8911N

TECHNICAL SPECIFICATION

INTRODUCTION

The TE model 8911N wireless vibration sensor combines an analog 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 complies with ATEX certification.

The model 8911N 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. configuration during sensor installation.

The model 8911N 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 8911N 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 8911N 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 8911N comes with different modes of operation which are listed below:

1.1   Modes of operation

Operating mode	Description	Condition
Standard	User mode.	None
DFU	Mode used during FW update.	OTA update

2   NORMAL MODE DESCRIPTION

The 8911N 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 flexibility needed within the application.

The 8911N consists of 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 a programmable interval.
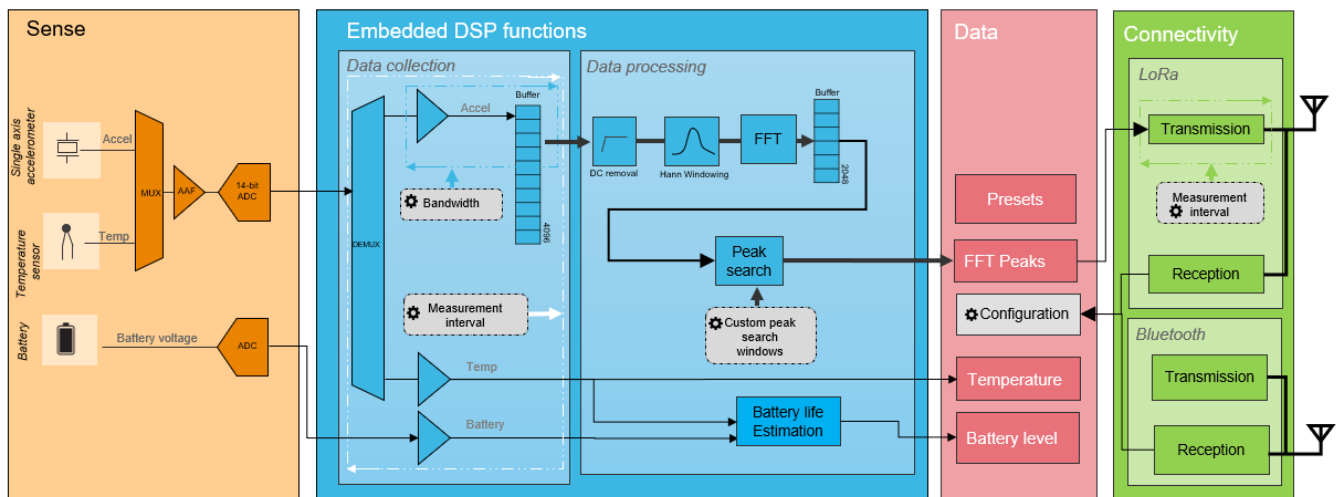
2.1 GENERAL DESCRIPTION

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. It's the only way to go into 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 proper battery insertion. From the sensor startup and for 1 hour, the device advertises every 1 second. This allows the 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.
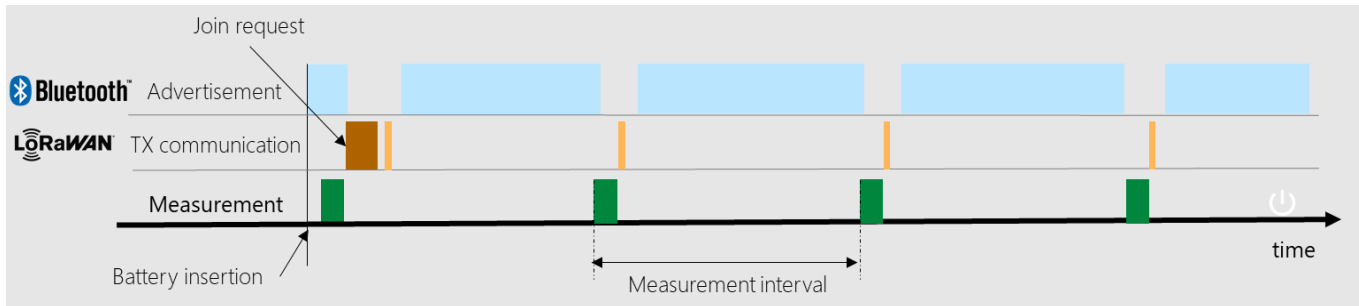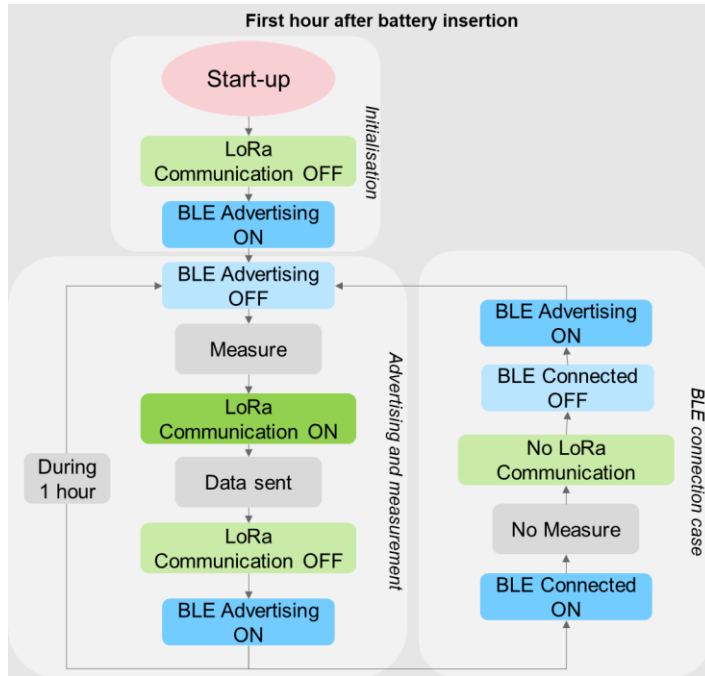
   - **LoRaWAN:**
     - When initiating a measurement and a LoRaWAN communication, BLE is disabled. Between BLE advertisement OFF and LoRaWAN communication ON it takes 4000ms.
     - The device performs an initial set of acquisition on the factory default settings, or user settings if overwritten. It then will process the measurements, depending on the 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 LoRaWAN network.
       - If Join Request procedure fails, the unit tries again based on the interval defined in section 2.5.1.2.2.2until request is accepted.

   Join Request signals from the Lora Radio transmitter are 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 an uplink message.
   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 (or after using a magnet):**
   o BLE is disabled.
   o The device acquires data from the sensor.
   o The measurements are processed, depending on the default parameters.
   o If this LoRaWAN join procedure succeeds, the data is transmitted through 1 uplink message.
   o Once LoRaWAN communication is ended, system go into an idle state.
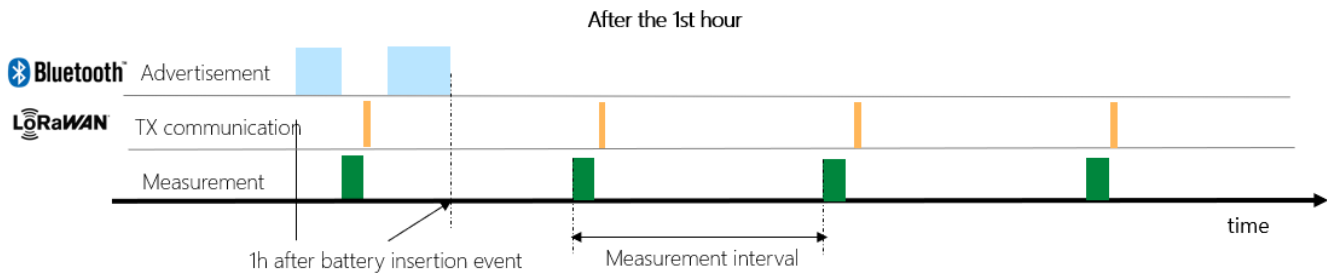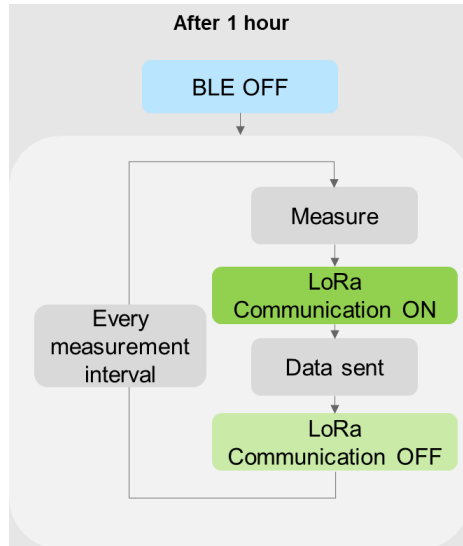
3. BLE Connected Mode

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.
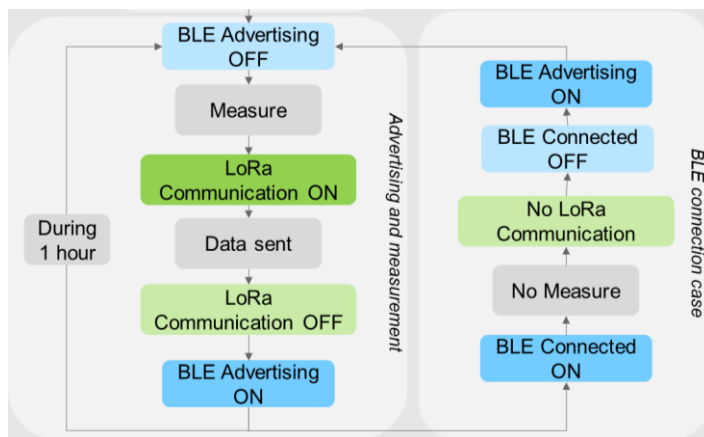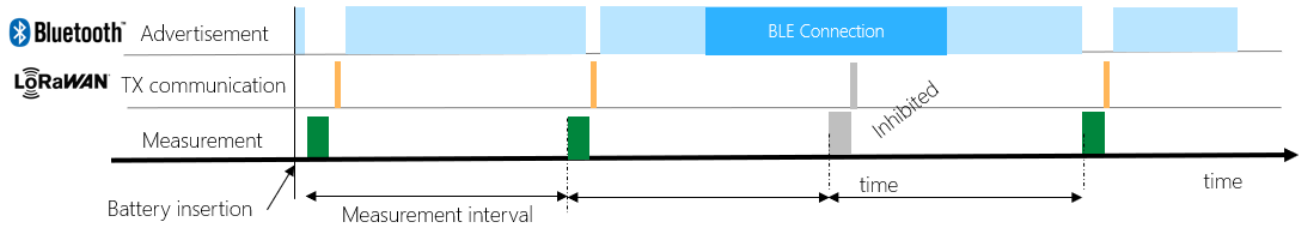
1. **Special event:**

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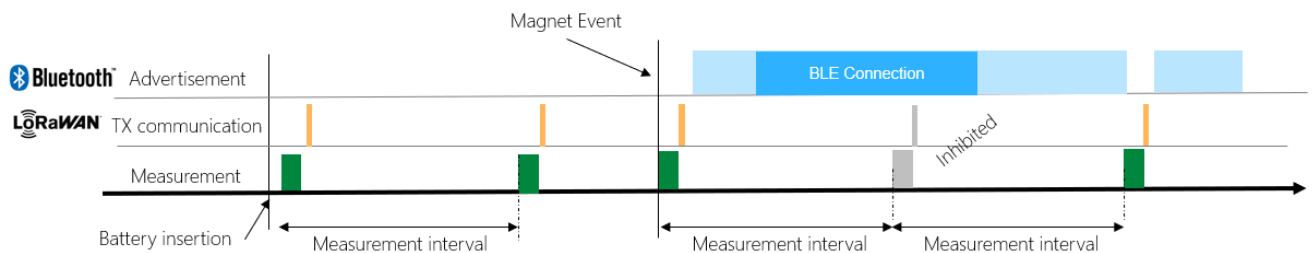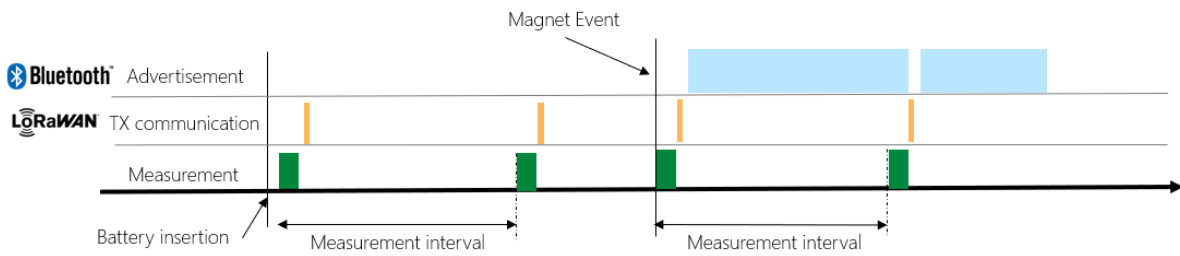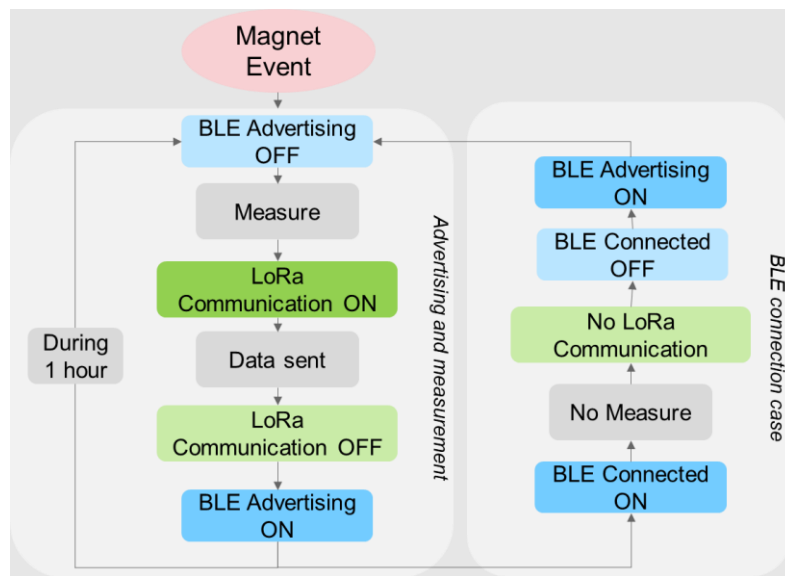
2.2 MODE OF OPERATIONS

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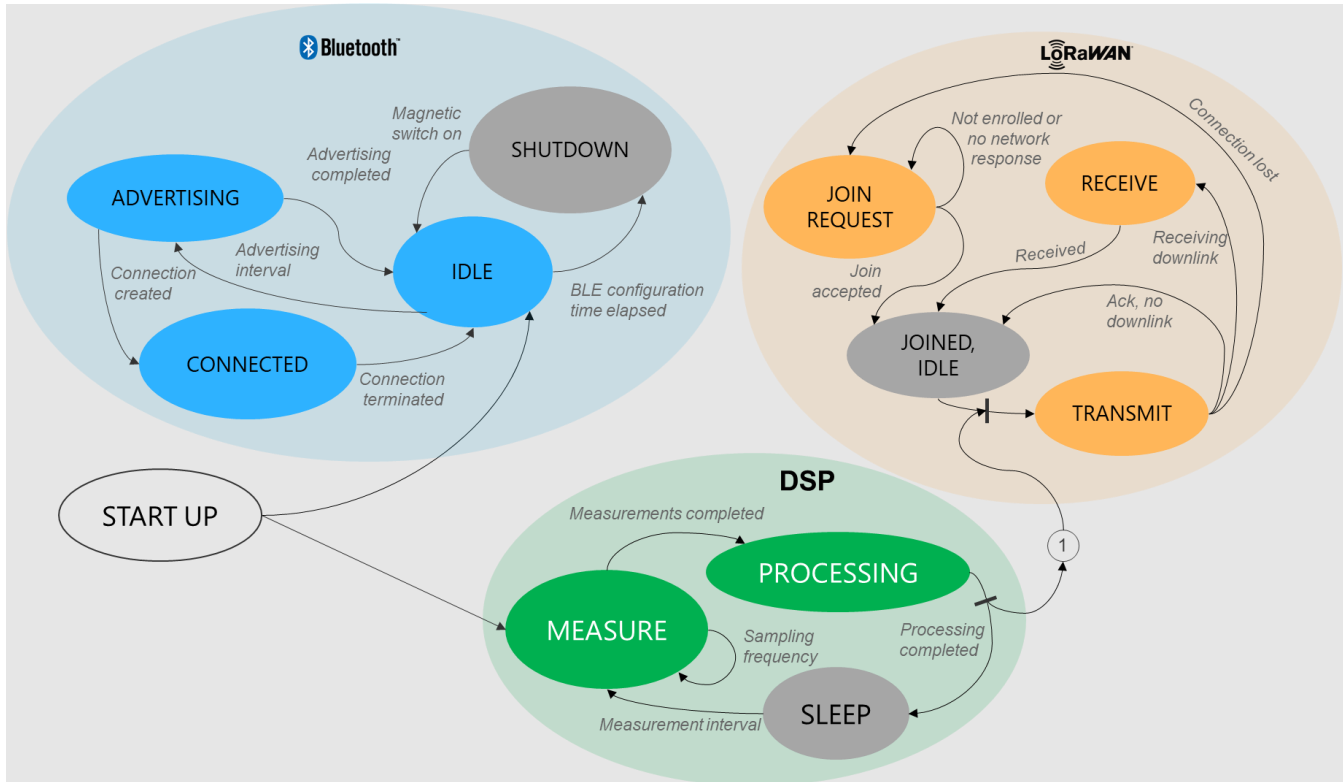
2.3 DATA COLLECTION

Sensor measurements are performed and transmitted at a configurable interval from 1 minute up to 24 hours. This is driven by the *Measurement interval* parameter.
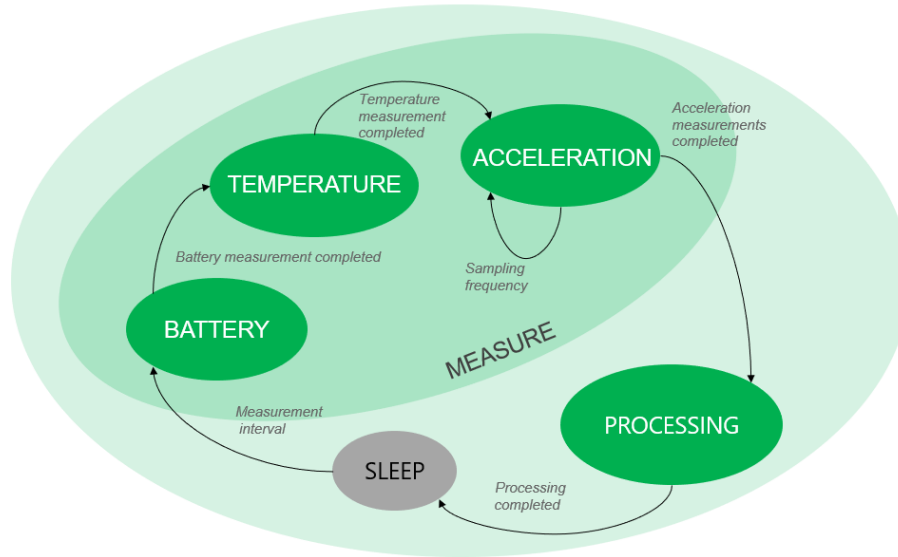
After a wake up of the sensor, the device powers on the sensing element and waits for about 3 seconds to let the accelerometer boot and stabilize its output (warm up).

A measurement consists of reading battery level, temperature, and a set of 4,096 acceleration values at a configurable rate (see *Bandwidth*).

Data	Unit	accessibility
Battery level	%	LoRaWAN, BLE
Temperature	°C	LoRaWAN, BLE
Acceleration	mg	None

2.4   DATA PROCESSING

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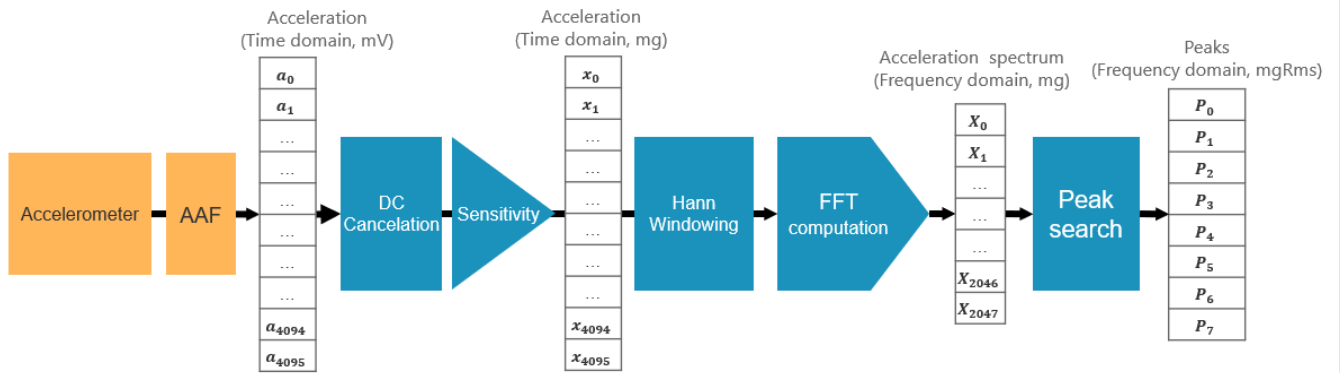
Acceleration data is collected at a chosen sampling frequency ($f_s = Bandwidth*2.56$) defined by the *Bandwidth* parameter. Raw data passes through an anti-aliasing filter (5th order Butterworth filter, $f_c = f_s/2$).

Once a set of acceleration reading is measured (4,096 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 won't be readable.

2.4.1   *Signal processing*

2.4.1.1   *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	

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

2.4.1.2   *DC cancellation plus sensitivity*

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

2.4.1.3   *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:

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

The graph below shows the effect of Hann windowing on a random raw acceleration signal.

Acceleration
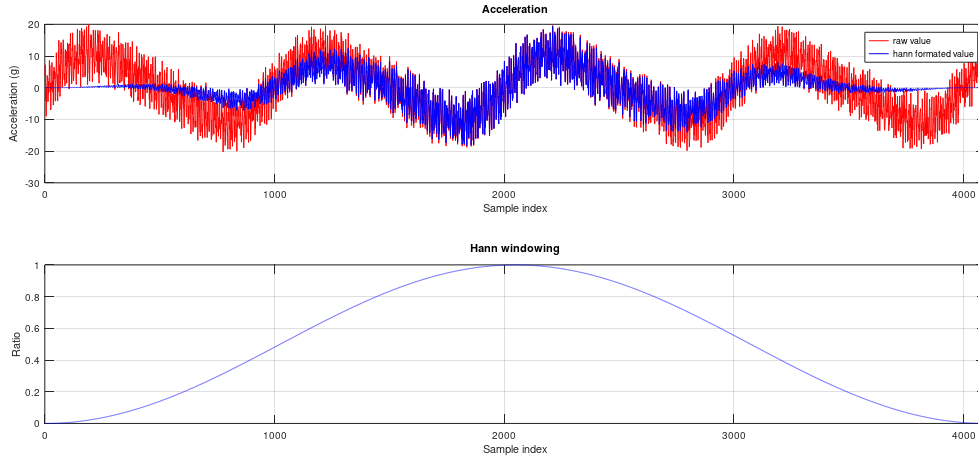
Hann windowing

2.4.1.4 *Fast Fourier transform (FFT)*

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

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

$$P_k = FFT(x_{(t)})$$
$$X_k = \frac{abs(P_k)}{N/2} , k = 1\ to\ \frac{N}{2} - 1$$
$$X_k = \frac{abs(P_k)}{N} , k = 0$$

2.4.1.5 *Peak search*

Parameters	Formula
Peak index	$Peak_{index}$ (index in FFT array)
INTEG_SIZE	$INTEG_{SIZE_{Hz}} = NB\_BIN_{LSB} * \Delta f_{Hz}$
Bin resolution	$\Delta f = \dfrac{BW * 2.56}{4096}$
Peak frequency	$Peak_{FREQ} = Peak_{index} * \Delta f$
Peak magnitude RMS	$Peak_{RMS} = \sqrt{\dfrac{8}{3}} * \sqrt{\displaystyle\sum_{i=bin-1}^{bin+1} \dfrac{X[k]^2}{2}}$
Time domain signal rms	$Signal_{RMS} = \sqrt{\dfrac{1}{4096}\displaystyle\sum_{k=0}^{4095} x_k^2}$

Total Spectrum rms	$Signal_{RMS} = \sqrt{\dfrac{8}{3}} * \sqrt{\displaystyle\sum_{k=0}^{2047} \dfrac{X[k]^2}{2}}$
Ratio	$Ratio_{energy} = 100 * \dfrac{\displaystyle\sum_{k=index-\frac{NB\_BIN}{2}}^{peak_{index}+\frac{NB\_BIN}{2}} X_{[k]}}{\sum_{k=0}^{2047} X_{[k]}}$

*purple colored text: Hann energy compensation

2.4.2 FFT configuration

2.4.2.1 Bandwidth

The user defines the bandwidth parameter depending on the application. This gives the maximum observable frequency of the 8911N. TE recommends picking the most appropriate value from the list below. Admissible range is 500Hz up to 19.2kHz.

Effective bandwidth $Bandwidth$ (kHz)	FFT resolution (Δf, Hz/Bin)	Sampling frequency (kHz)	Acquisition duration (ms)
1.6	1	4.096	1000
3.2	2	8.192	500
4.8	3	12.288	333.333
6.4	4	16.384	250
8	5	20.48	200
9.6	6	24.576	166.667
11.2	7	28.672	142.857
12.8	8	32.768	125
14.4 (Default)	9	36.864	111.111
16	10	40.96	100
17.6	11	45.056	90.9091
19.2	12	49.152	83.3333

2.4.3 Peak search algorithm

The 8911N 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 comes with the following information

Parameters	Description
Peak frequency	Frequency of the peak (Hz)
Peak magnitude RMS	Single frequency peak magnitude RMS (g RMS)
Ratio	Ratio of energy. Peak magnitude max plus around bins divided by the total energy of the spectrum

2.4.3.1 Peak Search window

By default, there is no window. The peak search covers the full spectrum.

Fast Fourier Transform Spectrum
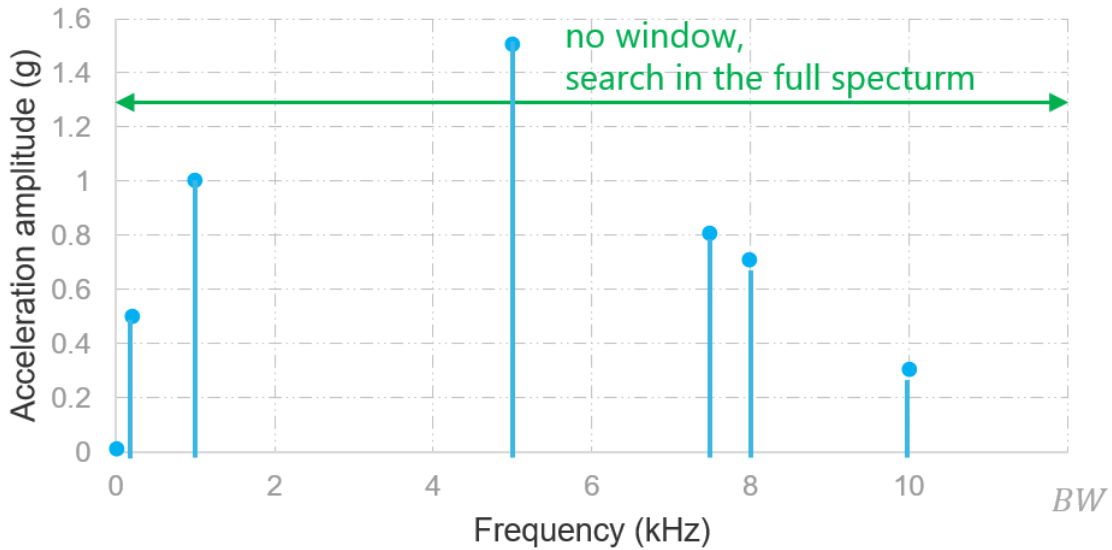
It is possible to program up to 8 custom windows to define several regions of interest.
Any peak ouside the windows will be ignored.

Fast Fourier Transform Spectrum
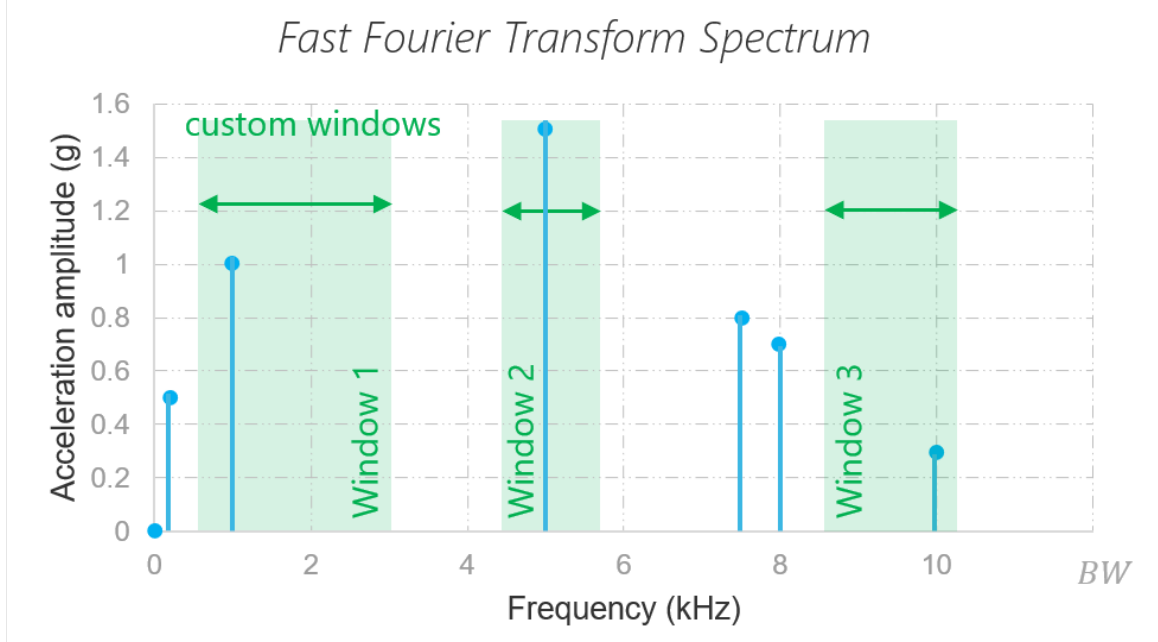
For each window the user can configure the following parameters:

Parameter	Description
Peak number	Number of peaks to be found (from 0 up to 24)
Number of bins	Number of bins around the main beam to be integrated into the ratio output. This parameter can be used to filter side lobes and avoid multiple peaks found around the same frequency
Min Frequency	Minimum frequency of the search window
Max Frequency	Maximum frequency of the search window

2.4.3.2 *Example*

In the 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	Parameter
1	Freq: [300 Hz – 3kHz], Nb of bins: 100 (100*8=800Hz) , Nb peak: 1
2	Freq: [4.2 kHz – 11kHz], Nb of bins: 150 (150*8=1.2kHz), Nb peak: 2

Legend	Symbol
Frequency min	
Frequency max	
Number of bins	
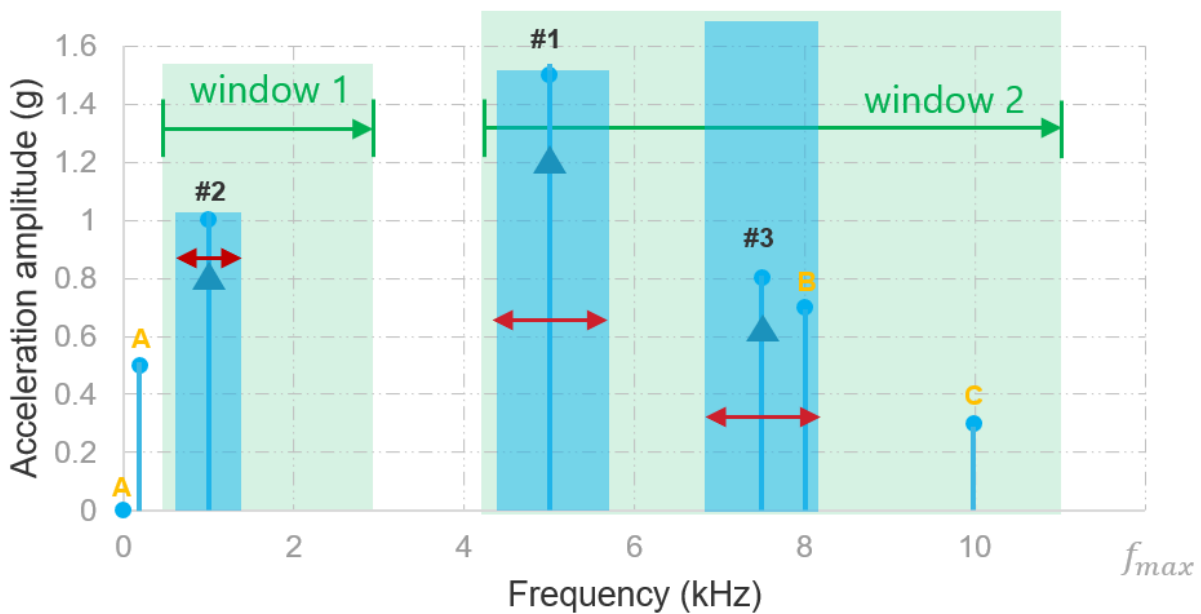
The peak search results: **#1**, **#2**, **#3**

Other peaks are filtered out from the search for the following reasons:
- All peaks outside the window (**A**) will be discarded from the peak search results.
- Any peak (**B**) located in the "integration size" area (number of bins) of a stronger one will be included in the energy ratio output (of peak #3 in the example) but won't show up as a detected peak.
- If the number of peaks for a dedicated window is reached, any new peak (**C**) inside the window will be ignored.

The result of the peak search is given as following:

Legend	Symbol
Peak frequency	
Peak magnitude RMS	
Ratio	/ signalRMS

2.5   CONNECTIVITY

2.5.1   *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.

2.5.1.1   *Regional parameters*

2.5.1.1.1   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

2.5.1.1.2   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).

2.5.1.1.2.1   EU868

For European regions, the 8911N supports data rates from 0 up to 7 in both uplink and downlink.

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

2.5.1.1.2.2   US915

For the US915, the data rates supported by the 8911N are:

Direction	Data Rate (DR)	Spreading Factor (SF)	Bandwidth (BW)	Bitrate (bit/s)
Uplink	0	SF10	125	980
	1	S9	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

2.5.1.1.3 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 8911N supports the following power:

2.5.1.1.3.1 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

2.5.1.1.3.2 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

2.5.1.1.4 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.

2.5.1.1.4.1.1 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, which 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 8911N sending 8 peaks							
DR	0	1	2	3	4	5	6
Number max of uplink per day	330	580	1290	4662	2326	7230	14540

Minimum uplink interval *(Measurement interval)*	4min20	2min30	1min7	40s* (*not supported)	22s* (*not supported)	11s* (*not supported)	4s* (*not supported)
Uplink data integrity	Varies* (*limited to 6 peaks if *fOptsLen*=15)	Varies * (*limited to 6 peaks if *fOptsLen*=15)	Varies * (*limited to 6 peaks if *fOptsLen*=15)	Yes	Yes	Yes	Yes

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.

2.5.1.1.4.1.2 Dwell time (US-915 only)

In the US915 regional specification, a LoRaWAN device has dwell time limit. This dwell time limit defines the maximum payload according to the data rate.
The table below shows the effect of the data rate on the maximum number of uplink messages that can be transmitted in a day.

Effect of US915 regulations for a 8911N							
DR	0	1	2	3	4	5	6
Uplink frame integrity	Yes* (*from 5 up to 6 fragments if *fOptsLen*=15)	Yes* (* up to 2 fragments if *fOptsLen*=15)	Yes	Yes	Yes	Yes	Yes

There are no duty cycle limitations under Federal Communications Commission (FCC), but the device must respect the limits 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.

2.5.1.1.4.1.3 Maximum payload

The maximum payload (MP) size of a LoRaWAN frame is fixed according to the used data rate.
The table 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 theoretical values and it does not take in account the possible fOpt requests from the gateway. The number of peaks is limited by 24 by the software.

Number of peaks vs Data Rate

2.5.1.2   *Mode of operation*

2.5.1.2.1   Device registration

To be recognized by the LoRaWAN server, the 8911N 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

2.5.1.2.2   Join and activation

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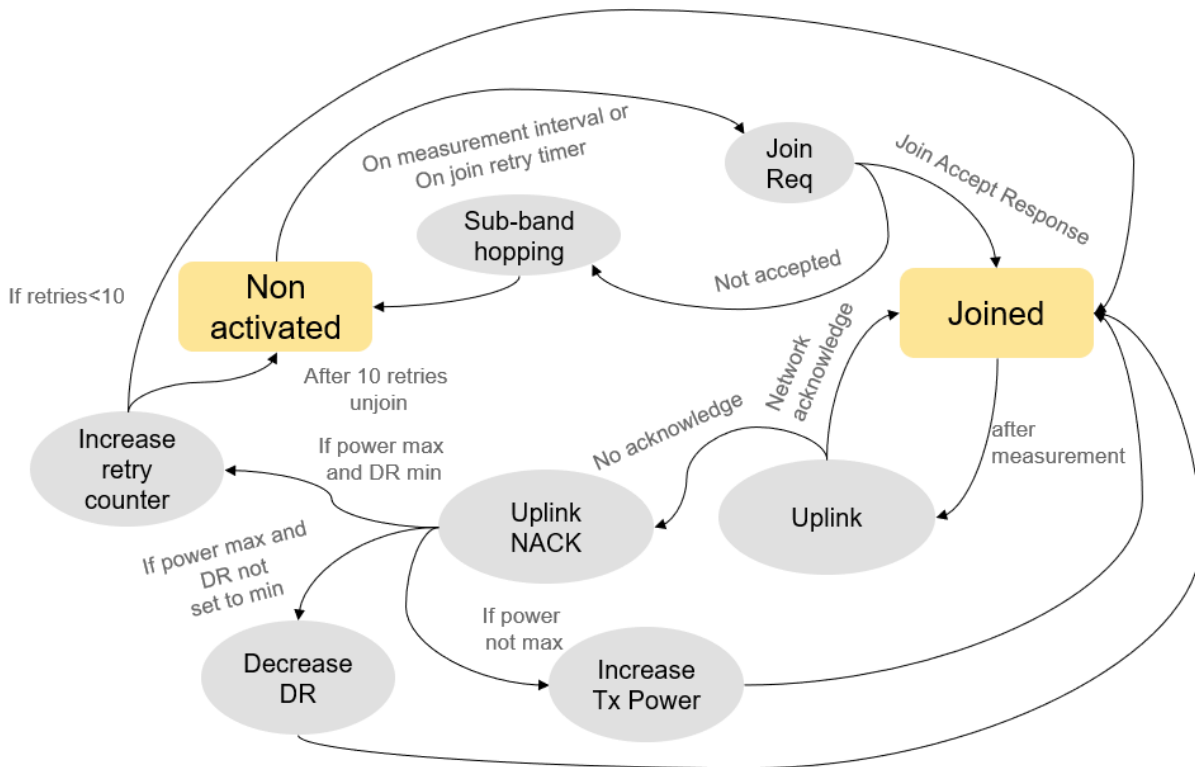
2.5.1.2.2.1 Join accept

In case of a sufficient LoRaWAN™ coverage and if the device was already registered in the Network and
application server database, the server responds to the join-request with a join-accept message.
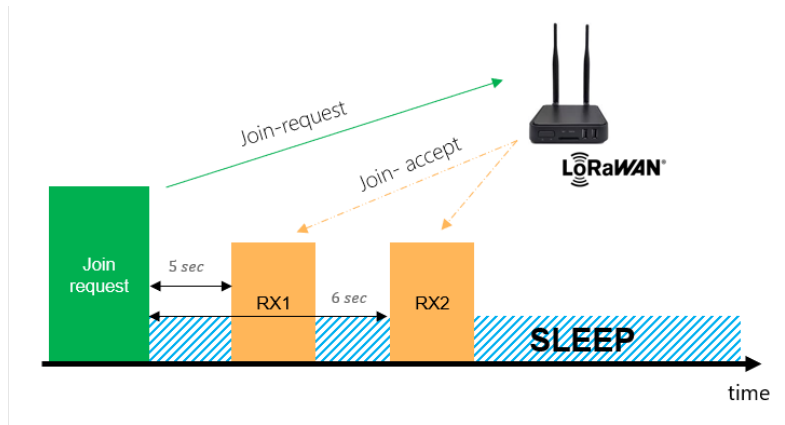
Figure 1:join accept

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.

2.5.1.2.2.2 Non-activated/Unjoined

If the LoRaWAN gateway is out of range for the 8911N or if the end-device is not registered on the network, the 8911N will not receive any join accept response and will remain in an unjoined state. In this state, the 8911N 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, the 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/Join retry timer in case of failure

2.5.1.2.3   Joined mode

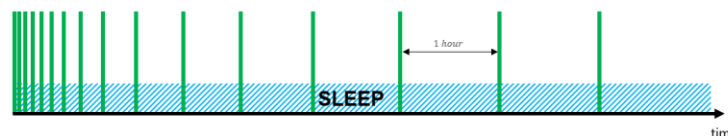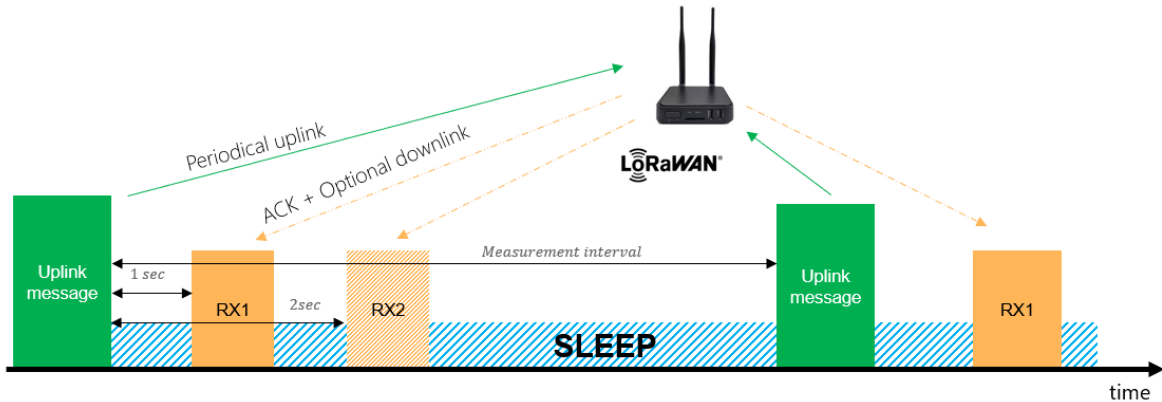Once the 8911N has joined the LoRaWAN network, it operates in normal mode.

Figure 3 Normal mode of operation

2.5.1.2.3.1 Uplink message

Every measurement determined by the measurement interval will trigger an uplink "live data" message. The uplink messages sent by the 8911N comes with the "confirmed data up" description embedded in the LoRaWAN application frame header (FType 0b100).

The 8911N 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 8911N 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 2.5.1.1.4 Time on air and payload limitations).

2.5.1.2.3.2 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 8911N in RX1, the device does open the second receive window (RX2).
The possible reception windows delays are:

Window	Parameters	Delay
RX1	RECEIVE_DELAY1	1s

RX2	RECEIVE_DELAY2	2s

2.5.1.3 *Messaging*

2.5.1.3.1   Uplink live message

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	48	Supported Data Rate: -EU868: 1 to 6 -US915: 2 to 6
FW revision	Sends the firmware revision	2	Variable	If downlink on fport 2

Important note:

- For EU868 DR=01,2, the uplink message may be truncated, and the number of peaks could go down to 6 peaks even if PEAK_CNT = 8. Only one fragment will be sent (duty cycle limitation).
- For US915 DR=0 or 1, the uplink message will be fragmented in several frames. In that case, the frames will be sent on a different Fport depending on the fragment.

US915 DR=0 or 1, or EU868 DR=0 only			
Type	Description	Fport	Payload length
Fragmented FFT peak data	Fragment of a "FFT Peak data" message	129	Variable (depending on DR)
Fragmented peak data end	Last fragment of the fragmented "FFT Peak Data" message	193	Variable (depending on DR)

2.5.1.3.1.1 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 little-endian (LE) system. Least-significant (LSB) byte is stored at the smallest address. The length of the frame depends on the number of peaks to be transmitted.

FFT Peak format (fPort=1)																	
Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	…	8+5*n-3	8+5*n-2	8+5*n-1	8+5*n
Description	BATT	PEAK_CNT	TEMP		SIG_RMS		DEVSTAT		PEAK_INFO_1						PEAK_INFO_n			

- ➢ *BATT*: battery level, in percentage (1 LSB = 1%). 8-bit unsigned value.
- ➢ *PEAK* CNT: number of peaks detected (8 by default). 8-bit unsigned value.
- ➢ *TEMP*: current temperature. Little-endian 16-bit unsigned value. A specific value of 0x7FFF is used as an error code.

$$Temperature_{(°C)} = \frac{TEMP_{(LSB)}}{10} - 100$$

- ➢ *SIG_RMS*: RMS value of the full signal (4096 samples) expressed in mg (RMS). Little-endian 16-bit unsigned value.

$$Signal\ RMS_{(g\ rms)} = \frac{SIG\ RMS_{(LSB)}}{1000}$$

- ➢ DEVSTAT: Device status

DEVSTAT																
byte				0								1				
bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
field	ACTIVE_PRESET_ID								ROT_EN	TEMP_ERR	ACC_ERR	RESERVED	RESERVED			

o *ACTIVE_PRESET_ID*: gives the active preset identifier
o *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

o *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

o *ROT_EN*: This bit tells the user if the rotating mode is enabled.

ROT_EN	Rotating mode
0	Disabled
1	Enabled

➢ *PEAK_INFO_n*: information related to a peak found in the FFT spectrum.

PEAK_INFO					
Byte	0	1	2	3	4
Description	FREQ		MAG_RMS		RATIO

o *FREQ*: Central frequency of the detected peak in Hz. Little endian 16-bit unsigned value.
o *MAG_RMS*: RMS magnitude of the single frequency detected peak. Little endian 16-bit unsigned value.

$$Magnitude\ RMS_{(g\ rms)} = \frac{MAG\ RMS_{(LSB)}}{1000}$$

o *RATIO*: Ratio of energy. Peak energy integrated on the "integration size" compared to the total energy of the full spectrum. In percent (0 to 100%).

2.5.1.3.1.2 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"

2.5.1.3.2 Downlink message

The supported downlink messages are listed below:

Type	Description	Fport	Payload length
DSP Configuration	Configures the DSP (BW and meas interval)	12	5
Search Window Configuration	Configures one window of the peak search	13	7
Active window search	Selects the number of active windows	13	1
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

2.5.1.3.2.1 DSP Configuration

Configures the DSP.

DSP config, fport = 12					
Byte	0	1	2	3	4
Description	0x01	BANDWIDTH		MEAS_INTERVAL	

- ➢ BANDWIDTH: FFT bandwidth refers to the observable FFT bandwidth coded on a Big-endian unsigned 16-bit value. 1 LSB = 1 Hz. Range is 500Hz to 19.2 kHz
- ➢ MEAS_INTERVAL: change the interval of measurement and uplink value in minutes. Big-endian unsigned 16-bit value. 1 LSB = 1 min. Range is 1min to 1440 min

2.5.1.3.2.2 Active window search

Defines the number of custom windows to be activated.

Error! Reference source not found., fport = 13	
Byte	0
Description	WINDOW_CNT

- ➢ WINDOW_CNT: number of active windows. 0 means the full spectrum with default parameters (BIN=20, PEAK_CNT=8). Others mean custom windows. From 0 up to 8 windows.
  For eg, 3 means the 3 first windows (1,2 and 3). If more than 1 window is configured, make sure that the total number of peaks of the combined windows does not exceed 24.

2.5.1.3.2.3 Search Window Configuration

Configuration a specific window.

Search window config, fport=13							
Byte	0	1	2	3	4	5	6
Description	WIN_ID	PEAK_NB	NB_BIN	FREQ_MIN		FREQ_MAX	

- ➢ WIN_ID: identifier of a window to be updated. Value from 1 up to 8.
- ➢ PEAK_NB: Number of peaks to be searched in that window (from 0 to 24)
- ➢ NB_BIN: Number of bins around the peak. (between 2 and 255). Should be an even number. The odd number would be written but computation will lead to trunk the value to the lower even value.
- ➢ FREQ_MIN: Minimum frequency of the search window. Big-endian 16-bit unsigned value.
- ➢ FREQ_MAX: Maximum frequency of the search window. Big-endian 16-bit unsigned value.

2.5.1.3.2.4 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".

2.5.1.3.2.5 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)

2.5.1.3.2.6 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	Any value

Example:

2.5.2 *Bluetooth® Low Energy*

The device includes a Bluetooth 5.0 Low Energy compliant interface. This is a low power communication technology which should be used at short distances. It makes the 8911N 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.

2.5.2.1 *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.
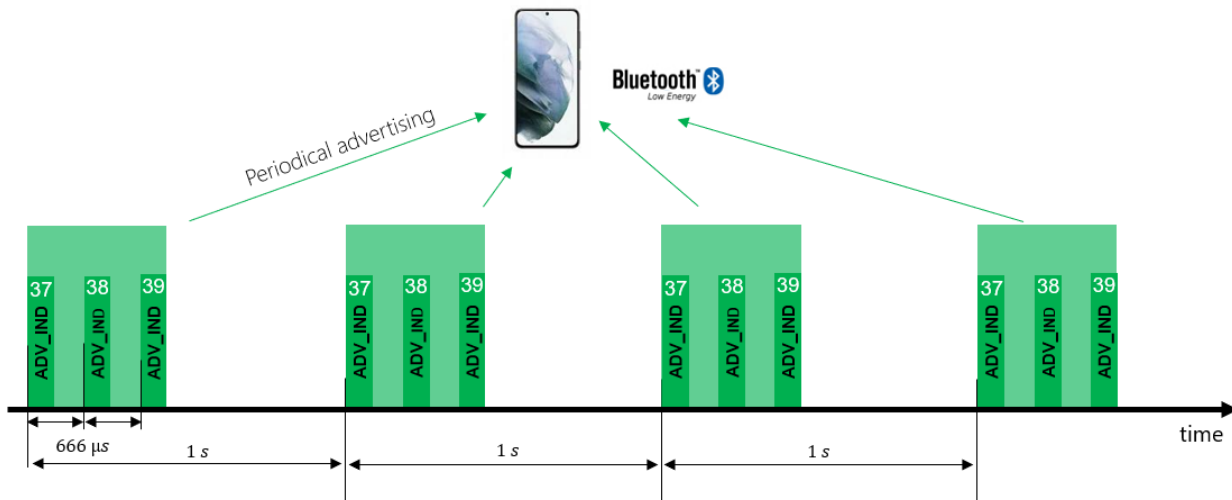
The Advertising packets (ADV_IND) contains both Flags and Manufacturer Specific Data. The fields are arranged as below.

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

2.5.2.1.1 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

2.5.2.1.2 Manufacturer specific data

All data fields are LSB first formatted.

	Manufacturer Specific Data																
Byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Fields	COMPANY IDENTIFIER		DT		CSD				MEAS CNT				BATT	FLAG	TEMP		ACC_RMS	

Default	0xDE	0x08	0xC1 D0	0xFFFFFFFF	0x00000000	0x64				

All values are endian-less formatted (LSB first).

- ➢ COMPANY IDENTIFIER: static 2-bytes field, identifies TE Connectivity
- ➢ DT: Device Type, value is set to C1D0 for an 8911N
- ➢ CSD: customer specific data. 4-byte customizable field.
- ➢ MEAS CNT: Measurement counter, this counter increments at each measurement interval
- ➢ BATT: Percentage of remaining battery level (1%/LSB)
- ➢ FLAG: Unused
- ➢ TEMP: current temperature. Little-endian 16-bit unsigned value. A specific value of 0x7FFF is used as an error code.
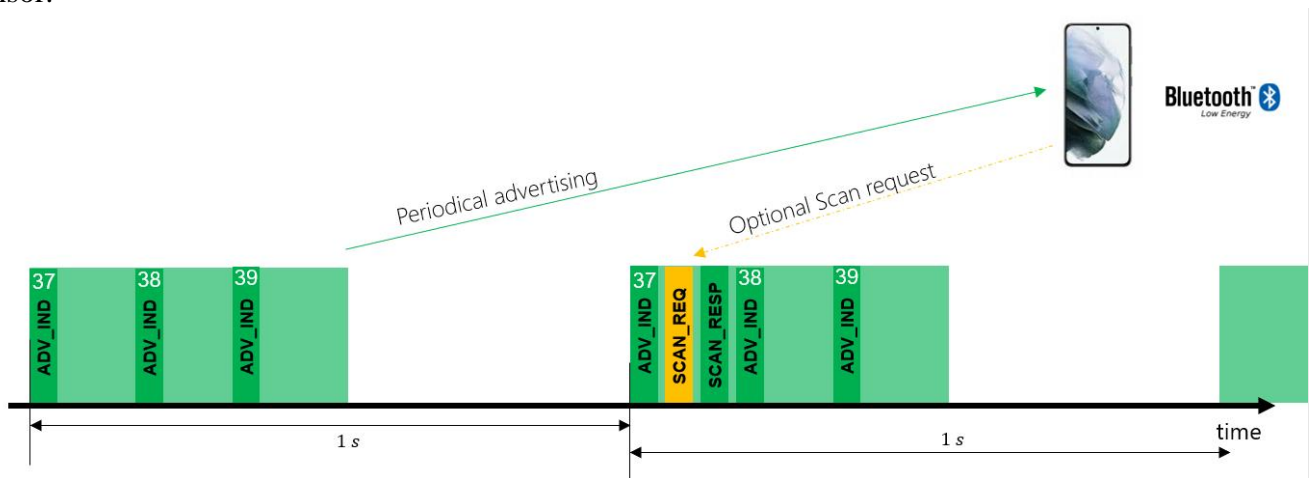
$$Temperature_{(°C)} = \frac{TEMP_{(LSB)}}{10} - 100$$

- ➢ ACC_RMS: RMS acceleration value of the full signal (4096 samples) expressed in mg (RMS). Little-endian 16-bit unsigned value. It equals 0x7FFF if erroneous.

$$Signal\ RMS_{(g\ rms)} = \frac{SIG\ RMS_{(LSB)}}{1000}$$

2.5.2.2 Scan response (peripheral)

The 8911N 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			TBD	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"

2.5.2.2.1 Complete local name

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

2.5.2.3 Connected mode (server)

The 8911N device offers many GATT services. These services and characteristics are exposed to the client once connected.
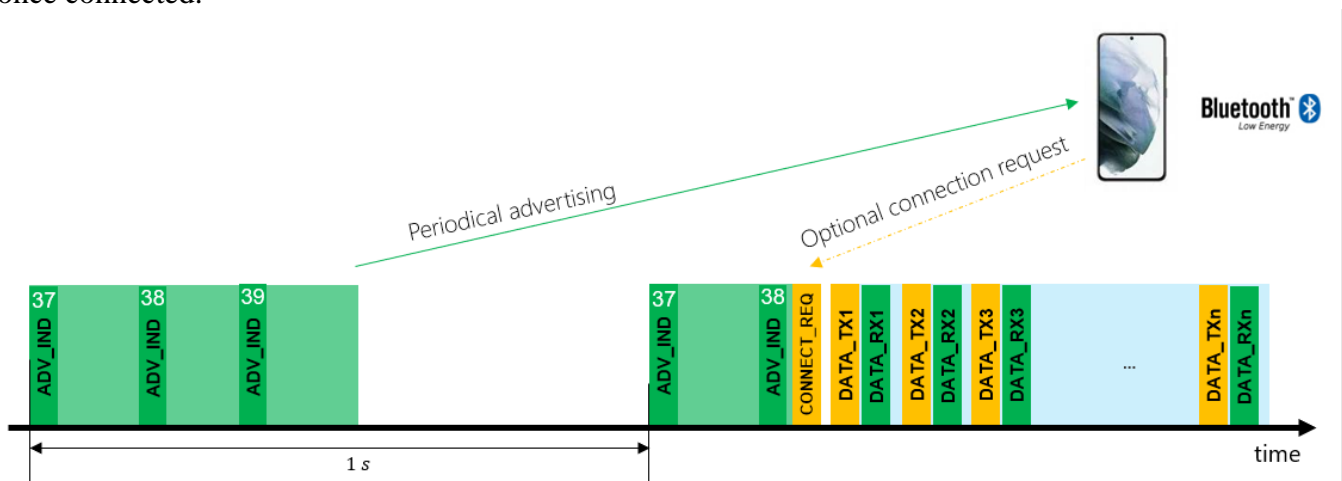
All available characteristics are listed below.

2.5.2.3.1   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

2.5.2.3.2   8911N 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	B006	R/W	12/4
		Bandwidth	B008	R/W	12/4
Battery	C000	Battery level	C001	R	4

		Battery replacement	C002	W	1
FFT Peak detection function	C170	Windows Configuration	C173	R/W	7/1,7
		Active window count	C172	R/W	1
		FFT Peak output	C171	R	125
Device scheduler	C1E0	Active preset	C1E1	R/W	1
		Rotating mode	C1E2	R/W	3
Bluetooth	CD00	Customer Specific Data	CD01	R/W	4

2.5.2.3.2.1 Device

2.5.2.3.2.1.1 Custom Device name

Surname of the BLE device. This is also shared when receiving scan requests. This is customizable. The length varies upon customer value.

Custom device name			
Byte	0	…	Up to 25
Description		CUST_DEVNAME	
Default		8911EX XXXX (4-digit of MAC address)	

➢ CUST_DEVNAME: string value

2.5.2.3.2.1.2 Default Device name

Read-only factory device name of the BLE device.

Default device name			
Byte	0	…	11
Description		DEF_DEVNAME	
Default		8911EX XXXX (4-digit of MAC address)	

➢ DEF_DEVNAME: string value

2.5.2.3.2.2 Data collection

2.5.2.3.2.2.1 Measurement interval (write)

Measurement interval				
Byte	0	1	2	3
Description		MEAS_INTERVAL		
Default		3600 (0x00000E10 -> [10 0E 00 00])		

➢ *MEAS_INTERVAL*: Interval of time in seconds between 2 measurements. Little-endian signed 32-bit value. The minimum admissible value is 60 seconds, and the maximum is 86400 sec (24 hours).

By default, this value is set to 3600 (1 hour).

2.5.2.3.2.2.2 Measurement interval (read)

Measurement interval												
Byte	0	1	2	3	4	5	6	7	8	9	10	11
Description	MEAS_INTERVAL				MIN				MAX			
Default	[10 0E 00 00]				[3C 00 00 00]				[80 51 01 00]			

2.5.2.3.2.2.3 Bandwidth (write)

Defines the effective FFT bandwidth.

It is recommended to use a value which is a multiple of 1600Hz to avoid resolution loss.

FFT effective bandwidth				
Byte	0	1	2	3
Description		BANDWIDTH		
Default		14400 (0x00003840 -> [40 38 00 00])		

➢ *BANDWIDTH*: FFT bandwidth in Hz. Little-endian signed 32-bit value. Range is 500Hz to 19.2 kHz.

2.5.2.3.2.2.4 Bandwidth (read)

FFT effective bandwidth											
Byte	0	1	2	3	4	5	6	7	8	9	10	11
Description	BANDWIDTH				MIN				MAX			
Default	[40 38 00 00]				[64 00 00 00]				[00 4B 00 00]			

2.5.2.3.2.3 Battery

2.5.2.3.2.3.1 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%.

2.5.2.3.2.3.2 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.

2.5.2.3.2.4 FFT Peak detection function

2.5.2.3.2.4.1 Peak search windows Configuration (read/write)

Configuration of a specific window. To select and read another window see 2.5.2.3.2.4.2 (same characteristics).

Peak search window configuration							
Byte	0	1	2	3	4	5	6
Description	WIN_ID	PEAK_NB	NB_BIN		FREQ_MIN		FREQ_MAX	

> WIN_ID: identifier of a window to be updated or being read. Value from 1 up to 8.
> PEAK_NB: Number of peaks to be searched in that window (from 0 to 24)
> NB_BIN: number of bins around the peak. (Between 2 and 254). Little -endian 16-bit unsigned value. Should be an even number. Odd number would be written but computation will lead to trunk the value to the lower even value.
> FREQ_MIN: Minimum frequency of the search window. Little-endian 16-bit unsigned value.
> FREQ_MAX: Maximum frequency of the search window. Little -endian 16-bit unsigned value.

2.5.2.3.2.4.2 Peak search windows configuration selection(write)

Selection of a window, this will update the result of 2.5.2.3.2.4.1 .

Peak search window configuration	
Byte	0
Description	WIN_ID

> WIN_ID: identifier of a window a specific window to be read. Value from 1 up to 8. If more than 1 window is configured, make sure that the total number of peaks of the combined windows does not exceed 24.

2.5.2.3.2.4.3 Active window search count

Defines the number of custom windows to be activated.

Active window search count	
Byte	0
Description	WINDOW_CNT

➢ WINDOW_CNT: number of active windows. 0 means the full spectrum with default parameters (BIN=20, PEAK_CNT=8). Others mean custom windows. From 0 up to 8 windows.
For eg, 3 means the 3 first windows (1,2 and 3).

2.5.2.3.2.4.4 FFT peak output

FFT peak output										
Byte	0	1	2	3	4	5	6	7	8	9	..
Description	PEAK_CNT	SIG_RMS		RESERVED		PEAK_INFO_n					…
						FREQ		MAG_RMS		RATIO	…

➢ *PEAK_*CNT: number of peaks detected (8 by default). 8-bit unsigned value.
➢ *SIG_RMS*: RMS value of the full signal (4096 samples) expressed in mg (RMS). Little-endian 16-bit unsigned value.

$$Signal\ RMS_{(g\ rms)} = \frac{SIG\ RMS_{(LSB)}}{1000}$$

➢ *PEAK_INFO_n*: information related to a peak found in the FFT spectrum.

PEAK_INFO					
Byte	0	1	2	3	4
Description	FREQ		MAG_RMS		RATIO

o *FREQ*: Central frequency of the detected peak in Hz. Little endian 16-bit unsigned value.
o *MAG_RMS*: RMS magnitude of the single frequency detected peak. Little endian 16-bit unsigned value.

$$Magnitude\ RMS_{(g\ rms)} = \frac{MAG\ RMS_{(LSB)}}{1000}$$

o *RATIO*: Ratio of energy. Peak energy integrated on the "integration size" compared to the total energy of the full spectrum. In percent (0 to 100%).

2.5.2.3.2.5 Device scheduler

2.5.2.3.2.5.1 Active preset

Read this active preset. Writing in this value it forces the device to toggle to another preset. The full configuration of the sensor will be updated. Note that other characteristics won't be updated accordingly when reading. To read back the value, it needs a disconnection then re-connection of the sensor.

Active preset	
Byte	0
Description	PRESET_ID

➢ PRESET_ID: identifier of the preset to be loaded.

2.5.2.3.2.5.2 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

➢ ROT_MODE:

ROT_MODE	Rotating mode
0	Disable rotation and load ID_0. ID_1 is not used
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

2.5.2.3.2.6 Bluetooth

2.5.2.3.2.6.1 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 (2.5.2.1.2).

2.5.2.3.2.7 Generic Access

2.5.2.3.2.7.1 Device name

Contains device name. (Used for scan response). By default, contain model number plus 4 last digit of the mac address "8911 ed75".

2.5.2.3.2.7.2 Appearance

Sets to 00-02

2.5.2.3.2.7.3 Peripheral Preferred Connection Parameters

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

2.5.2.3.2.7.4 Central address resolution

Sets to 01

2.5.2.3.2.8 Device Information

2.5.2.3.2.8.1 Model Number

Contains model of the sensor in ASCII. Looks like "8911EX"

2.5.2.3.2.8.2 Serial Number

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

2.5.2.3.2.8.3 Firmware revision

Contains Firmware revision string in ASCII. Looks like "SW_8911-FFT_PTFB-B_1.7.8".

2.5.2.3.2.8.4 Hardware revision

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

2.5.2.3.2.8.5 Manufacturer

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

2.5.2.3.2.9 Generic attribute

2.5.2.3.2.9.1 Service change
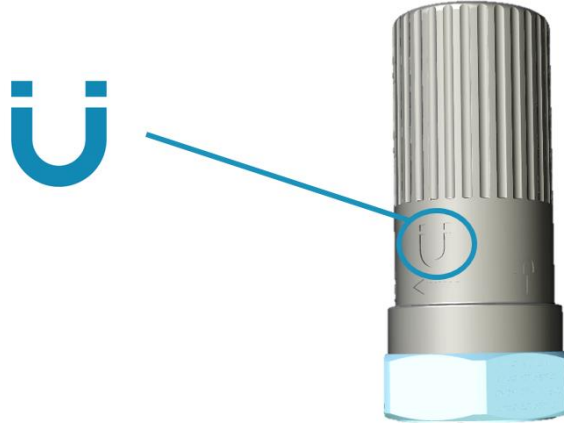
Not used.

2.5.2.3.2.10   Secure DFU Service

2.5.2.3.2.10.1 Buttonless DFU without bond

Use to switch into DFU mode.

2.6 MAGNETIC SWITCH

The 8911N contains an internal reed switch. This contactless button can be activated when approaching a strong magnet at closed state 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, you should see fast blinking LED. Release the magnet once a very long orange LED appears

2.7 LED

The orange LED indicates the state of the 8911N .

Category	Mode	Description	Pattern
	Power-on/Reset	Led turned on at start up to confirm the battery insertion.	2 sec 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 sec long on

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

2.7.1 *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: In case no response from the gateway, and after about 6 sec after the 3 short blinks, the LED is turned on for approximately 1 second.
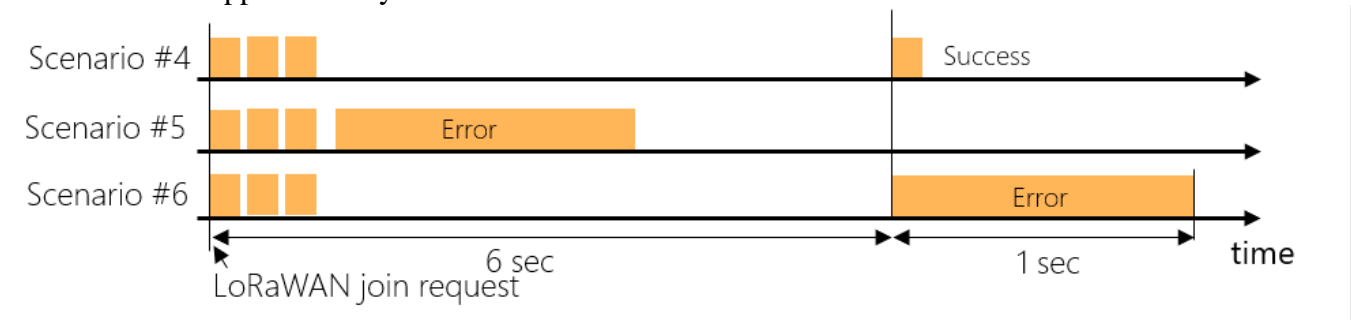

2.7.2 *LoRaWAN uplink transmission examples*

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).
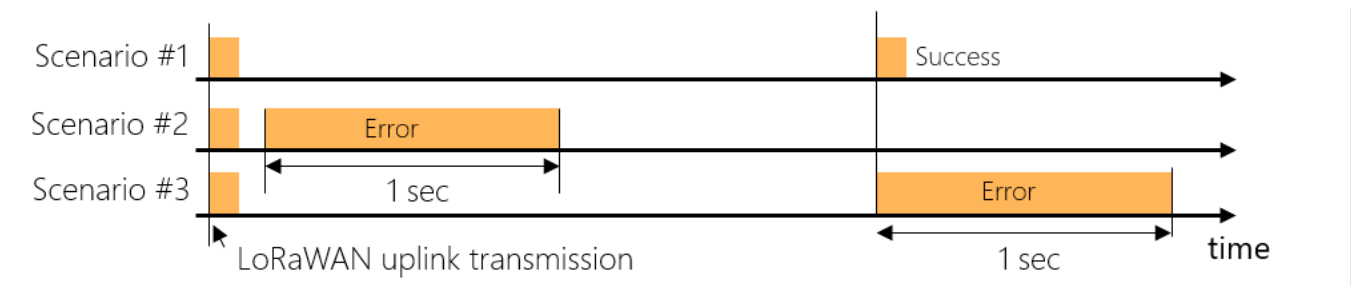
2.8 PRESETS

The 8911N comes with a new concept called "Preset". It adds to the end user a very high flexibility in term of configuration and offer various pre-configured modes.

The presets are divided in 2 different categories:

- **User**: editable area which allows the user to create his own configurations.
- **Factory predefined**: read only preset which are callable for an easy and fast configuration

2.8.1 *Preset list*

By default, the 8911N uses the "user preset 0". Any change to the sensor settings such as bandwidth, measurement interval, window count… will affect the "user preset 0" only.

If the user does not need multiple configuration options in the field, this section can be ignored.

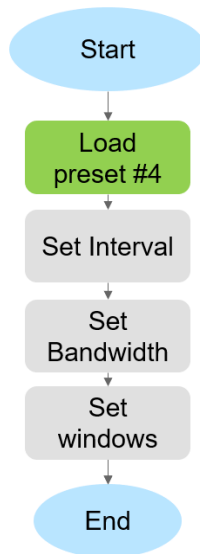| Category	Preset Name	ID	BW (Fs/2.56)	Meas interval	Windows Count	Windows FreqMin	FreqMax	Integ bin	Peaks
User	**User preset 0**	**0**	**14.4k**	**1 hour**	**0**	**bandwidth**		**20**	**8**
	User preset 1	1	14.4k	1 hour	0	bandwidth		20	8
	…	..	..	..	..	..	..	..	..
	User preset 15	15	14.4k	1 hour	0	bandwidth		20	8
Factory Predefined	8911_Legacy	64	14.4k	1 hour	0	bandwidth		20	8
	BW1K6_ULP	65	1.6k	1 day	1	0	1.6k	4	8
	BW4K8_ULP	66	4.8k	1 day	1	0	4.8k	4	8
	BW9K6_ULP	67	9.6k	1 day	1	0	9.6k	4	8
	BW1K6_LP	68	1.6k	0.5 day	1	0	1.6k	4	8
	BW4K8_LP	69	4.8k	0.5 day	1	0	4.8k	4	8
	BW9K6_LP	70	9.6k	0.5 day	1	0	9.6k	4	8
	BW1K6_STD	71	1.6k	1 hour	1	0	1.6k	4	8
	BW4K8_STD	72	4.8k	1 hour	1	0	4.8k	4	8
	BW9K6_STD	73	9.6k	1 hour	1	0	9.6k	4	8
	BW1K6_HR	74	1.6k	10 min	1	0	1.6k	4	8
	BW4K8_HR	75	4.8k	10 min	1	0	4.8k	4	8
	BW9K6_HR	76	9.6k	10 min	1	0	9.6k	4	8
	BW9K6_RTH	77	9.6k	5 min	1	1.6k	9.6k	4	8
	BW1K6_RTL	78	1.6k	55 min	1	0	1.6k	4	8

2.8.2   Manage preset

By default, the sensor uses the "User Preset 0". It is possible to switch between 2 presets by writing the preset identifier to be loaded in a specific register. It can be done anytime.

Once the preset loaded, the parameters shown in the previous table are applied and are instantaneously effective.

Without preset

Custom config using factory presets:
Customer uses an existing preset.

```
  Start                               Start
    |                                   |        ┌──────────────────┐
    v                                   |        │ 1 step configuration │
Set Interval                            v        └──────────────────┘
    |                              Load preset #65
    v                                   |
Set Bandwidth          Time saving      |
    |                 ─────────►         v
    v                                  End
Set windows
    |
    v
   End
```
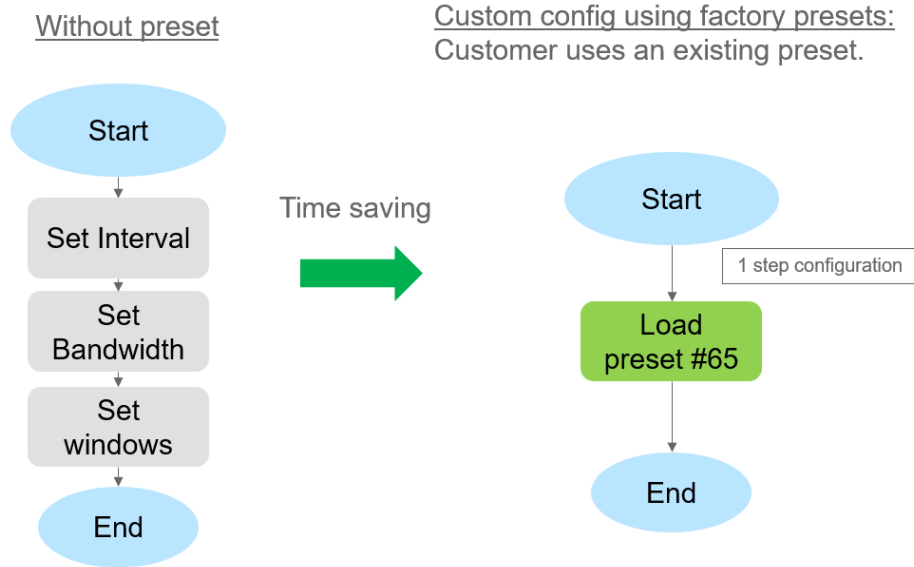
If the selected preset is a user preset, the parameters of the active preset can be modified (and saved) in the usual way (over BLE or LoRaWAN) using the default commands.

```
         Start
           |
           v
      Load preset #4
           |
           v
      Set Interval
           |
           v
      Set Bandwidth
           |
           v
      Set windows
           |
           v
          End
```

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

2.8.3   *Rotating preset mode*

In addition to the presets, the 8911N implements a new mode called "rotating mode". This allows the user to run 2 presets consecutively. After the execution of the preset mode, the second preset queued in the mode will be loaded, then once executed it comes back to the first.

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

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

	#0	#1
BW	2kHz	10kHz
Measurement Interval	55 min	5 min
Window	0-2kHz	2kHz-10KHz
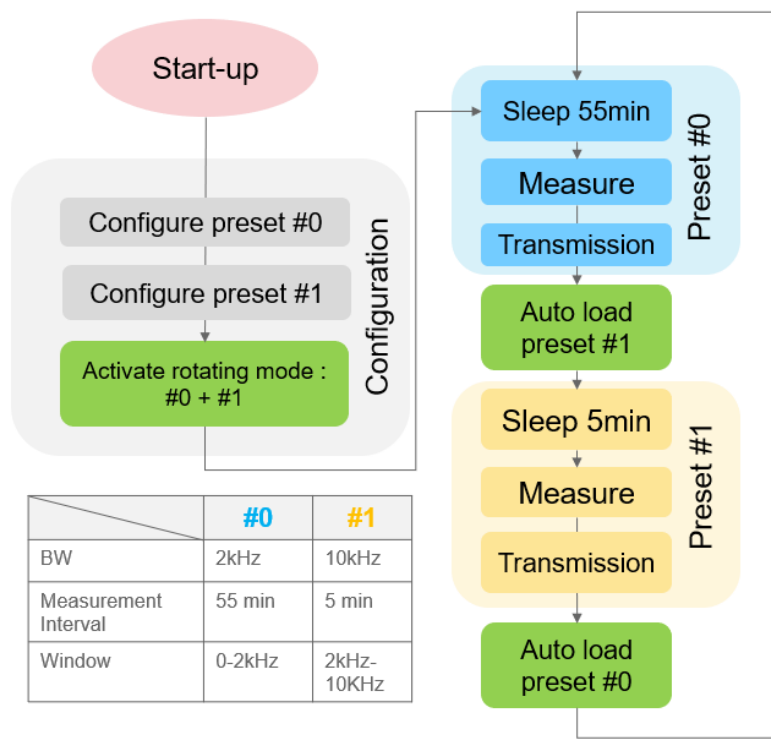
In the following example, 2 measurements will occur at an hourly interval: one with a high frequency band and another (5min later) with a low bandwidth but with a higher resolution.
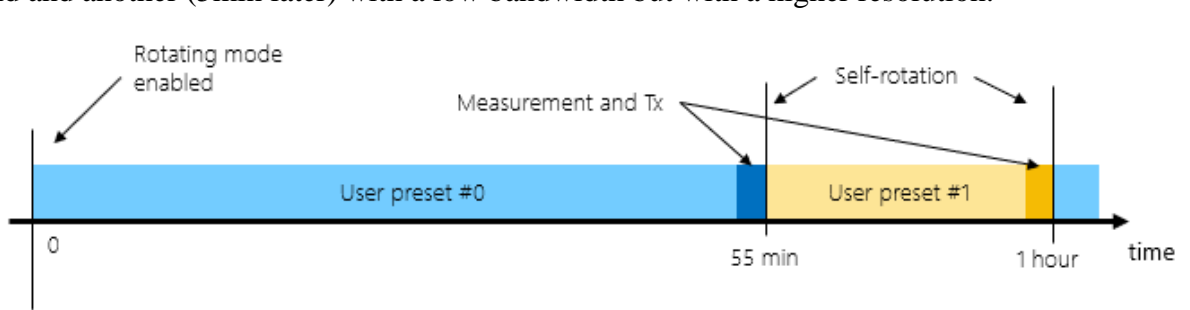
2.8.4   *Rotating examples using LoRaWAN updates*

The following examples demonstrate how to update the measurement interval of user preset #0 when the rotating mode is activated.

The startup configuration is:
- rotating mode enabled between user presets #0 (default) and #1

- Preset #0: measurement interval set to 10 minutes
- Preset #1: measurement interval set to 1 minutes

2.8.4.1 *"Safe" update*

Any user preset can be modified using the LoRaWAN downlink. It is recommended to disable the rotating mode before changing any parameter. The sequence includes a "rotation mode de-activation with a load of the preset to be modified" followed by an update of the "measurement interval". Once completed, the user can reactivate the rotating mode.
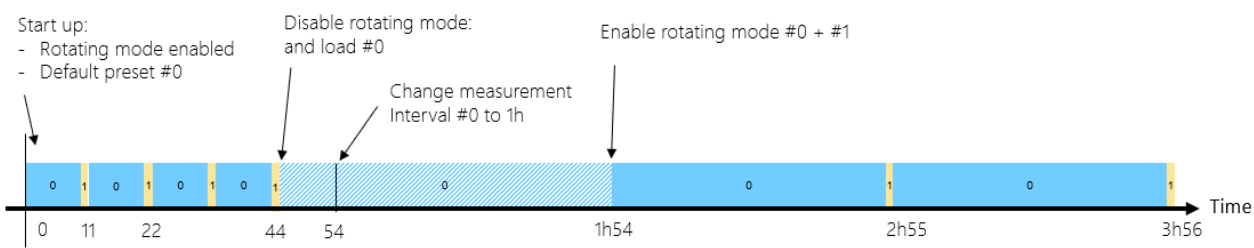
2.8.4.2 *'On the fly' update*

It is also possible to change a parameter ad-hoc, but this requires good synchronization between the uplink and downlink messages. The command must be sent immediately after an uplink is received from the previous preset.

For example, to update preset #0 the user/gateway must send a downlink just after having received an uplink of preset #1. If the downlink transmission is not well handled, preset #1 may updated instead of #0.
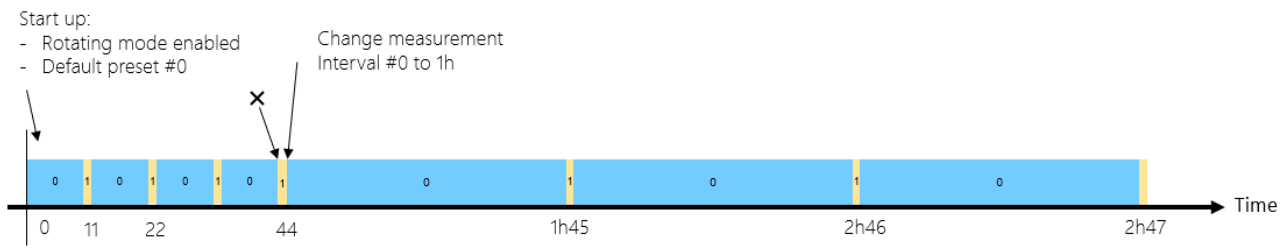
2.9 BATTERY

2.9.1 SAFT LS17330

The 8911N should be used with a 3.6V SAFT 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

2.9.2 Battery life

Depending on customer settings (measurement interval) and on LoRaWAN network quality, the 8911N battery life could last up to 4 years in ideal conditions.
The lower number of measurements per day, the longer the battery life will last.

Battery life vs measurement interval
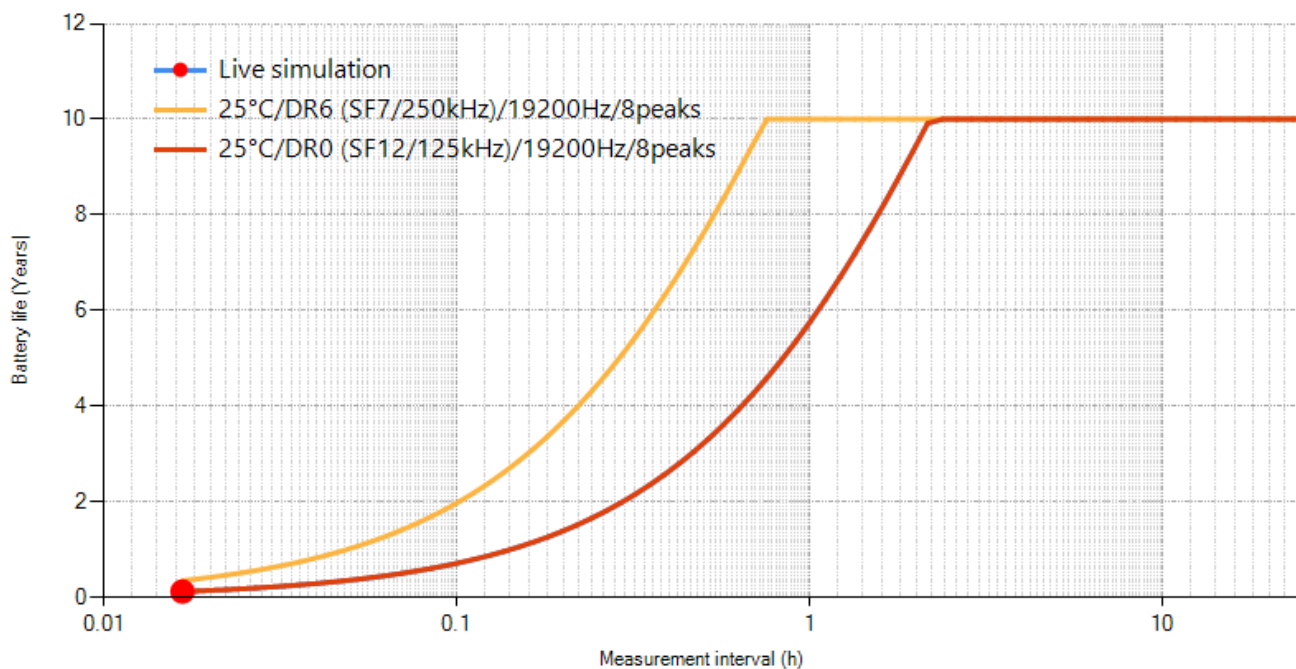
2.9.3 Battery replacement

If the battery of the 8911N is empty, it can be replaced. To access the battery, unscrew the plastic housing and remove it from the base. Carefully pull on the orange tab to remove the battery. Note that the battery must be replaced with the same model as the original one, as using other types may cause damage or unpredictable behavior of the sensor. Double-check the polarity and then insert the new battery inside the holder. Finally, reposition the plastic cover onto the sensor. After replacing the battery, the user must use the BLE 'battery replacement' characteristic value to reset the battery estimation algorithm.
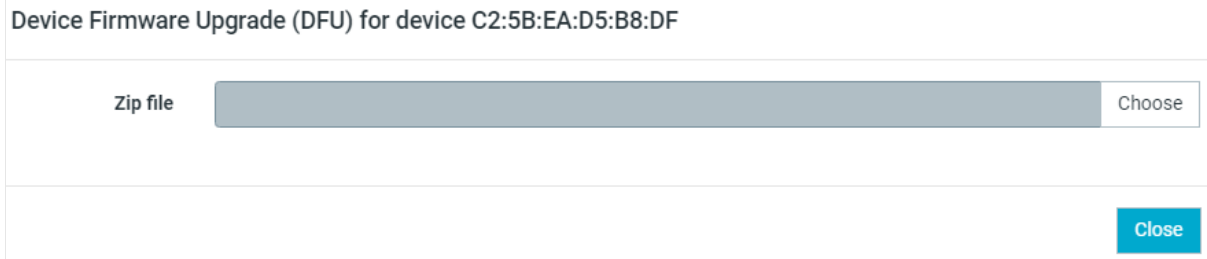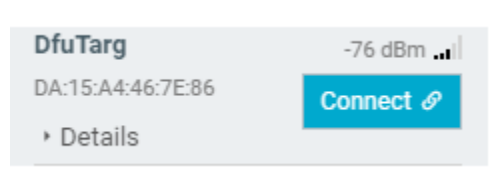
3   DFU MODE DESCRIPTION

DFU mode should be used to upgrade the sensor firmware. It is accessible from the standard mode.

The new firmware to be loaded must be signed by TE Connectivity.

The DFU works with a single bank only. This means that if the firmware update is interrupted (power cut off or BLE disconnection), the application firmware will be corrupted, and the sensor will stay in DFU mode. The user will have to repeat the upgrading process. Note that the DFU MAC address is the sensor MAC address +1.