IOT PLATFORM BLE VIBRATION 8531

TECHNICAL SPECIFICATIONS

INTRODUCTION

The TE model 8531RV wireless vibration sensor combines an accelerometer, a data collector, and a radio into one compact, battery-operated device that measures both vibration and temperature data. It was designed for hash environment and comes with the ATEX certification.

The model 8531RV wireless accelerometer uses the Bluetooth Low Energy communication protocol, offering 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

The model 8531RV incorporates a piezo-electric accelerometer which offers a wide bandwidth to >15kHz, outstanding measurement resolution and superior long-term stability compared to design using MEMS solutions.

Because of this feature, the 8531RV directly provides the raw data to plot trends and monitor changes in the performance and condition of factory machinery.

Bluetooth® 5.0 communication protocol

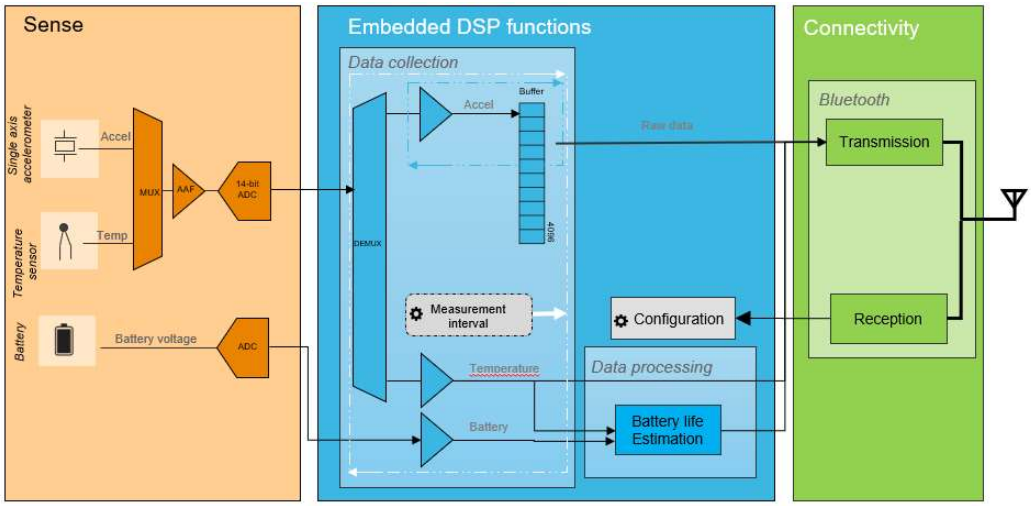
DATE	REVISION	COMMENTS	Author	Aprover
02/10/2022	Rev0	Initial revision	Anthony Duhamel	
05/17/2022	Rev1	Update including reed switch, battery management and factory mode	Romain Marty	Mainekhel Folliot Bernard Kamel

Table des matières

1 GENERAL DESCRIPTION

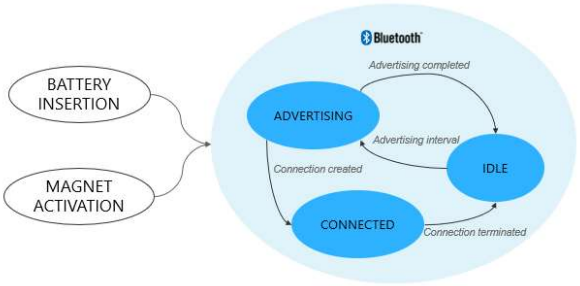
The 8531RV operates as a smart device. It offers sensing, processing, and wireless communication capabilities.

The solution consists of sensitive elements such as accelerometer and temperature sensors combined with embedded microprocessor. The device acquires raw data and then it transmits its over Bluetooth at the programmable interval.

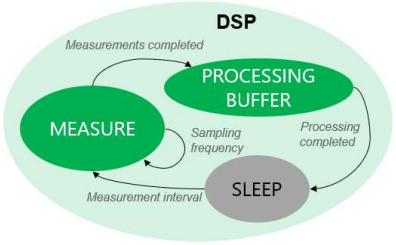


When the device is powered on, a yellow LED blinks to confirm the proper battery insertion.

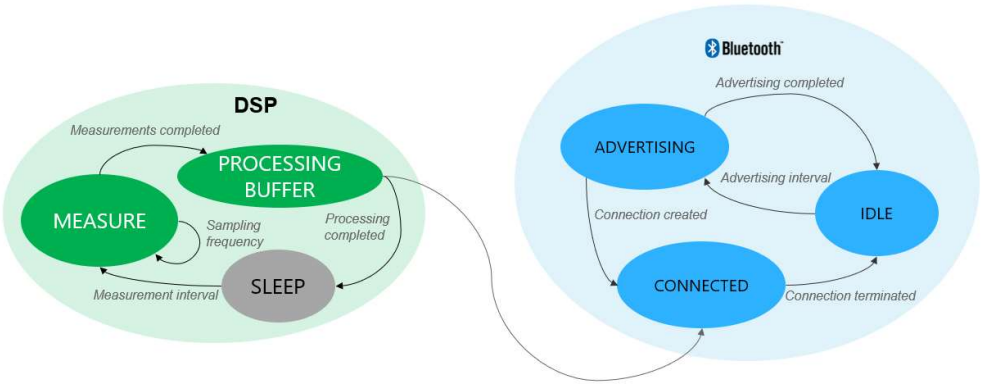
1. **BLE beaconing enabled for pairing**
   From the sensor startup and for 10min, the device operates as a beacon and advertise every 1 sec.
   A magnet can be used to reactivate the BLE transceiver after it has turned off automatically.



2. **Initial measurement & processing:**
   The device performs an initial set of acceleration readings based on the factory default settings. Then it processes the measurements depending on the default parameters.



3. **Data transfer through BLE**
   Once the acquisition is done data can be collect via BLE.



The 8531JC comes with different modes of operation which are listed below:

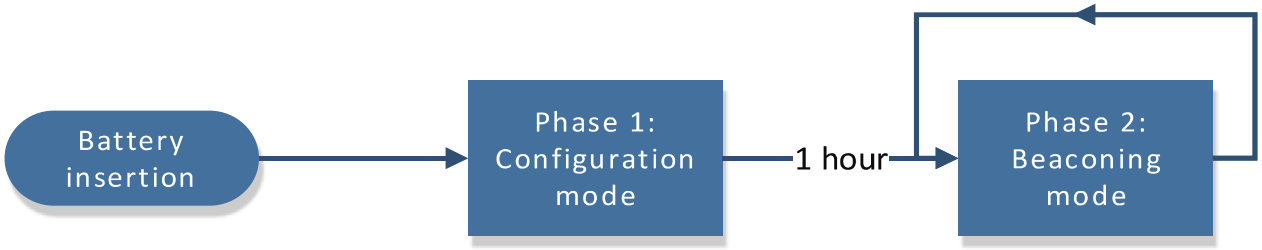
Operating mode	Description	Condition
Factory	Mode used by manufacturing. It allows sensor calibration and offer dedicated test-mode functionalities for RF testing, calibration, and current consumption measurements.	Factory entry
User	User mode.	None
DFU	Mode used during FW update.	OTA update

2 USER MODE

2.1 Advertisement

INTERVALS

When the battery is inserted, a yellow LED will light for 500ms to confirm proper battery insertion.



Phase 1: Configuration mode (1 hour since start up)

At startup an initial measurement was performed then new measurements are performed based on the setup configurable period between 10minutes to 24 hours.

During all this phase, the device will advertise at 1s interval. The content of the manufacturer specific data in the advertising frame is given below.

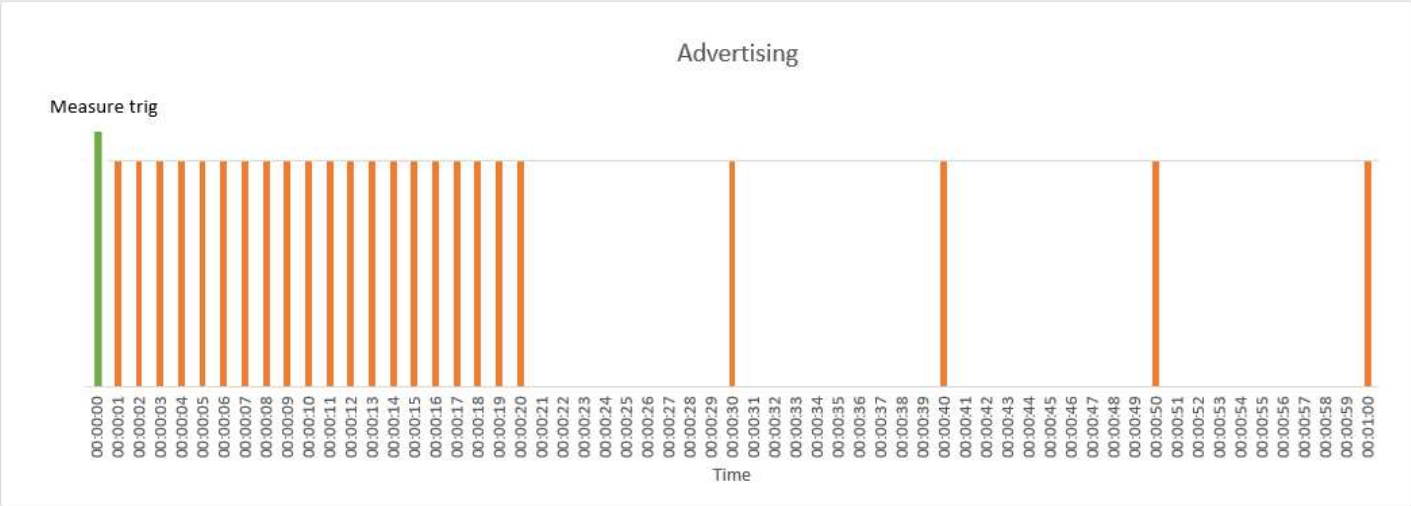
Phase 2: Beaconing mode

After the configuration mode (1 hour), the device will go in beaconing mode

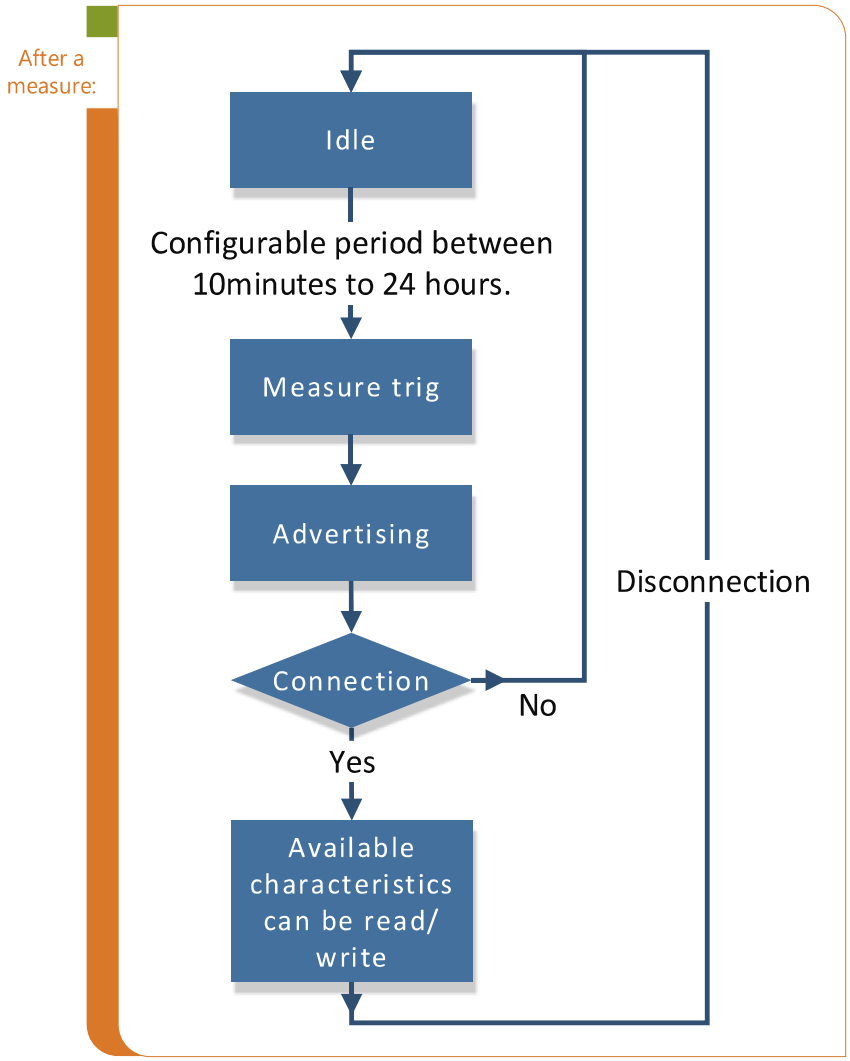
Measurement is performed based on the same setup configurable period between 10 minutes to 24 hours.

After each measurement, the device will advertise at 1s interval for 20 seconds. This will give multiple chances to the gateway to connect to the device.

After 20 seconds, the device will advertise at 10s interval till the next measurement. During, this phase, the connection could be impossible.



Connection is possible after each measurement



This sensor is compatible with BLE 5 and older versions.

If a connection occurs, the user will have the opportunity to update manufacturer specific fields or retrieve last measurement data through the vibration sensor services and its Datalog commands. Note that available data are only from the last trigged measurement event, there is not data history storage.

The content of the manufacturer specific data in the advertising frame is given below.

FLAGS

- LE General Discoverable Mode
- BR/EDR not supported

MANUFACTURER SPECIFIC DATA

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
CI		CST										CNT				BATT	FLAG	SAX		SAY		SAZ		ST	

(LSB FIRST)

CI *2 Bytes* *Unsigned integer*
TE Connectivity Company Identifier
Constant value: 0x08DE

CST *10 Bytes* *Unsigned integer*
Custom Data
Default value: 0xFFFFFFFFFFFFFFFFFFFF

CNT *4 Bytes* *Unsigned integer*
Number of measures done since the sensor start-up or last reset.
Reset Counter: *use command "R3S3T" (0x5233533354) in advertisement data characteristic*

BATT *1 Byte* *Unsigned integer*
Battery Level (%)
Resolution = 1
Range value = [0 - 100]

FLAG *1 Byte*
(Reserved)

SAX *2 Bytes* *Signed integer*
RMS value of X-axis (g RMS)
Acceleration = SAX / 100
Resolution: 0.01
Default value: 0x7FFF
Error value: 0x7FFF

SAY *2 Bytes* *Signed integer*
RMS value of Y-axis (g RMS)
Acceleration = SAY / 100
Resolution: 0.01
Default value: 0x7FFF
Error value: 0x7FFF

SAZ *2 Bytes* *Signed integer*
RMS value of Z-axis (g RMS)
Acceleration = SAZ / 100
Resolution: 0.01
Default value: 0x7FFF
Error value: 0x7FFF

ST *2 Bytes* *Signed integer*
Temperature value (° C)
Temperature = ST / 100
Resolution: 0.01
Default value: 0x7FFF
Error value: 0x7FFF

2.2 Scan Response

FULL NAME

"8531RV " + 4 last digits of MAC address.

It could be changed with the Device Name Service.

2.3 Services

2.3.1 *Vibration sensor service*

UUID	B614B000-B14A-40A6-B63F-0166F7868E13

Vibration Sensor Service allows to read the value of sensor in BLE connected mode.

Retrieving datalogging buffers is done using the following process:

1. Read Datalog Status
2. If “remaining data block” field > 0
3. Write read command to retrieve in Datalog Command
4. Sample data will be available in Data characteristic
5. Go to 3 until no more data available (remaining data block == 0)

AVAILABLE CHARACTERISTICS

FUNCTION	NAME	UUID	BYTES	READ WRITE	NOTIFIED
Retrieving value	Data	B614B001-B14A-40A6-B63F-0166F7868E13	2 ...112	Read	YES
Retrieving value	Datalog Status	B614B002-B14A-40A6-B63F-0166F7868E13	8	Read	NO
Retrieving value	Datalog Command	B614B003-B14A-40A6-B63F-0166F7868E13	1	Write	NO
Setup	Measurement interval	B614B004-B14A-40A6-B63F-0166F7868E13	12 (read) 4 (write)	Read Write	NO
Setup	Sampling Frequency	B614B005-B14A-40A6-B63F-0166F7868E13	12 (read) 4 (write)	Read Write	NO
Status	Status	B614B00F-B14A-40A6-B63F-0166F7868E13	1	Read	NO

DATA CHARACTERISTIC BYTES FIELDS

Data is composed of a minimum of 2 parts: 1 header + X measures

Header for each axis measurement (minimum size is 32 Bytes fields):

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
MAGIC				TEMP				AXIS				CNT				NB_POINT				NB_BLOCK				FREQUENCY				FIRST_SEQ			

(LSB FIRST)

MAGIC *4 Bytes* *Unsigned integer*
Integrity indicator
Constant value: 0xAAABBAAA

TEMP *4 Bytes* *Signed integer*
Temperature value (°C)
Temperature = TEMP / 100
Resolution: 0.01
Default value: 0x7FFF
Error value: 0x7FFF

AXIS *4 Bytes* *Unsigned integer*
AXIS value
Range value: [1 - 3] (1 for X, 2 for Y, 3 for Z)
Error value: 0x0

CNT *4 Bytes* *Unsigned integer*
Number of measures done since the sensor start-up or last reset.
Range value: *Full range*

NB_POINT *4 Bytes* *Unsigned integer*
Number of points
Range value: [256 - 25600]

NB_BLOCK *4 Bytes* *Unsigned integer*
Number of blocks
Range value: [5 - 458]

FREQUENCY *4 Bytes* *Unsigned integer*
Frequency sampling
Range value: [256 – 25600]

FIRST_SEQ *4 Bytes* *Unsigned integer*
Sequence number of the first datalogger block

OTHERS… *X Bytes*
(Reserved)

Measures is a maximum of 112 bytes fields.

0	1	2	3	4	5	6	7	8	9	10	11	…	…	108	109	110	111
MEASURE		MEASURE		MEASURE		MEASURE		MEASURE		MEASURE		…		MEASURE		MEASURE	

(LSB FIRST)

MEASURE *2 Bytes* *Signed integer*
Vibration raw value (g)
Acceleration = MEASURE / 100
Resolution: 0.01 g
Error value: 0x7FFF

Example:

For each measurement, we read several times DATA CHARACTERISTICS (after writing 0x01 in Datalog command)

- One block for the header. It indicated Count = 1, Axis = 1 (=X)
- Several blocks (nb_block) for the data for axis X
- One block for the header. It indicated Count = 1, Axis = 2 (=Y)
- Several blocks (nb_block) for the data for axis Y
- One block for the header. It indicated Count = 1, Axis = 3 (=Z)
- Several blocks (nb_block) for the data for axis Z

Then after the next measurement:

- One block for the header. It indicated Count = 2, Axis = 1 (=X)
- Several blocks (nb_block) for the data for axis X
- Etc.…

DATALOG STATUS CHARACTERISTIC BYTES FIELDS

0	1	2	3	4	5	6	7
FIRST_DATA_BLOCK				REMAINING_DATA_BLOCK			

(LSB FIRST)

FIRST_DATA_BLOCK 4 Bytes *Unsigned integer* Indicates the ID of first available block in the datalogger memory
Range value: Full range

REMAINING_DATA_BLOCK 4 Bytes *Unsigned integer* Indicate the number of blocks which are not retrieved yet in the datalogger memory
Range value: [0 - 458]

DATALOG COMMAND CHARACTERISTIC BYTES FIELDS

1
COMMAND

COMMAND *1 Byte* *Unsigned integer* Write 0x01 to make the next available block in DATA CHARACTERISTIC

MEASUREMENT INTERVAL CHARACTERISTIC BYTES FIELDS

0	1	2	3	4	5	6	7	8	9	10	11
MEAS_INTERVAL				MIN				MAX			

(LSB FIRST)

MEAS_INTERVAL 4 Bytes *Unsigned integer* Measurement interval between 2 measurements (milliseconds)
Range value: [600000 - 86400000] (10 minute – 24 hours)
Default value = 0x00BADB00 (4 hours)

MIN 4 Bytes *Unsigned integer* Minimum value of measurement interval (milliseconds)
Constant value: 0xC0270900 (10 minute)

MAX 4 Bytes *Unsigned integer* Maximum value of measurement interval (milliseconds)
Constant value: 0x005C2605 (24 hours)

FREQUENCY SAMPLING CHARACTERISTIC BYTES FIELDS

0	1	2	3	4	5	6	7	8	9	10	11
FREQ_SAMPLING				MIN				MAX			

(LSB FIRST)

FREQ_SAMPLING 4 Bytes *Unsigned integer* Frequency sampling (hertz)
Range value: [256 - 25600]
Default value = 0xD4300000 (12500)

MIN 4 Bytes *Unsigned integer* Minimum value of frequency sampling (hertz)
Constant value: 0x00010000 (256)

MAX 4 Bytes *Unsigned integer* Maximum value of frequency sampling (hertz)
Constant value: 0x00640000 (25600)

STATUS CHARACTERISTIC BYTES FIELDS

1

SENSOR_ERROR

SENSOR_ERROR *1 Byte* *Unsigned integer* Sensor status
0x00 => Sensor OK
0x01 => Sensor ERROR

2.3.2 *Battery service*

UUID	B614C000-B14A-40A6-B63F-0166F7868E13

AVAILABLE CHARACTERISTICS

NAME	UUID	BYTES	READ / WRITE	NOTIFIED
Data	B614C001-B14A-40A6-B63F-0166F7868E13	4	Read	YES
Battery change	B614C002-B14A-40A6-B63F-0166F7868E13	1	Write	NO

DATA CHARACTERISTIC BYTES FIELDS

1	2	3	4
BATTERY_LEVEL			

BATTERY_LEVEL *4 Bytes* *Float (IEEE-754)* Battery Level (%)
Range value = [0 - 100]

ATEX version will use a specific battery which will be implemented

BATTERY CHANGE CHARACTERISTIC BYTES FIELDS

1
BATT_RESET

BATT_RESET *1 Byte* *Unsigned integer* Write 0x01 to reset the battery algorithm.
Led blink 2 seconds to indicate the reset.

2.3.3 *Device name service*

UUID	B614FA00-B14A-40A6-B63F-0166F7868E13

AVAILABLE CHARACTERISTICS

NAME	UUID	BYTES	READ / WRITE	NOTIFIED
Device Name	B614FA01-B14A-40A6-B63F-0166F7868E13	18	Read/Write	NO
Default Device Name	B614FA02-B14A-40A6-B63F-0166F7868E13	18	Read	NO

Both Device Name and Default Device name are in ASCII format. Unused bytes should be nulled.

Default Device Name is “VIB1 ” for 1 axis or “VIB3 ” for 3 axis followed by 4 last digits of MAC address.

2.3.4 *Custom data service*

UUID	B614CD00-B14A-40A6-B63F-0166F7868E13

AVAILABLE CHARACTERISTICS

NAME	UUID	BYTES	READ / WRITE	NOTIFIED
Custom Advertisement Data	B614CD01-B14A-40A6-B63F-0166F7868E13	10	Read/Write	NO

Custom Advertisement Data is a 10 bytes field.
This characteristic allows to change the data sent in the CST field of the advertisement frame.

2.4 BATTERY

2.4.1 *SAFT LS17330*

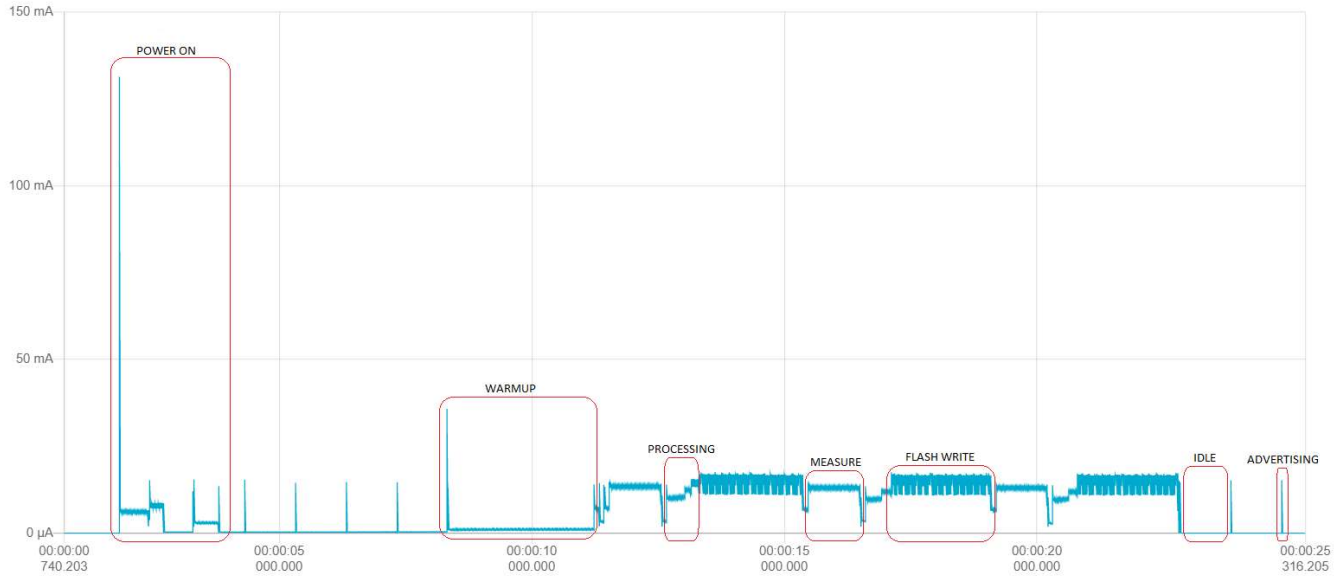
The 8911EX is delivered with a 3.6V battery.

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
Operating temperature range	- 60°C/+ 85°C

2.4.2 *Battery life*

Depending on customer settings (measurement interval) and how often BLE connection is done, the 8531JC battery life could go up to 10 years.

2.4.2.1 *Battery estimation algorithm*



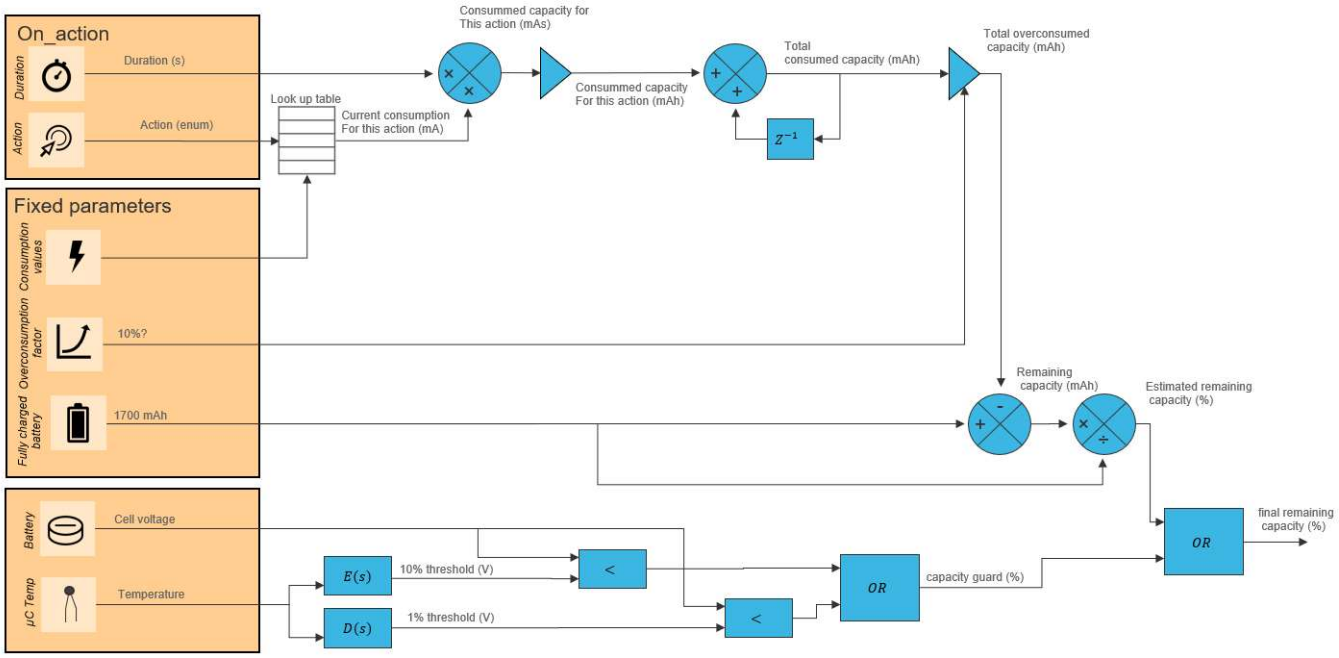
2.4.2.2 *High level Implementation*

Battery capacity baseline: 1.7Ah

Every action is transformed into an energy and subtract from the baseline.

The battery voltage is used to check 1% and 10% threshold to confirm the battery estimation. This threshold condition has the priority.

Action	Current consumption	Duration
Idle	3.1uA	991ms
Warm up	1.1mA	2917ms
Measurement @Fs=25.6kHz	12.9mA	1035ms
Measurement @Fs=18kHz	12.7mA	1027ms
Measurement @Fs=12.8kHz	11.7mA	1024ms
Measurement @Fs=5kHz	8.7mA	1008ms
Measurement @Fs=256Hz	6.9mA	1006ms
Processing @Fs=25.6kHz	8.8mA	499ms
Processing @Fs=18kHz	8.29mA	428ms
Processing @Fs=12.8kHz	7.4mA	316ms
Processing @Fs=5kHz	5.8mA	189ms
Processing @Fs=256Hz	3.4mA	109.84ms
BLE Advertisement	4.1mA	5.3ms
BLE Transmission @FS=25.6kHz	2.5mA	9391ms
BLE Transmission @FS=18kHz		6675ms
BLE Transmission @FS=12.8kHz		4863ms
BLE Transmission @FS=5kHz		1907ms
BLE Transmission @FS=256Hz		129ms



2.4.2.3 *Baseline values*

Properties

- Capacity based on 1700mAh (cap at 55°C)
- Capacity Consumed in mAh = mA * hour (float)
- Action inputs : action type and duration (float in s)
- Action type : Ble, WarmUp, Measure, Processing, BLE, IDLE, Reed switch

Actions

- *Reed switch*: BLE adv 40uA (every trig) 1 hour
- *Warmup*: no timing fixed to 3secs. 5mA.
- *Measurement*: based on Frequency Sampling. No timer fixed value 1/fs * (4096*1.02) (2% added). 11.3mA
- *Processing*: no timer, fixed time to 1.1 sec, 11.6mA
- *BLE advertisement*
- *BLE connection*
- *Idle: Duration =Measurement interval, Idle depends on ((Temp+Temp-1)/2)*

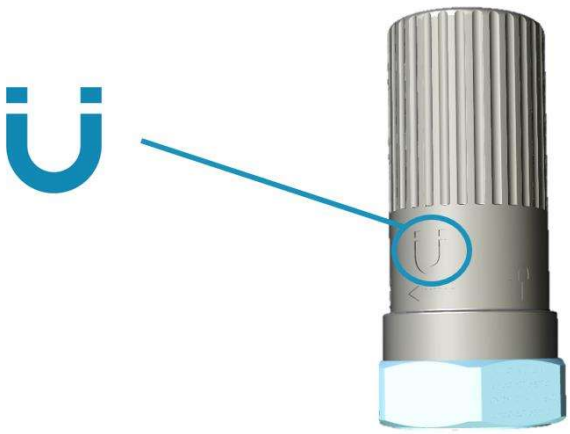
Guards

The battery voltage is used to confirm the battery estimation. If 10% or 1% is detected using the cell voltage and confirmed 5 consecutive times. The guard ignores the estimation and only relies on the cell voltage.

2.5 MAGNETIC SWITCH

The 8531JC owns an internal reed switch. This contactless button can be activated approaching a strong magnet at closed 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 trigs a new measurement.	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 going to initiate a sensor reset.
Resets the sensor.	Hold the magnet for 10 seconds.	Wait for at least 10 seconds, to see the very fast blink. Release the magnet once a very long orange led appears

3 DEVICE FIRMWARE UPDATE (DFU)

The device contains a bootloader. It can be flashed by OTA DFU (Over-The-Air Device-Firmware-Update) using Nordic tools.

4 Q&A

At startup, if the yellow led lit up for up to 4 minutes:

There is a case which occurs when the sensor is power cycle during the internal flash writing. In this case, the flash should be totally erased. Please wait that the led stop.

When the sensor is connected in BLE, no measurement will be done at each measurement interval. You should disconnect the sensor to have new measurements performed.

5 REGULATION

5.1 FCC

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

NOTE: The grantee is not responsible for any changes or modifications not expressly approved by the party responsible for compliance. Such modifications could void the user's authority to operate the equipment

5.2 IC

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference.

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1) L'appareil ne doit pas produire de brouillage;

2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.