spectrum (0xFF if sensor error). It refers to 2.3.2.6

2.3.2.6 FFT Peak info

PEAK_INFO

Bit	10	9	8	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
field	FREQUENCY INDEX											MAG							

- FREQ_INDEX: index of the peak in bin from 0 up to 2047. The real frequency can be calculated knowing the FFT resolution. (MSB first)
- MAG: magnitude in gRMS of the found peak. It refers to 2.3.2.6

2.4 Connectivity

2.4.1 LoRaWAN™

The device includes a LoRaWAN® MAC 1.0.3 rev A compliant interface (see LoRaWAN® 1.0.3 Specification). It operates as a Class A end-device.

2.4.1.1 Regional parameters

2.4.1.1.1 Frequency plans

The LoRaWAN communication protocol operates in an unlicensed radio spectrum. The part number must be selected to match with the region of operation and be in line with the local regulation.

Region	Frequency	Channel Plan	Common name
Europe (EU)	868 MHz	EU862-870	EU868
United State (US)	915 MHz	US902-928	US915

2.4.1.1.2 Data rates

Following the LoRaWAN specification, each data rate is a combination of one spreading factor and one bandwidth. The data rate cannot be set, it is adaptative and depends on the network quality (negotiated with the gateway).

2.4.1.1.2.1 EU868

For European regions, the 8931N supports data rate from 0 up to 7 in both uplink and downlink ways.

Data Rate (DR)	Spreading Factor (SF)	Bandwidth (BW)	Bitrate (bit/s)
0	SF12	125 kHz	250
1	SF11	125 kHz	440
2	SF10	125 kHz	980
3	SF9	125 kHz	1 760
4	SF8	125 kHz	3 125
5	SF7	125 kHz	5 470
6	SF7	250 kHz	11 000

2.4.1.1.2.2 US915

For the US915, the data rates supported by the 8931N are:

Direction	Data Rate (DR)	Spreading Factor (SF)	Bandwidth (BW)	Bitrate (bit/s)
Uplink	0	SF10	125	980
	1	SF9	125	1760
	2	SF8	125	3125
	3	SF7	125	5470
	4	SF8	500	12500
Downlink	8	SF12	500	980
	9	SF11	500	1760
	10	SF10	500	3900
	11	SF9	500	7000
	12	SF8	500	12500
	13	SF7	500	21900

2.4.1.1.3 TX power

RF transmitting systems must adhere to certain rules set by the regulatory bodies such as FCC or ETSI. Radio devices must not exceed certain ERP or EIRP values set by these regulatory bodies.

Depending on the regional parameters the 8931N supports the following power:

2.4.1.1.3.1 EU868

TX Power	Power (dBm)	Power (mW)
0	+16, limited to+8	39.8, limited to 6.3
1	+14, limited to+8	25, limited to 6.3
2	+12, limited to+8	16, limited to 6.3
3	+10, limited to+8	10, limited to 6.3
4	+8	6.3
5	+6	4
6	+4	2.5
7	+2	1.6

2.4.1.1.3.2 US915

TX Power	Power (dBm)	Power (mW)
0	+30 , limited to+8	1000, limited to 6.3
1	+28, limited to+8	630, limited to 6.3
2	+26, limited to+8	398, limited to 6.3
3	+24, limited to+8	250, limited to 6.3
4	+22, limited to+8	158, limited to 6.3
5	+20, limited to+8	100, limited to 6.3
6	+18, limited to+8	63, limited to 6.3
7	+16, limited to+8	40, limited to 6.3
8	+14, limited to+8	25, limited to 6.3
9	+12, limited to+8	16, limited to 6.3
10	+10, limited to+8	10, limited to 6.3

2.4.1.1.4 Time on air and payload limitations

Depending on the region, an end-node must respect a specific time on air to avoid network overflow on the shared free bands.

2.4.1.1.4.1.1 Duty cycle (EU-868 only)

In Europe, a LoRaWAN device must follow duty cycle and maximum payload rules.

The table below shows the effect of the data rate on the maximum number of uplink messages that could be transmitted in a day and if the whole frame is sent. Fragmentation does not work in EU868 because of the duty cycle, the next fragment(s) will be discarded.

Effect of EU868 regulations for a 8931N sending max peaks assuming 1% DC

DR	0	1	2	3	4	5	6
Peaks	18	18	18	45	63	63	63
Airtime (ms)	2794	1479	699	677	482	272	136
Number max of uplink per hour	12	24	51	53	73	132	265
Minimum uplink interval sec - (min)	279.4 - (4.66**)	147.9 – (2.47)	69.9 – (1.17)	67.7 (1.13)	48.2 – (0.8)	27.2 - (0.45)	13.6 – (0.23)
Number max of uplink per hour with 3-axis	4	8	17	17	24	44	45

Minimum measurement interval (min) with 3-axis	14*	7.4*	3.5*	3.4*	2.4*	1.35*	0.69*

*Minimum is 15min for 8931N. **Transmission between each axis is 5min for 8931N.

The European Telecommunications Standards Institute (ETSI) sets the maximum duty cycle (DC) for the EU868 at 1%, which is the maximum amount of time a device may spend communicating.
This means that in a day, a device should not transmit more than 864 seconds.

2.4.1.1.4.1.2 Dwell time (US-915 only)

In the US915 regional specification, a LoRaWAN device has only a dwell time limit. This dwell time limits defines the maximum payload according to the data rate.

The table below show the effect of the data rate on the maximum number of uplink messages that could be transmitted in a day.

Effect of US915 regulations for a 8931N on the number of peaks

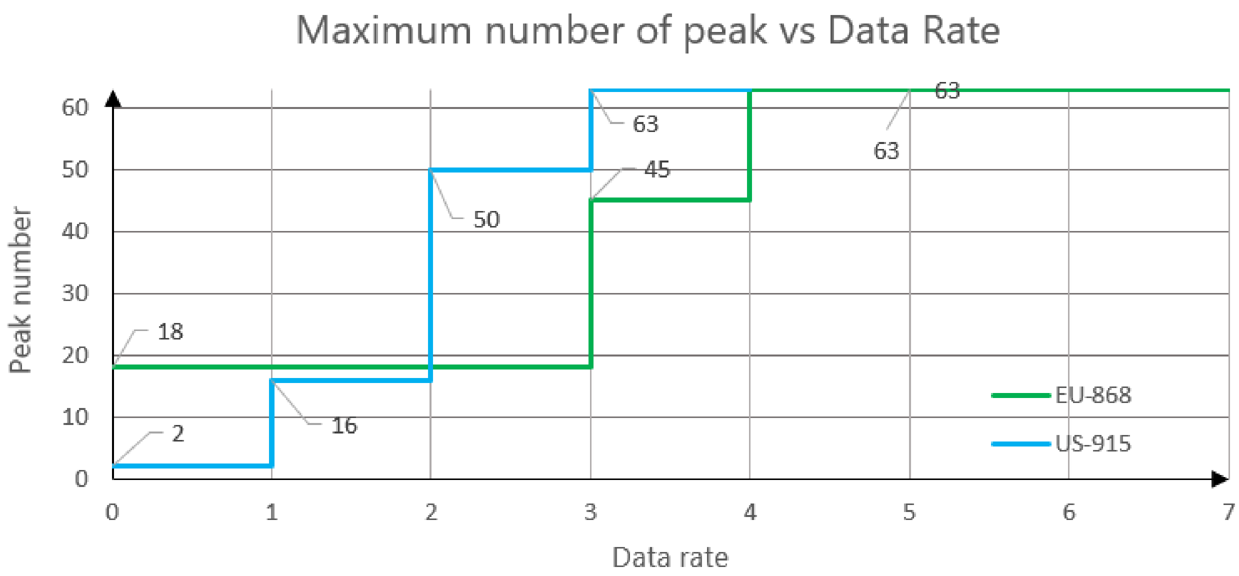
DR	0	1	2	3	4
Peaks	2	16	50	63	63

There are no duty cycle limitations under Federal Communications Commission (FCC), but the device must respect a certain limit of transmission duration. This parameter is called “dwell time” and should not exceed 400ms per channel. The dwell time is the amount of time needed for a transmission.

2.4.1.1.4.1.3 Maximum payload

The maximum payload (MP) size of a LoRaWAN frame is fixed according to the used data rate.

The chart below shows the maximum number of peaks that could be sent without fragmentation in a unique LoRaWAN uplink message depending on the data rate. Note that these are theorical values and it does not take in account the possible fOpt requests from the gateway. The number of peaks is limited to 63 by the software.



2.4.1.2 Mode of operation

2.4.1.2.1 Device registration

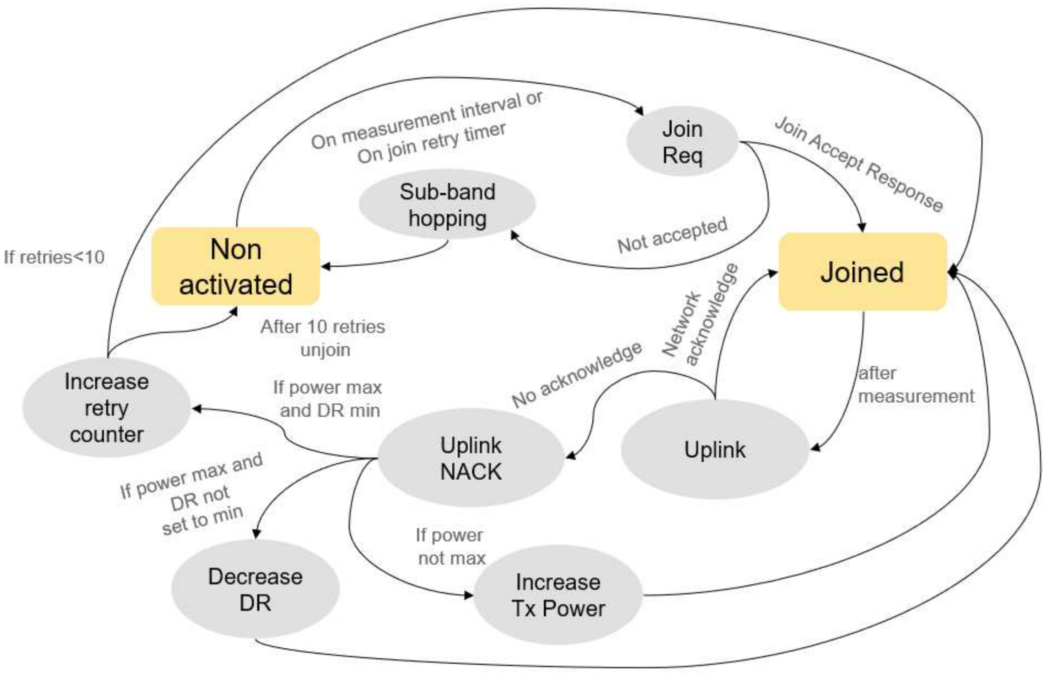
To be recognized by the LoRaWAN server, the 8931N must be enrolled on the final application server.

Use the LoRaWAN keys provided be TE Connectivity with the device.

Dev EUI	64-bit unique identifier of the end-device. Pre-provisioned by TE
App EUI	64-bit extended unique identifier. Provided by TE
App KEY	128-bit Pre-provisioned by TE Connectivity

2.4.1.2.2 Join and activation

After power on, the end-device performs a self-diagnostic test then it initiates a join-request to the LoRaWAN™ network using Over-The-Air-Activation (OTAA).



2.4.1.2.2.1 Join accept

In case of a sufficient LoRaWAN™ coverage and if the device was already enrolled in the server database, the network server responds to the join-request with a join-accept message.

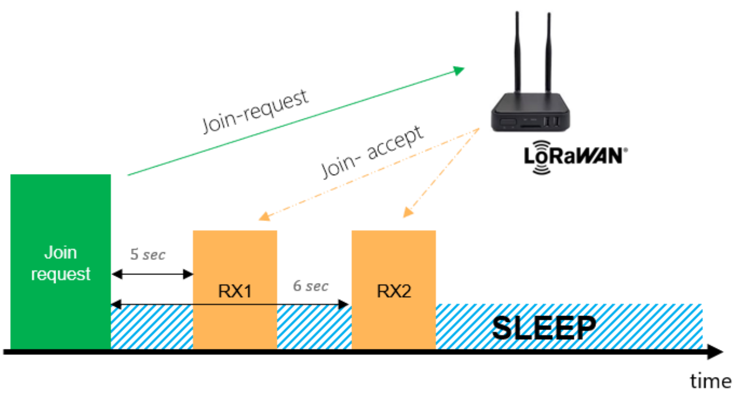


Figure 1:join accept

The possible reception windows delays are:

Window	Parameters	Delay
RX1	JOIN_ACCEPT_DELAY1	5s
RX2	JOIN_ACCEPT_DELAY2	6s

During that operation, the end-device shares with the server the sessions keys.

2.4.1.2.2.2 Un-joined

If the LoRaWAN gateway is out of range for the 8931N or if the end-device is not registered on the network, the 8931N will not receive a join accept response and will remain in an un-joined state. In this state, the 8931N will attempt to rejoin the network every 8 seconds, and the join timer will increase by 25% in case of failure, up to a maximum of 30 minutes.

However, this rejoin timer may conflict with the measurement interval. If the rejoin timer value is greater than the measurement interval, the measurement event will synchronize with the rejoin mechanism.

The value of the retry timer can be found below:

Try index	Calculation	Next retry (sec)
1	N/A	8
2	8*1.25	10
3	10*1.25	12.5
4	12.5*1.25	15.625
N	n-1*1.25	Limited to 30 min

Note that for EU868 region, the join-request may be sent only every 8 hours due to duty-cycle restriction and low data-rate.

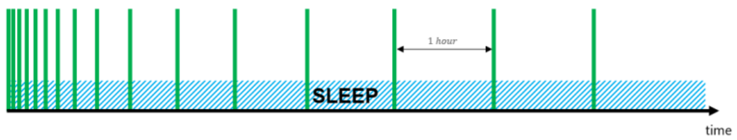


Figure 2: Rejoin procedure in case of failure

2.4.1.2.3 Joined mode

Once the 8931N has joined the LoRaWAN network, it operates in normal mode.

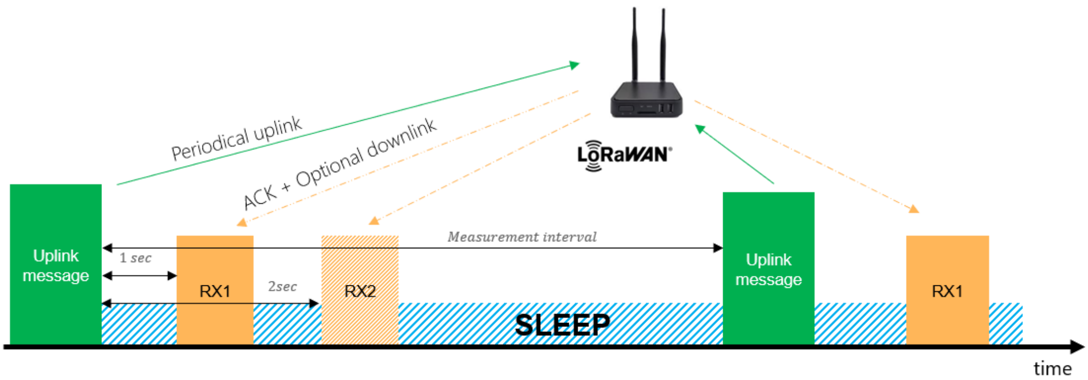


Figure 3 Normal mode of operation

2.4.1.2.3.1 Uplink message

Every measurement determined by the measurement interval will trigger an uplink “live data” message.
The uplink messages sent by the 8931N comes with the “confirmed data up” description embedded in the LoRaWAN application frame header (FType 0b100).

The 8931N device sends an uplink transmission and waits for a confirmation of reception from the LoRaWAN network server. If the server does not send back the LoRaWAN ACK flag, the 8931N follows the steps below:

- First, it checks the TX power. If it is not set to the maximum, the device increases the power by one step. This new power level will be used as a reference for the next uplink transmission
- If the TX power is already set to the maximum, the device reduces the data rate by one. This new data rate will be used as a reference for the next uplink transmission
- If the TX power is at the maximum and the data rate is at the minimum, the device increments an error counter
- If the error counter reaches 10, the sensor goes back to unjoin mode, and the rejoin mechanism is activated to attempt to rejoin the LoRaWAN network. (Note that before incrementing the error counter, the TX power and data rate are changed. So, the total number of retries can vary from 10 up to 15)

Therefore, the device continuously adjusts its transmission parameters to ensure successful transmission, and in case of repeated failures, it triggers the rejoin mechanism to regain network access. Any uplink message may be fragmented or truncated depending on the quality of the network and on the regional parameters (see 2.4.1.1.4 Time on air and payload limitations).

2.4.1.2.3.2 Downlink message

Following each uplink transmission, the end-device (Class A) opens one or two receive windows for potential downlink message. If no packet is destined for the 8931N in RX1, the device opens the second receive window (RX2).
The possible reception windows delays are:

Window	Parameters	Delay
RX1	RECEIVE_DELAY1	1s
RX2	RECEIVE_DELAY2	2s

2.4.1.3 Messaging

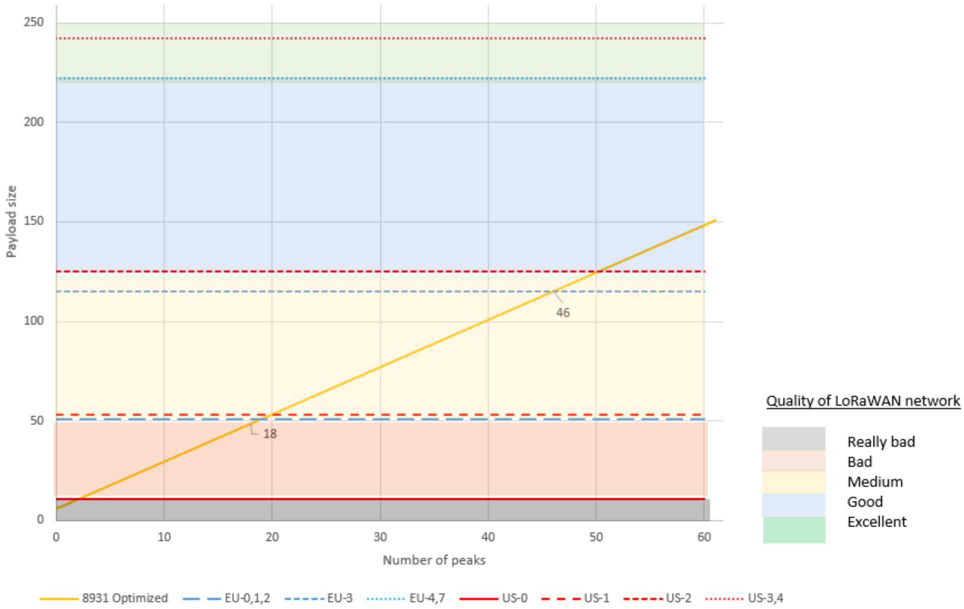
2.4.1.3.1 Uplink messages

The supported uplink messages are listed below:

Type	Description	Fport	Payload length	Condition
FFT Peak Data	Contains the peak values, sent every measurement interval (1 frame per axis)	5*	Varies depending on peak number	
FW revision	Sends the firmware revision	2	Variable	If downlink on fport 2

*Important note, if the ratio between the number of peaks and the network quality is not respected the uplink message may be:

- Truncated in EU-868. fPort “133” will be used instead of “5”.
- Fragmented in US-915. All frame fragments will be on fPort “133” except for last fragment on fPort “197”



2.4.1.3.1.1 FFT Peak Data

Contains the sensor values such as temperature and peak information. This uplink message is sent at every measurement interval. All values are expressed in the big-endian (BE) system. Most-significant (MSB) byte is stored at the smallest address. The length of the frame depends on the number of peaks to be transmitted.

FFT peak uplink (fport 5*)

byte	0	1	2	3	4	5	6	7	8	…	6+(19*n/8)
field	DEVSTAT		TEMPERATURE	FFT_INFO	AXIS_INFO		PEAK_INFO_1		PEAK_INFO_2	…	PEAK_INFO_n

- DEVSTAT: refers to 2.3.2.3
- TEMPERATURE: refers to2.3.2.5
- FFT_INFO: refers to 2.3.1.2
- AXIS_INFO: refers to 2.3.2.5
- PEAK_INFO_n: refers to 2.3.2.6

2.4.1.3.1.2 FW revision

This uplink message replaces the FFT Peak Data message if a downlink request was received.

FW revision format (fPort=2)

Byte	0	1	..	n
Description	FW_REV			

- *FW_REV:* firmware revision in a string format. Example of string [31 2e 36 2e 32 2d 31 39 2d 67 31 30 65 33 62 64 36] => "1.6.2-19-g10e3bd6"

2.4.1.3.2 Downlink messages

The supported downlink messages are listed below:

Type	Description	Fport	Payload length
DSP Configuration 1	Configures the DSP (BW and Meas interval)	12	3
Search Window Configuration	Configures one window of the peak search	13	7
Activate Preset	Load a specific preset	14	1
Rotating mode	Activate the rotating mode	15	3

FW revision request	Request the FW revision	2	1

2.4.1.3.2.1 DSP Configuration 1

Configures the DSP.

DSP config, fport = 12

Byte	0	1	2
Description	FFT INFO	MEAS_INTERVAL	

- FFT_INFO: refers to 2.3.1.2
- MEAS_INTERVAL: 2.3.1.1

2.4.1.3.2.2 Search Window Configuration

Configuration a specific window. The frame must be sent of fPort13.

Search window config, fport=13

Byte	0	…	5
Description	WIN_CFG_n		

- WIN_CFG_n: Refers to 2.3.1.3

2.4.1.3.2.3 Activate preset

Force the device to toggle to another preset. The whole configuration of the sensor will be updated.

Load preset, fport = 14

Byte	0
Description	PRESET_ID

- PRESET_ID: identifier of the preset to be loaded. From 0 up to “255”

Rotating mode

Activate and configure the rotating mode.

Rotating mode, fport = 15

Byte	0	1	2
Description	ROT_MODE	ROT_ID_0	(ROT_ID_1) only if rotation is enabled

ROT_MODE:

ROT_MODE	Rotating mode
0	Disabled rotation and reload ID_0
1	Enable rotation between ID_0 and ID_1. It automatically loads ID_0

- ROT_ID_0: identifier of the 1st preset to be loaded
- ROT_ID_1: identifier of the 2nd preset to be loaded after 1st rotation (enable only)

2.4.1.3.2.4 FW revision request

This downlink message can be used to request the firmware version. Note that the result of this request will replace the standard FFT Peak uplink message.

FW revision request, fport = 2

Byte	0
Description	To be filled with 0x00

Example:

```
↑ 13:49:50  Forward uplink data message          Payload: { firmware_version: "1.6.2-19-g10e3bd6" }  31 2E 36 2E 32 2D 31 39 …  FPort: 2  Data rate: SF8BW125  SNR: 12  RSSI: -60
↑ 13:49:50  Successfully processed data message  DevAddr: 26 0B 17 03  FCnt: 3  FPort: 2  Confirmed uplink  Data rate: SF8BW125  SNR: 12  RSSI: -60
↓ 13:49:27  Schedule data downlink for transmissi…  FPort: 2  MAC payload: 36  Rx1 Delay: 5
↑ 13:49:27  Forward uplink data message          Payload: { bat: 10, integ: 125, peak_nb: 8, peaks: […], sig_rms: 0.032, temp: 20 }  0A 08 B0 04 20 00 7D 00 …  FPort: 1  Data rate: SF8BW125  SNR: 10.75  RSSI: -58
↑ 13:49:27  Successfully processed data message  DevAddr: 26 0B 17 03  FCnt: 2  FPort: 1  Confirmed uplink  Data rate: SF8BW125  SNR: 10.75  RSSI: -58
↓ 13:48:21  Forward downlink data message        FPort: 2  Payload: 00
```

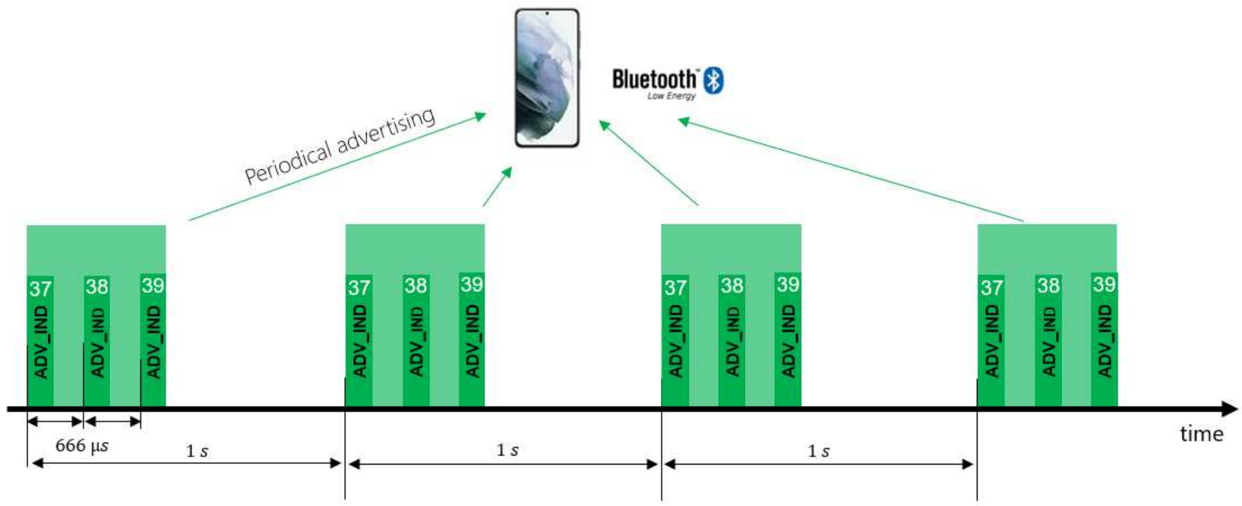
2.4.2 Bluetooth® Low Energy

The device includes a Bluetooth 5.0 Low Energy (BLE) compliant interface. This is a low power communication technology which should be used at short distances. It makes the 8931N a connectable beacon that acts as a peripheral by default and switches to a server role once a remote device (central) is connected.
The BLE interface should be used for configuration only.

After 1 hour, the BLE is deactivated.

2.4.2.1 Advertisements (peripheral)

BLE advertising interval is set to 1 second. As defined by the BLE specification, 3 channels (37, 38 and 39) are dedicated to advertising transmissions.



The Advertising packets (ADV_IND) contains both Flags and Manufacturer Specific Data. The fields are arranged as below.

Byte	0	1	2	3	4	5	…	22
Field	Length	Type	Value	Length	Type	Value		
Default	02	0x01	Flags	0x13	0xFF	Manufacturer Specific Data		

Example of advertising data: 0x020106 13 ff de08ffffffffffffc95300006400e4044200

2.4.2.1.1 Flags

The advertising packet contains the following flags:

- LE General Discovery Mode
- Br/Edr Not Supported
- Le Only Limited Discovery Mode
- Le Only General Discovery Mode

2.4.2.1.2 Manufacturer specific data

All data fields are formatted as shown below.

Manufacturer Specific Data

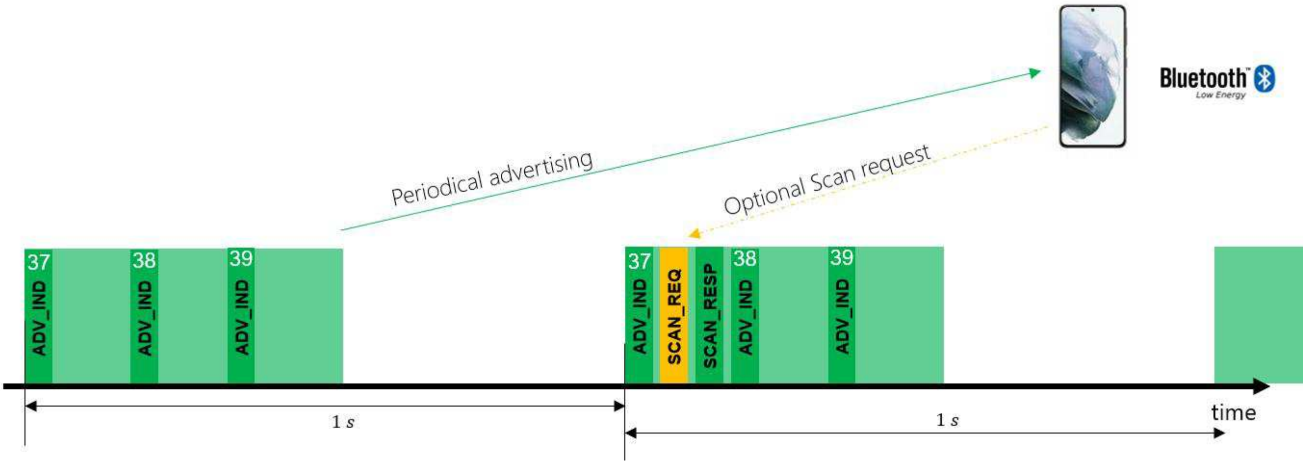
Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fields	CI		DEVTYPE		CSD				CNT	DEVSTAT		TEMP	X_RMS	Y_RMS	Z_RMS	X_P2P	Y_P2P	Z_P2P
Default	DE08		C1D1		FF	FF	FF	FF	xx	00	0A	xx	xx	xx	xx	xx	xx	xx

- COMPANY IDENTIFIER: static 2-bytes field, identifies TE Connectivity

- DEVTYPE: Device Type, value is set to C1D1 for an 8931N
- CSD: customer specific data. 4-byte customizable field.
- CNT: Measurement rolling counter, this counter increments at each measurement interval
- DEVSTAT: device status, refers to 2.3.2.3
- TEMP: Device temperature, refers to 2.3.2.5
- X_RMS: Root mean square value of the time domain acceleration on the X-axis. Refers to 2.3.2.6
- Y_RMS: Root mean square value of the time domain acceleration on the Y-axis. Refers to 2.3.2.6
- Z_RMS: Root mean square value of the time domain acceleration on the Z-axis. Refers to 2.3.2.6
- X_P2P: Peak to peak value of the time domain acceleration on the X-axis. Refers to 2.3.2.6
- Y_P2P: Peak to peak value of the time domain acceleration on the Y-axis. Refers to 2.3.2.6
- Z_P2P: Peak to peak value of the time domain acceleration on the Z-axis. Refers to 2.3.2.6

2.4.2.2 Scan response (peripheral)

The 8931N supports active scanning requests. This can be used to ask for more information about the sensor.



It provides the Complete Local Name.

Byte	0	1	2	…	17	18	19	20	…
Field	Length	Type	Value			Length	Type	Value	
Default	11	07	Reserved			Varies	0x09	Complete local name	

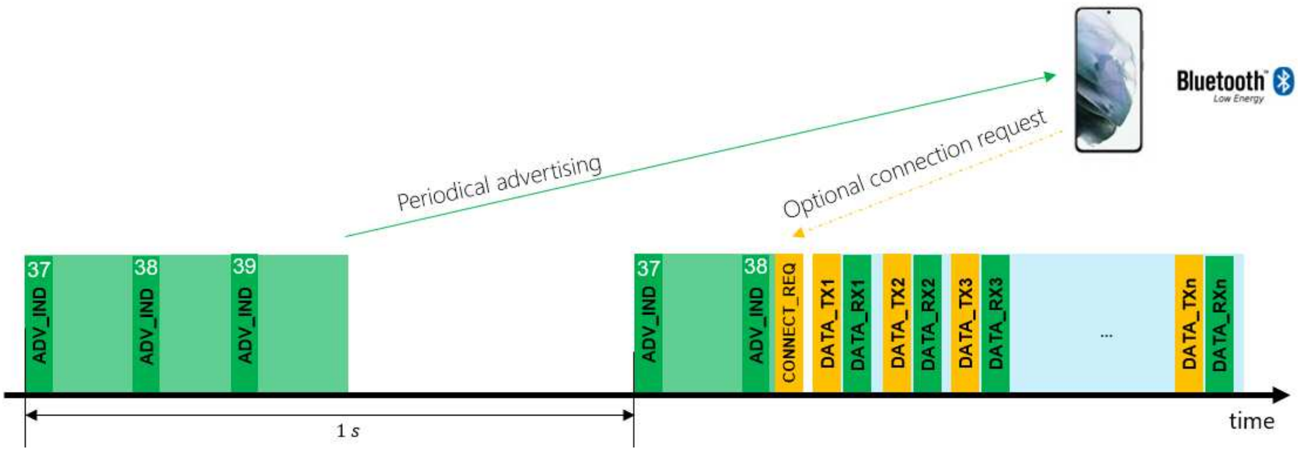
Example of scan response data: 0x11-07-15-4B-88-1E-0D-E5-00-00-96-00-04-DC-9D-9C-14-59-0C-09-38-39-31-31-45-58-20-30-30-30-31"

2.4.2.2.1 Complete local name

Contains the name of the sensor in ASCII. It refers to "Custom Device name" (see GATT list)

2.4.2.3 Connected mode (server)

The 8931N device offers many GATT services. These services and characteristics are exposed to the client once connected.



All available characteristics are listed below.

2.4.2.3.1 Generic BLE service and characteristics list

Services	UUID Service Key	Characteristics	UUID Characteristics Key	Read/Write, notification
Generic Access	1800	Device name	2A00	R
		Appearance	2A01	R
		Peripheral Preferred Connection Parameters	2A04	R
Generic Attribute	1801	Service change	2A05	I
Secure DFU Service	FE59	Buttonless DFU without bond		W/I
Device Information	180A	Manufacturing Name String	2A29	R
		Model Number	2A24	R
		Hardware Revision String	2A27	R
		Firmware Revision String	2A26	R
		Serial Number String	2A25	R

2.4.2.3.2 8931N specific service and characteristics list

Every service and characteristic share a common UUID. Only byte #3 and #4 (XXXX) differ from the identifier.

Generic UUID	B614XXXX-B14A-40A6-B63F-0166F7868E13
Specific UUID	XXXX

Services	UUID Service Key	Characteristics	UUID Characteristics Key	Read/Write, notification	Payload length (bytes)
Device	FA00	Custom Device name	FA01	R/W	<=25
		Default Device name	FA02	R	11
Data collection	B000	Measurement interval min	B009	R/W	2
		Bandwidth	B00A	R/W	1
Battery	C000	Battery level	C001	R	1
		Battery replacement	C002	W	1
FFT Peak detection function	C180	Windows Configuration 0	C181		
		Windows Configuration 1	C182		
		Windows Configuration 2	C183		

		Windows Configuration 3	C184	R/W	6
		Windows Configuration 4	C185		
		Windows Configuration 5	C186		
		Windows Configuration 6	C187		
		Windows Configuration 7	C188		
		X-Axis FFT peaks	C18A	R	Varies
		Y-Axis FFT peaks	C18B	R	Varies
		Z-Axis FFT peaks	C18C	R	Varies
Device scheduler	C1E0	Active preset	C1E1	R/W	1
		Rotating mode	C1E2	R/W	3
BluetoothLE	CD00	Customer Specific Data	CD01	R/W	4
LoRaWAN	F800	DevEUI	F801	R	8
		AppEUI	F802	R	8
		Region	F803	R	1
		NetID	F804	R	4
		Status	F805	R	
		Percentage of confirmed uplink	F806	R/W	1

2.4.2.3.2.1 Device

2.4.2.3.2.1.1 Custom Device name

Surname of the BLE device. This is also shared when receiving scan requests. This is customizable.

Custom device name

Byte	0	…	11
Description	CUST_DEVNAME		
Default	8931EX XXXX (4-last digit of MAC address)		

- CUST_DEVNAME: string value

2.4.2.3.2.1.2 Default Device name

Read-only factory device name of the BLE device.

Default device name

Byte	0
Description	DEF_DEVNAME
Default	8931EX XXXX (4-last digit of MAC address)
Byte	0

- DEF_DEVNAME: string value

2.4.2.3.2.2 Data collection

2.4.2.3.2.2.1 Measurement interval min

Refers to 2.3.1.1

2.4.2.3.2.2.2 Bandwidth Mode

Refers to 2.3.1.2

2.4.2.3.2.3 Battery

2.4.2.3.2.3.1 Battery level

Battery level

Byte	0	1	2	3
Description	BATT			
Default	100 (0x42c80000-> [00 00 C8 42])			

BATT: Battery level in percentage (range from 0 to 100%). This value is coded on a little endian 32-bit float value following the IEE-754 standard. Resolution is 1%.

2.4.2.3.2.3.2 Battery replacement

This characteristic has to be used when replacing the battery.

Battery replacement

Byte	0
Description	BATT_CHANGE

- BATT_CHANGE: write 0x01 after having changed the battery by a new one.

2.4.2.3.2.4 FFT Peak detection function

2.4.2.3.2.4.1 Window Peak search

Window config

Byte	0	…	5
Description	WIN_CFG_n		

- WIN_CFG_n: Refers to 2.3.1.3

2.4.2.3.2.5 X,Y,Z-Axis FFT peaks

x-Axis FFT peaks

Byte	0	1	2			M-1	M
Description	AXIS_INFO		PEAK_INFO1	PEAK_INFO1	….		PEAK_INFON

AXIS_INFO: refers to 2.3.2.5

FFT Peaks : array of PEAK_INFO. It contains as many peaks as described in PEAK_COUNT (AXIS_INFO). Refers to 2.3.2.6

2.4.2.3.2.6 Device scheduler

2.4.2.3.2.6.1 Active preset

Refers to 2.3.1.5

2.4.2.3.2.6.2 Rotating mode

Refers to 2.3.1.6

2.4.2.3.2.7 Bluetooth

2.4.2.3.2.7.1 Customer specific data

Customer specific data

Byte	0	1	2	3
Description	CSD			
Default	[FF FF FF FF]			

- CSD: Customer specific data. 4-byte array to store any data. This value will be part of the BLE manufacturer specific data in every advertising message (2.4.2.1.2)

2.4.2.3.2.8 LoRaWAN

2.4.2.3.2.8.1 DevEUI

This number is the 64-bit Device Extended Unique Identifier of the sensor. It is generated by TE and must be derived from the TE Organizationally Unique Identifier (OUI) assigned from the IEEE Registration Authority.

2.4.2.3.2.8.2 AppEUI

This number is the 64-bit application Extended Unique Identifier of the sensor.

2.4.2.3.2.8.3 Net ID

Contains the operator network identifier coded on the 4-byte value (LSB first). The list of all possible operators are listed below.

https://www.thethingsnetwork.org/docs/lorawan/prefix-assignments/

For example, 0x00000013 identifies “The Things Network”.

2.4.2.3.2.8.4 Status

Reserved

2.4.2.3.2.8.5 Percentage of confirmed uplink messages

Refers to 2.3.1.4

2.4.2.3.2.9 Generic Access

2.4.2.3.2.9.1 Device name

Contains device name. (Used for scan response). By default, contain model number plus 4 last digit of the mac address "8931 ed75".

2.4.2.3.2.9.2 Appearance

Sets to 00-02

2.4.2.3.2.9.3 Peripheral Preferred Connection Parameters

Could by 08-00-18-00-00-00-28-00

2.4.2.3.2.9.4 Central address resolution

Sets to 01

2.4.2.3.2.10 Device Information

2.4.2.3.2.10.1 Model Number

Contains model of the sensor in ASCII. Looks like "8931EX".

2.4.2.3.2.10.2 Serial Number

Contains mac Address of the sensor in ASCII. Looks like "f72010e4ed75".

2.4.2.3.2.10.3 Firmware revision

Contains Firmware revision string in ASCII. Looks like "SW_8931-FFT_PTFB-B_2.0.0".

2.4.2.3.2.10.4 Hardware revision

Contains Hardware revision string in ASCII. Looks like "HCC512B".

2.4.2.3.2.10.5 Manufacturer

Contains Manufacturer string in ASCII. Fixed to "TE Sensor".

2.4.2.3.2.11 Generic attribute

2.4.2.3.2.11.1 Service change

Not used.

2.4.2.3.2.12 Secure DFU Service

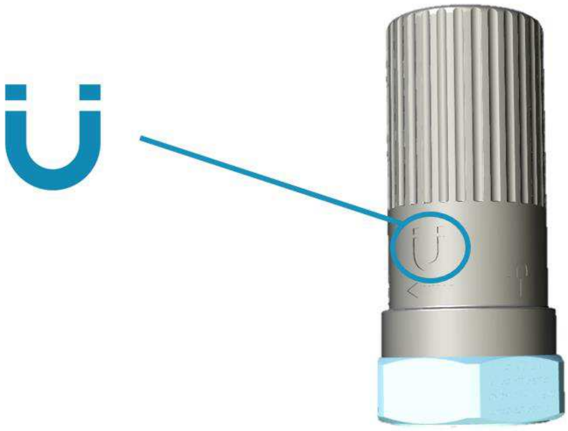
2.4.2.3.2.12.1 Buttonless DFU without bond

Use to switch into DFU mode.

2.5 Magnetic Switch

The 8931N contains an internal reed switch. This contactless button can be activated approaching a strong magnet at closed position to the magnetic sensor location.

The magnetic switch location is indicated by the magnet drawing on the plastic housing.



Two different functions are available depending on the user action:

Function	User action	LED
Activates BLE for another one hour plus triggers a new measurement and a LoRaWAN transmission (uplink if joined, else join request).	Short tap	One short blink. If user holds the magnet close to the switch for a longer duration, the LED will blink faster. Remove the magnet to only initiate a transmission. Else it will initiate a sensor reset.
Resets the sensor.	Hold the magnet for 10 seconds.	Wait for at least 10 seconds, until the LED begins a rapid blink. Release the magnet once a long orange led appears

2.6 LED

The orange LED indicates the state of the 8931N .

Category	Mode	Description	Pattern
	Power-on/Reset	Led turned on at start up to confirm the battery insertion.	2 seconds long on
	LoRaWAN™ join request	Join request message sent	3 very short blinks
	Uplink	Sending uplink message	very short blink
Status	Success	Operation successful	very short blink
	Fail	Operation failed	1 second long on

The following plots shows the possible different states of the sensor.

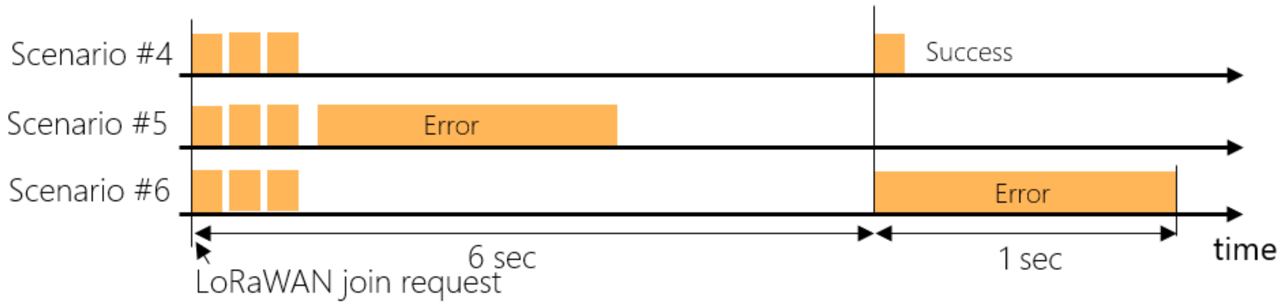
2.6.1 LoRaWAN join request examples

A normal join request gives 3 fast blinks (few milliseconds on), a 6 second delay then another short blink. In case of error, the LED is turned on for about 1 second.

Scenario #4: A LoRaWAN join request is shown with 3 short blinks (few milliseconds on) and about a 6 second later, another short blink (join accept from the gateway).

Scenario #5: For EU-868 region, if an error pattern (1 sec on) is shown just after the 3 blinks, it means the device hasn't sent the message due to duty cycle restrictions.

Scenario #6: If no response from the gateway, and after about 6 sec after the 3 short blinks, the LED is turned on for about 1 second.

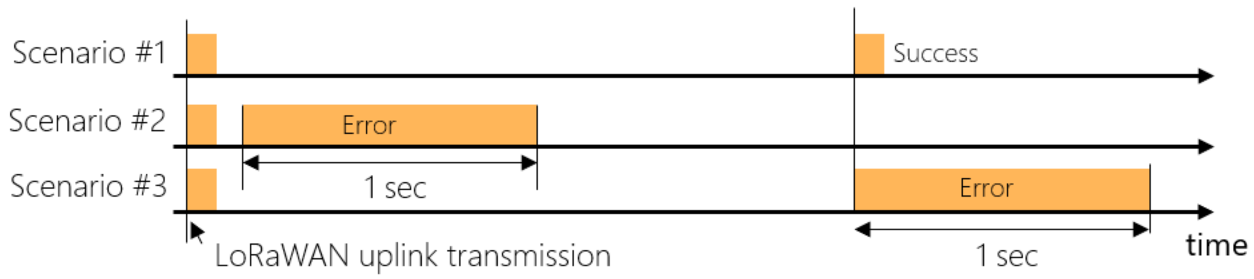


2.6.2 LoRaWAN uplink transmission examples

Scenario #1: A normal uplink transmission gives 1 short blink (few milliseconds on) and few seconds later, another short blink (ack from the gateway).

Scenario #2: For EU-868 region, if an error pattern (1 sec on) is shown just after a short blink, it means the device hasn't sent the message due to duty cycle restrictions.

Scenario #3: In case no response from the gateway (Confirmed message up needs a downlink with an acknowledge), delay is about 8 sec after the short blink, the LED is turned on for about 1 second NACK).



2.7 Battery

2.7.1 SAFT LS17330

The 8931N is delivered with a 3.6V battery.

Parameters	Typical value
Manufacturer	SAFT
Reference	LS 17330
Technology	Primary lithium-thionyl chloride (Li-SOCl2)
Nominal voltage	3.6 V
Capacity at 20°C	2100 mA

2.7.2 Battery life

Depending on customer settings (measurement interval) and on LoRaWAN network quality, the 8931N battery life could last up to 10 years in ideal conditions.

The lower number of measurements per day, the longer the battery life will last.

2.7.3 Battery replacement

The 8931N's battery can be changed if depleted. Unscrew the plastic housing and remove it from the base. Carefully use a small tool (such as a flat screwdriver) to remove the battery. Note that it MUST be replaced by the same battery referenced (others may damage and/or bring uncontrolled behavior of the sensor). Double check the polarity and then insert the new battery inside the holder. Reposition the plastic cover on the sensor.

Once done, the user must have to use the BLE "battery replacement" characteristic value to reset the battery estimation algorithm.

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