# LPN Multisense

## User Guide (English)

August 2023

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# Versions

| Version | Date | Author | Details |
|---------|------|--------|---------|
| 1 | 17/09/2020 | Swisscom, mb | Initial version<br>**Valid for devices of the pre-release, with Firmware-version v01.xxx** |
| 2 | 02/11/2020 | Swisscom, mb | Minor firmware changes for the first productive series:<br>- Additional byte on port 100 for the choice of the transmission power level!<br>- Battery lifetime adapted for the highest power setting.<br>**Valid for devices of the release v02.xxx** |
| 2.1 | 16/02/2022 | Swisscom, mb | E-Mail and SMS alarms added |
| 3 | 31/08/2023 | Swisscom, dr | New structure, decoder |

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# 1. Product description

## 1.1. Scope of Delivery

The following parts are included in the box:

- LPN Multisense device, battery already included and not removable
- Wall holder (optional)
- Neodym magnet, for installation as described in the guide
- 2 strips of double-sided tape for the installation

## 1.2. Overview



LPN Multisense

Wall holder

Reed contact

Pushbutton

LED (green / red)
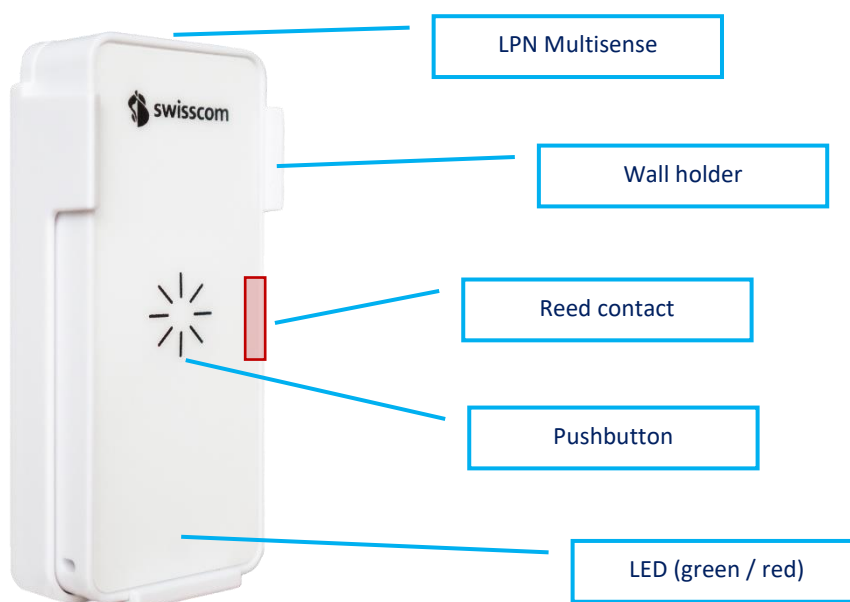
### 1.2.1 Start of operation

With the Data as a Service offering, your device is already provisioned out-of-the box. To start the device, you need to press the button for at least 3 seconds. The devices starts to join the network, which is indicated by short blink sequence in green. If the join was successful, the sequence will be followed by a long green blink. If the join failed, this will be indicated with a red blink.

With a button press of **3s or longer**, a **restart of the device** can be initiated at any time.

### 1.2.2 QR code definition

The QR code on the back follows the LoRa Alliance Technical Recommendation for LoRaWAN QR code onboarding (basic).

The QR code on the device contains 48 bytes of data as follows:

LW:D0:1122334455667788:AABBCCDDEEFF0011:AABB1122

The information in the example represent:

- JoinEUI of 11-22-33-44-55-66-77-88
- DevEUI of AA-BB-CC-DD-EE-FF-00-11
- ProfileID of AABB-1122
  - AABB: VendorID
  - 1122: VendorProfileID

## 1.3.    Pre-defined modes

Together with the Data as a Service starter-kit, we offer the following 5 pre-defined modes to cover most of the applications. Custom modes can be created using the payload description explained later on in this guide. We also program customer specific firmware on request.

If you don't use our Data as a Service offering, you can still configure those modes by sending the device-specific pin-code, followed by the mode payload marked in "**Downlink payload**" to the device on **Port 100**, for more information see 2.2.

**Update for firmware v02.xxx:** All battery lifetimes are estimated with the highest power setting.

### 1.3.1    Service Button (Default)

This mode will trigger a network-confirmed uplink message for each button press. If the button isn't pressed within 24 hours, the device will trigger a life sign message to report it is still working and under network coverage.

**Use-cases:** Customer satisfaction, service request, indication of problems, product order, doorbell, panic button, voting, etc…

**Button behavior:** Button presses will trigger a confirmed uplink message sequence, indicated by the LED as described below.

**LED behavior:** During the transmission of the message, the device will emit a short blinking sequence in green. A successful transmission will be indicated with a long green blink. An unsuccessful transmission will be indicated with a short red blinking sequence.

**Battery lifetime:** Depends on network coverage and typical number of button presses per day.

| Scenario | SF7 coverage | SF9 coverage | SF12 coverage |
|---|---|---|---|
| 1x button press per day | >10 years | >10 years | >10 years |
| 10x button presses per day | >10 years | >10 years | ~3.95 years |
| 200x button presses per day | ~5.22 years | ~1.89 years | ~0.25 years |

**Downlink payload:** [PINCODE]b8a710030000000080817f7f000000000000

## 1.3.2    Workplace occupancy

This mode will use the internal accelerometer to measure the occupation of a desk by the vibrations on that surface. The occupancy or usage of any other object could also be measured, however the configuration of this mode is matched for the workplace occupancy.

**Use-cases:** Flexible workspaces, KPI reporting, desk finder, employee satisfaction, maximum office occupancy supervision, etc…

**Button behavior:** The button is activated and will report button presses and extend the inactivity timer.

**LED behavior:** Only button presses and the restart procedure will be indicated on the LED.

**Standard timing:**

- 5min reaction time to a new desk occupation
- 30min interval during usage to check if the desk is still in use
- 1h inactivity timer to report that the workplace is not used any more.
  (This message is generated by the platform and not by the device!)

**Battery lifetime:** Depends on the network coverage and office activity.

| Scenario | SF7 coverage | SF9 coverage | SF12 coverage |
|---|---|---|---|
| 9h desk activity per day | >10 years | ~10 years | ~3.43 years |

**Downlink payload:** [PINCODE]082710030100050607


## 1.3.3    Temperature & Humidity monitoring

This mode reports the temperature and relative humidity of the sensor in regular intervals.

**Use-cases:** Indoor climate, energy optimization, smart building IoT retrofit, supply chain monitoring, logistics, etc…

**Button behavior:** Off

**LED behavior:** Off except restart procedure

**Sensor accuracy:** Typical accuracy of $\pm\,2\%$RH and $\pm\,0.3°$C, for more detailed information please refer to the Sensirion SHT31 datasheet.

**Standard timing:**

- 30min interval for temperature and humidity reporting

**Battery lifetime:** Depends on the network coverage, message timing and ambient temperature.

| Scenario | SF7 coverage | SF9 coverage | SF12 coverage |
|---|---|---|---|
| 30min interval @ 20°C | ~6.06 years | ~2.21 years | ~0.32 years |
| 30min interval @ 0°C | ~4.55 years | ~1.66 years | ~0.24 years |
| 30min interval @ -20°C | ~3.03 years | ~1.11 years | ~0.16 years |

**Downlink payload:** [PINCODE]0827100300001e0130007f7f000000000000

## 1.3.4 Reed / Door counter

This mode counts the number of times a magnet has approached the reed contact on the device. With a correct installation, this can be used to count door openings or other cycles of mobile parts.

**Use-cases:** Door cycles, predictive maintainance, monitoring moving parts, etc…

**Button behavior:** Off

**LED behavior:** Off except restart procedure

**Installation:** Check the position of the reed sensor in the overview picture (1.2), which is positioned in the middle of the right side, *on top* of the device. The magnet and the device need to be positioned on the door such that the distance between the reed and the magnet is around 2-3mm in closed state.
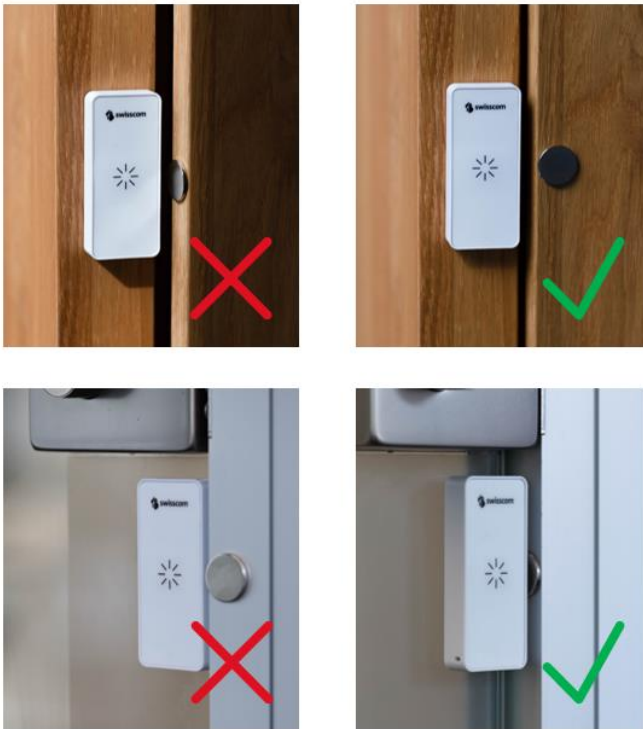
**Standard timing:**

- 1h interval for reed counter reports

**Battery lifetime:** Depends on the network coverage, message timing and ambient temperature.

| Scenario | SF7 coverage | SF9 coverage | SF12 coverage |
|---|---|---|---|
| Standard: 1h interval @ 20°C | >10 years | ~9.31 years | ~1.90 years |

**Downlink payload:** [PINCODE]0827100300003c0140a17f7f000000000000

**Test mode:** For a better experience during the installation, the mode *"Reed installation & test"* can be used. In this mode, each reed event will trigger a message and a LED signal.

**Attention:** For battery life considerations, the test mode must be deactivated immediately after the installation, as it can trigger a lot of messages and quickly drains the battery.

**Reed installation & test mode downlink payload:**

[PINCODE]08a7100300000001c0e17f7f000000000000

## 1.3.5 Vibration counter

This mode counts the number of times an acceleration is detected above the defined threshold, no matter the directionality.

**Use-Cases:** Predictive maintainance, object usage, motion detection, thief protection, etc…

**Button behavior:** Off

**LED behavior:** Off except restart procedure

**Standard timing:**

- 1h interval for vibration counter reports

**Accelerometer default threshold:** 160 mg

**Battery lifetime:** Depends on the network coverage, message timing and ambient temperature.

| Scenario | SF7 coverage | SF9 coverage | SF12 coverage |
|---|---|---|---|
| Standard: 1h interval @ 20°C | >10 years | ~6.80 years | ~1.47 years |

**Downlink payload:** [PINCODE]0827100300003c0108007f7f0000000a2000

## 1.3.6 Demo mode (all sensors on)

This mode is only for demo purpose and enables all sensors for an immediate feedback on the device while demonstrating. The demo mode is not intended for a productive use and might drain the battery quickly. After using the demo mode, please reset the device to a standard mode.

**Button behavior:** On, confirmed uplinks

**LED behavior:** On

**Standard timing:** 24 hours if no other event occurs

**Accelerometer default threshold:** 160mg on counter, 500mg on axis

**Accelerometer:** On (counter and immediate reporting on orientation change)

**Reed / magnet sensor:** On (counter and immediate reporting)

**Temperature / humidity**: On, transmitted only together with other events

**Workpace occupancy**: Off (the accelerometer is already used differently in this mode)

**Downlink payload:** [PINCODE]0880640300000001f8e17f7f0000000ae555

## 1.4.    LED behavior

| Blinking profiles | Meaning |
| --- | --- |
| GREEN 1x 1 second pulse | Device in NORMAL mode (Device active) |
| GREEN 2x 25 ms pulses | BUTTON action detected and BUTTON EVENT UL started. |
| GREEN 1x 25 ms pulse every second | When LoRaWAN activity carried out and LED on TxRx option ON |
| GREEN 1x 300 ms pulse | LoRaWAN activity carried out successfully (Joining, Tx/Rx) and LED on TxRx option ON |
| RED 1x 300 ms pulse | LoRaWAN activity failed (Joining, Tx/Rx) and LED on TxRx option ON |
| RED static ON | Startup test failed, ERROR HANDLER reached. |
| RED 2x 25 ms pulses | BUTTON action detected, but device is busy. BUTTON EVENT carried out as soon as possible. |

# 2. Payload specification

## 2.1. Custom configuration

The device can be set to any custom configuration using LoRaWAN Downlink commands on Port 100. The PIN-Code of each device is defined by the first 2 and last 2 bytes of the AppKey.

## 2.2. Payload Structure for Hardware-only mode

You will need the following payload structure, if you purchase Multisense as hardware-only. In this case, you can use the decoder in chapter 2.5 or write your own payload decoder.

Multisense supports Uplinks and Downlinks in the following LoRaWAN ports:

- PORT 3: APP Uplink
- PORT 100: CFG Uplink/Downlink
- PORT 101: INFO Uplink/Downlink
- PORT 102: REMOTE REJOIN Downlink

All Uplinks include the same exact "header".

**Firmware logics of mode 0 (OPEN SENSORS):** Basically, two things can be set: The uplink reason and the uplink data. Whenever an uplink is triggered due to the reasons set (motion, temperature alarm, etc.), an uplink will be sent containing the defined measurement data. This embedded logic allows for almost any use-case to be configured over the air.

## 2.3.    Uplink

### 2.3.1    Uplink Port 3 APP

The application data sent on LoRaWAN port 3 is structured as follows

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00 | Payload Version | UINT8 |
| 01 | Mode | UINT8<br>0 -> Normal Mode (OPEN SENSORS)<br>1 -> Workplace Detection Mode<br>(RFU, max. 255) |
| 02 | Status (depends on MODE and Uplink type) | Mode 0:<br>TIMED EVENT \| BUTTON EVENT \| REED EVENT \| TEMP EVENT \| HUM EVENT \| MOTION EVENT \| LIFE SIGN EVENT \| 0<br>TIMED EVENT: Event fired by measurement Interval<br>BUTTON EVENT: Event fired by Button<br>REED EVENT: Event fired by REED<br>TEMP EVENT: Event fired by MIN/MAX TEMP thresholds<br>HUM EVENT: Event fired by MIN/MAX HUM thresholds<br>MOTION EVENT: Event fired by DELTA AXIS thresholds<br>LIFE SIGN EVENT: Event fired only if no message has been sent in the last 24 hours<br>Mode 1:<br>USAGE START EVENT \| USAGE CHECK EVENT \| BUTTON EVENT \| LIFE SIGN EVENT \| 0 \| 0 \| 0 \| 0<br>USAGE START EVENT: Event fired when first motion was detected at workplace<br>USAGE CHECK EVENT: Event fired by inactivity multiplicator<br>BUTTON EVENT: Event fired by Button<br>LIFE SIGN EVENT: Event fired only if no message has been sent in the last 24 hours |
| 03 | Battery Voltage | UINT8<br>6mV steps, where 0 equals 2V or less. Max. Value @ 254 -> 3524mV. 0xFF if ERROR |
| 4 | Payload ID | UINT8, see chapter 2.3.2 for more details |
| 5 - X | Payload DATA | See chapter 2.3.2 for more details |
| X+1 - Y | Payload ID | UINT8, see chapter 2.3.2 for more details |
| Y+1 - Z | Payload DATA | See chapter 2.3.2 for more details |

## 2.3.2    Payload IDs

The payload ID defines length and type of data that is sent afterwards. Multiple data types can follow each other no matter the order, as described previously.

| Payload ID (HEX) | Function | Structure | Size in Bytes w/ ID |
|---|---|---|---|
| 01 | Temperature | - 2 Bytes: INT16 MSB First, 0.01°C steps. 0x7FFF if ERROR. | 3 |
| 02 | Humidity | - 1 Byte: UINT8 (0 to 200), 0.5% steps. 0xFF if ERROR. | 2 |
| 03 | REED Counter | - 2 Bytes: UINT16 MSB First, single steps. Overflow @ 65535. | 3 |
| 04 | MOTION Counter | - 2 Bytes: UINT16 MSB First, single steps. Overflow @ 65535. | 3 |
| 05 | Accelerometer | - 2 Bytes: ACC X-Axis<br>- 2 Bytes: ACC Y-Axis<br>- 2 Bytes: ACC Z-Axis<br>All ACC values are INT16 MSB First, 1 mg steps. 0x7FFF if ERROR. | 7 |
| 06 | Temperature History | - 2 Bytes: Temperature NOW<br>- 2 Bytes: Temperature NOW – 1* Measurement Interval<br>- 2 Bytes: Temperature NOW – 2* Measurement Interval<br>- 2 Bytes: Temperature NOW – 3* Measurement Interval<br>- 2 Bytes: Temperature NOW – 4* Measurement Interval<br>- 2 Bytes: Temperature NOW – 5* Measurement Interval<br>- 2 Bytes: Temperature NOW – 6* Measurement Interval<br>- 2 Bytes: Temperature NOW – 7* Measurement Interval<br>All Temperature values are INT16 MSB First, 0.01°C steps. 0x7FFF if ERROR, 0x7FFE if not used/empty.<br>**\* If History option activated, History ID is sent only on TIMED EVENTS** | 17 |
| 07 | Humidity History | - 1 Byte: Humidity NOW<br>- 1 Byte: Humidity NOW – 1* Measurement Interval<br>- 1 Byte: Humidity NOW – 2* Measurement Interval<br>- 1 Byte: Humidity NOW – 3* Measurement Interval<br>- 1 Byte: Humidity NOW – 4* Measurement Interval<br>- 1 Byte: Humidity NOW – 5* Measurement Interval<br>- 1 Byte: Humidity NOW – 6* Measurement Interval<br>- 1 Byte: Humidity NOW – 7* Measurement Interval<br>All Humidity values are UINT8 (0 to 200), 0.5% steps. 0xFF if ERROR, 0xFE if not used/empty.<br>**\* If History option activated, History ID is sent only on TIMED EVENTS** | 9 |

## 2.3.3    Uplink Port 3 payload examples

**UPLINK IDs ALL, NO HISTORY ACTIVE (RAW):**

000080A701090B0250030005040103050000FFFAFC17

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 80 | TIMED Event |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 01 | Payload ID 01 |
| 05-06 | 090B | Temperature: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 07 | 02 | Payload ID 02 |
| 08 | 50 | Humidity: 80 → 80 * 0.5% → 40.0 % |
| 09 | 03 | Payload ID 03 |
| 10-11 | 0005 | REED Counter: 5 |
| 12 | 04 | Payload ID 04 |
| 13-14 | 0103 | MOTION Counter: 259 |
| 15 | 05 | Payload ID 05 |
| 16-17 | 0000 | ACC X-Axis: 0 mg |
| 18-19 | FFFA | ACC Y-Axis: -6 mg |
| 20-21 | FC17 | ACC Z-Axis: -1001 mg |

**UPLINK IDs ALL, TEMP HISTORY ACTIVE (RAW):**

000080A702500300050401030500 00FFFAFC1706090B090B090B090B090B090B090B090B

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 80 | TIMED Event |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 01 | Payload ID 01 |
| 05-06 | 090B | Temperature: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 07 | 02 | Payload ID 02 |
| 08 | 50 | Humidity: 80 → 80 * 0.5% → 40.0 % |
| 09 | 03 | Payload ID 03 |
| 10-11 | 0005 | REED Counter: 5 |
| 12 | 04 | Payload ID 04 |
| 13-14 | 0103 | MOTION Counter: 259 |
| 15 | 05 | Payload ID 05 |
| 16-17 | 0000 | ACC X-Axis: 0 mg |
| 18-19 | FFFA | ACC Y-Axis: -6 mg |
| 20-21 | FC17 | ACC Z-Axis: -1001 mg |
| 22 | 06 | Payload ID 06 |
| 23-24 | 090B | Temp NOW – 0: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 25-26 | 090B | Temp NOW – 1: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 27-28 | 090B | Temp NOW – 2: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 29-30 | 090B | Temp NOW – 3: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 31-32 | 090B | Temp NOW – 4: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 33-34 | 090B | Temp NOW – 5: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 35-36 | 090B | Temp NOW – 6: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 37-38 | 090B | Temp NOW – 7: 2315 → 2315 * 0.01 °C → 23.15 °C |

**UPLINK IDs ALL, HUM HISTORY ACTIVE (RAW):**

000080A701090B030005040103050000FFFAFC17075050505050505050

| Byte-Nr | HEX | Meaning |
|---------|------|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 80 | TIMED Event |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 01 | Payload ID 01 |
| 05-06 | 090B | Temperature: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 07 | 02 | Payload ID 02 |
| 08 | 50 | Humidity: 80 → 80 * 0.5% → 40.0 % |
| 09 | 03 | Payload ID 03 |
| 10-11 | 0005 | REED Counter: 5 |
| 12 | 04 | Payload ID 04 |
| 13-14 | 0103 | MOTION Counter: 259 |
| 15 | 05 | Payload ID 05 |
| 16-17 | 0000 | ACC X-Axis: 0 mg |
| 18-19 | FFFA | ACC Y-Axis: -6 mg |
| 20-21 | FC17 | ACC Z-Axis: -1001 mg |
| 22 | 07 | Payload ID 07 |
| 23 | 50 | Humidity NOW – 0: 80 -> 80 * 0.5% -> 40.0 % |
| 24 | 50 | Humidity NOW – 1: 80 -> 80 * 0.5% -> 40.0 % |
| 25 | 50 | Humidity NOW – 2: 80 -> 80 * 0.5% -> 40.0 % |
| 26 | 50 | Humidity NOW – 3: 80 -> 80 * 0.5% -> 40.0 % |
| 27 | 50 | Humidity NOW – 4: 80 -> 80 * 0.5% -> 40.0 % |
| 28 | 50 | Humidity NOW – 5: 80 -> 80 * 0.5% -> 40.0 % |
| 29 | 50 | Humidity NOW – 6: 80 -> 80 * 0.5% -> 40.0 % |
| 30 | 50 | Humidity NOW – 7: 80 -> 80 * 0.5% -> 40.0 % |

## UPLINK IDs ALL, TEMP/HUM HISTORY ACTIVE (RAW):

000080A7030005040103050000FFFAFC1706090B090B090B090B090B090B090B090B075050505050505050

| Byte-Nr | HEX | Meaning |
|---------|------|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 80 | TIMED Event |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 01 | Payload ID 01 |
| 05-06 | 090B | Temperature: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 07 | 02 | Payload ID 02 |
| 08 | 50 | Humidity: 80 → 80 * 0.5% → 40.0 % |
| 09 | 03 | Payload ID 03 |
| 10-11 | 0005 | REED Counter: 5 |
| 12 | 04 | Payload ID 04 |
| 13-14 | 0103 | MOTION Counter: 259 |
| 15 | 05 | Payload ID 05 |
| 16-17 | 0000 | ACC X-Axis: 0 mg |
| 18-19 | FFFA | ACC Y-Axis: -6 mg |
| 20-21 | FC17 | ACC Z-Axis: -1001 mg |
| 22 | 06 | Payload ID 06 |
| 23-24 | 090B | Temp NOW – 0: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 25-26 | 090B | Temp NOW – 1: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 27-28 | 090B | Temp NOW – 2: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 29-30 | 090B | Temp NOW – 3: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 31-32 | 090B | Temp NOW – 4: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 33-34 | 090B | Temp NOW – 5: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 35-36 | 090B | Temp NOW – 6: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 37-38 | 090B | Temp NOW – 7: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 39 | 07 | Payload ID 07 |
| 40 | 50 | Humidity NOW – 0: 80 -> 80 * 0.5% -> 40.0 % |
| 41 | 50 | Humidity NOW – 1: 80 -> 80 * 0.5% -> 40.0 % |
| 42 | 50 | Humidity NOW – 2: 80 -> 80 * 0.5% -> 40.0 % |
| 43 | 50 | Humidity NOW – 3: 80 -> 80 * 0.5% -> 40.0 % |
| 44 | 50 | Humidity NOW – 4: 80 -> 80 * 0.5% -> 40.0 % |

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 45 | 50 | Humidity NOW – 5: 80 -> 80 * 0.5% -> 40.0 % |
| 46 | 50 | Humidity NOW – 6: 80 -> 80 * 0.5% -> 40.0 % |
| 47 | 50 | Humidity NOW – 7: 80 -> 80 * 0.5% -> 40.0 % |

**UPLINK IDs 01, 04 (RAW):** 000020A701090B040103

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 20 | REED EVENT |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 01 | Payload ID 01 |
| 05-06 | 090B | Temperature: 2315 → 2315 * 0.01 °C → 23.15 °C |
| 07 | 02 | Payload ID 02 |
| 08 | 50 | Humidity: 80 → 80 * 0.5% → 40.0 % |
| 09 | 03 | Payload ID 03 |
| 10-11 | 0005 | REED Counter: 5 |
| 12 | 04 | Payload ID 04 |
| 13-14 | 0103 | MOTION Counter: 259 |

**UPLINK IDs NONE (EVENT ONLY) (RAW):** 000040A7

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 40 | BUTTON EVENT |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |

## 2.3.4 Uplink Port 100 active configuration

This message is usually sent after a join or mode change, to report the currently configured parameters.

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00 | Payload Version | UINT8 |
| 01 | Mode | UINT8<br>0 -> Normal Mode (OPEN SENSORS)<br>1 -> Workplace Detection Mode<br>(RFU, max. 255) |
| 02 | Status (depends on MODE and Uplink type) | DEFAULT:<br>STARTUP EVENT \| GET EVENT \| SET EVENT \| 0 \| 0 \| 0 \| 0 \| 0<br>STARTUP EVENT: CFG sent at startup (mode switches are also taken as startup into account)<br>GET EVENT: CFG sent as a response of a GET CFG request<br>SET EVENT: CFG sent as a response of a SET CFG request |
| 03 | Battery Voltage | UINT8<br>6mV steps, where 0 equals 2V or less. Max. Value @ 254 -> 3524mV. 0xFF if ERROR |
| 04-07 | DEV CFG LoRa | BYTE 4:<br>Bit 7: CONFIRMED/UNCONFIRMED (1 for confirmed, 0 for unconfirmed uplinks, not valid for TIMED EVENTS, TIMED EVENTS are always sent unconfirmed)<br>Bits 6-4: CONFIRMED Tries (0 to 7, where 0 equals 1 try, 1 equals 2 tries and so on, max. Tries 8)<br>Bit 3: ADR ON/OFF (1 for ON, 0 for off)<br>Bits 2-0: Datarate when ADR OFF (0 to 5, where 0 equals SF12, 1 equals SF11 and so on, max. Datarate SF7)<br>BYTES 5-6:<br>Bit 15: LEDOnTxRx (1 LEDs are used to signalize ongoing and finished TXRX, 0 LEDs not used for TXRX signalization)<br>Bit 14: RFU<br>Bits 13-0: Rejoining Trigger, number of uplinks needed to fire a rejoin on next uplink. 0 for no automatic Rejoin function, max. 16384 (14 bits, MSB first)<br>BYTE 7:<br>Bits 7-2: RFU<br>Bits 1-0: RF POWER LEVEL (1 to 3, where 1 equals LOW POWER, 2 equals MEDIUM POWER and 3 equals HIGH POWER) |
| 08 | MODE SELECTOR | UINT8, see chapter 2.3.1 for more details |
| 09-X | DOWNLINK MODE | See chapter 2.3.1 for more details |

## 2.3.5 Uplink Port 100 active configuration examples

**UPLINK CFG MODE 0 (RAW):** 000080A70827100300000F01F8A17F7FFFFF00066000

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 80 | STARTUP EVENT |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 08 | UNCONFIRMED Uplinks, CONFIRMED Tries 1 (DON'T CARE), ADR ON, default DR 0 (SF12, DON'T CARE) |
| 05-06 | 2710 | Rejoining Trigger → 10000 counts |
| 07 | 03 | TX Power level HIGH |
| 08 | 00 | MODE 0 |
| 09-10 | 000F | Measurement Interval → 15 minutes |
| 11 | 01 | TX/RX Trigger → 1 |
| 12 | F8 | ACTIVE SENSORS → BUTTON ON, REED ON, TEMP ON, HUM ON, MOTION ON |
| 13 | A1 | REED Options [DON'T CARE, OFF]: Detection RISING, REED Event OFF, REED Counter ON, REED Debounce 100ms |
| 14-15 | 7F7F | TEMPERATURE Options: TEMP HIGH Thres → 127 → OFF, TEMP LOW Thres → 127 → OFF |
| 16-17 | FFFF | HUMIDITY Options: HUM HIGH Thres → 255 → OFF, HUM LOW Thres → 255 → OFF |
| 18 | 00 | TEMPERATURE/HUMIDITY History Options: TEMP History OFF, HUM History OFF |
| 19-21 | 066000 | MOTION Options: MOTION Thres. → 6 → 6 * 16 mg → 96mg<br><br>MOTION Event OFF, MOTION TX RAW ON, MOTION COUNTER ON<br><br>DELTA X AXIS OFF, DELTA Y AXIS OFF, DELTA Z AXIS OFF |

**UPLINK CFG MODE 0, BUTTON ONLY (RAW):** 000080A7082710030000000080A17F7FFFFF00066000

| Byte-Nr | HEX | Meaning |
|---|---|---|
| 00 | 00 | Payload Version |
| 01 | 00 | MODE 0 |
| 02 | 80 | STARTUP EVENT |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 08 | UNCONFIRMED Uplinks, CONFIRMED Tries 1 (DON'T CARE), ADR ON, default DR 0 (SF12, DON'T CARE) |
| 05-06 | 2710 | Rejoining Trigger → 10000 counts |
| 07 | 03 | TX Power level HIGH |
| 08 | 00 | MODE 0 |
| 09-10 | 0000 | Measurement Interval → 0 minutes, no interval |
| 11 | 00 | TX/RX Trigger → 0, no TIMED EVENT |
| 12 | 80 | ACTIVE SENSORS → BUTTON ON, REED OFF, TEMP OFF, HUM OFF, MOTION OFF |
| 13 | A1 | REED Options [DON'T CARE, OFF]: Detection RISING, REED Event OFF, REED Counter ON, REED Debounce 100ms |
| 14-15 | 7F7F | TEMPERATURE Options: TEMP HIGH Thres → 127 → OFF, TEMP LOW Thres → 127 → OFF |
| 16-17 | FFFF | HUMIDITY Options: HUM HIGH Thres → 255 → OFF, HUM LOW Thres → 255 → OFF |
| 18 | 00 | TEMPERATURE/HUMIDITY History Options: TEMP History OFF, HUM History OFF |
| 19-21 | 066000 | MOTION Options: MOTION Thres. → 6 → 6 * 16 mg → 96mg  MOTION Event OFF, MOTION TX RAW ON, MOTION COUNTER ON  DELTA X AXIS OFF, DELTA Y AXIS OFF, DELTA Z AXIS OFF |

**UPLINK CFG MODE 1 (RAW):** 000180A70827100301000A0C06

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 00 | Payload Version |
| 01 | 01 | MODE 1 |
| 02 | 80 | STARTUP EVENT |
| 03 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 04 | 08 | UNCONFIRMED Uplinks, CONFIRMED Tries 1 (DON'T CARE), ADR ON, default DR 0 (SF12, DON'T CARE) |
| 05-06 | 2710 | Rejoining Trigger → 10000 counts |
| 07 | 03 | TX Power level HIGH |
| 08 | 01 | MODE 1 |
| 09-10 | 000A | Measurement Interval → 10 minutes |
| 11 | 0C | Motion Check Multiplicator: 12 → 12 * 10 minutes → 120 minutes |
| 12 | 06 | MOTION Options: MOTION Thres → 6 → 6 * 16 mg → 96mg |

## 2.3.6　Uplink Port 101 INFO

Getting the device info is useful to calculate a correct, temperature compensated battery level.

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00 | Payload Version | UINT8 |
| 01 | Mode | UINT8<br>0 -> Normal Mode (OPEN SENSORS)<br>1 -> Workplace Detection Mode<br>(RFU, max. 255) |
| 02 | Status (depends on MODE and Uplink type) | DEFAULT:<br>STARTUP EVENT \| GET EVENT \| 0 \| 0 \| 0 \| 0 \| 0<br>STARTUP EVENT: INFO sent at device startup<br>GET EVENT: INFO sent as a response of a GET INFO request |
| 03 | Battery Voltage | UINT8<br>6mV steps, where 0 equals 2V or less. Max. Value @ 254 -> 3524mV. 0xFF if ERROR<br>Example: |
| 04 | APP Main Version | UINT8 |
| 05 | APP Minor Version | UINT8 |
| 06-07 | Temperature | INT16 MSB First, 0.01°C steps. 0x7FFF if ERROR. |

## 2.3.7    Uplink Port 101 INFO examples

**Device INFO (RAW):** 000040A70000090B

| Byte-Nr | HEX | Meaning |
|---|---|---|
| 01 | 00 | Payload Version |
| 02 | 00 | MODE 0 |
| 03 | 40 | GET EVENT |
| 04 | A7 | Battery Voltage: 167 → 2000mV + 167 * 6 mV → 3002 mV |
| 05 | 00 | APP Main Version 00 |
| 06 | 00 | APP Minor Version 00 |
| 07-08 | 090B | Temperature: 2315 -> 2315 * 0.01 °C -> 23.15 °C |

## 2.4. Downlink

### 2.4.1 Downlink MODEs

The available modes for configuration are described here. For the according downlink message, check the following chapter.

| DOWNLINK MODE (HEX) | Function | Structure | Size in Bytes w/ MODE |
|---|---|---|---|
| 00 | Normal Mode (OPEN SENSORS) | - 2 Bytes: Measurement Interval<br><br>(UINT16) Measurement Interval in minutes (0 for no interval)<br><br>- 1 Byte: TX/RX Trigger<br><br>(UINT8) Multiple of measurement interval on which a TIMED EVENT uplink will be fired (0 for no TIMED EVENT uplink)<br><br>- 1 Byte: ACTIVE SENSORS<br><br>Bit 7: BUTTON ON/OFF (1 if ON [which also turns on its event], 0 if OFF)<br><br>Bit 6: REED ON/OFF (1 for ON, 0 for OFF)<br><br>Bit 5: TEMPERATURE ON/OFF (1 for ON, 0 for OFF)<br><br>Bit 4: HUMIDITY ON/OFF (1 for ON, 0 for OFF)<br><br>Bit 3: MOTION ON/OFF (1 for ON, 0 for OFF)<br><br>Bits 2-0: RFU<br><br>- 1 Byte: REED Options<br><br>Bit 7: REED DETECTION RISING/FALLING (1 for RISING, 0 for FALLING)<br><br>Bit 6: REED EVENT ON/OFF (1 for ON, 0 for OFF)<br><br>Bit 5: REED COUNTER ON/OFF (1 for ON, 0 for OFF)<br><br>Bits 4-0: REED Debounce time (0 to 31, in 100ms steps)<br><br>- 2 Bytes: TEMPERATURE Options<br><br>MSB Byte: (INT8) TEMP HIGH EVENT Threshold in °C, where 0x7F means OFF<br><br>LSB Byte: (INT8) TEMP LOW EVENT Threshold in °C, where 0x7F means OFF<br><br>- 2 Bytes: HUMIDITY Options<br><br>MSB Byte: (UINT8) HUM HIGH EVENT Threshold in %, max. Value 99%, min. Value 1%. Any value outside range means OFF.<br><br>LSB Byte: HUM LOW EVENT Threshold in %, max. Value 99%, min. Value 1%. Any value outside range means OFF.<br><br>- 1 Byte: TEMPERATURE/HUMIDITY History Options<br><br>Bits 2-7: RFU<br><br>Bit 1: HUMIDITY History ON/OFF | 14 |

| | | | |
|---|---|---|---|
| | | Bit 0: TEMPERATURE History ON/OFF | |
| | | - 3 Bytes: MOTION Options | |
| | | MSB Byte: (UINT8) MOTION Threshold in 16 mg steps, max. Value 2000 mg (125), 0 for OFF. | |
| | | NEXT Byte: | |
| | | Bit 7: MOTION EVENT ON/OFF | |
| | | Bit 6: MOTION TX RAW ON/OFF | |
| | | Bit 5: MOTION COUNTER ON/OFF | |
| | | Bit 4: RFU | |
| | | Bits 3-0: DELTA X AXIS EVENT Threshold in 100mg steps, 0 for OFF | |
| | | LSB Byte: | |
| | | Bits 7-4: DELTA Y AXIS EVENT Threshold in 100mg steps, 0 for OFF | |
| | | Bits 3-0: DELTA Z AXIS EVENT Threshold in 100mg steps, 0 for OFF | |
| 01 | Workplace Detection Mode | - 2 Bytes: Measurement Interval<br>(UINT16) Measurement Interval in minutes (0 for no interval), acts also as USAGE START EVENT trigger when needed.<br>- 1 Byte: Motion Check Multiplicator<br>(UINT8) Multiple of measurement interval on which a USAGE CHECK EVENT is carried out when needed.<br>- 1 Byte: MOTION Options<br>(UINT8) MOTION Threshold in 16 mg steps, max. Value 2000 mg (125), 0 for OFF. | 5 |

## 2.4.2 Downlink Port 100 configuration

This message structure will be used to configure the device, based on the downlink modes described in 2.4.1. Two different payload structures are supported depending on the PL size. If payload size > 1, then the downlink sent must have a SET CFG structure. Whereas if the payload size = 1, then the downlink sent must have a GET CFG structure.

**SET CFG STRUCTURE**

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00-03 | DEV PIN CODE | First 2 and last 2 bytes of device's AppKEY |
| 04-07 | DEV CFG LoRa | BYTE 4: <br> Bit 7: CONFIRMED/UNCONFIRMED (1 for confirmed, 0 for unconfirmed uplinks, not valid for TIMED EVENTS, TIMED EVENTS are always sent unconfirmed) <br> Bits 6-4: CONFIRMED Tries (0 to 7, where 0 equals 1 try, 1 equals 2 tries and so on, max. Tries 8) <br> Bit 3: ADR ON/OFF (1 for ON, 0 for off) <br> Bits 2-0: Datarate when ADR OFF (0 to 5, where 0 equals SF12, 1 equals SF11 and so on, max. Datarate SF7) <br> BYTES 5-6: <br> Bit 15: LEDOnTxRx (1 LEDs are used to signalize ongoing and finished TXRX, 0 LEDs not used for TXRX signalization) <br> Bit 14: RFU <br> Bits 13-0: Rejoining Trigger, number of uplinks needed to fire a rejoin on next uplink. 0 for no automatic Rejoin function, max. 16384 (14 bits, MSB first) <br> BYTE 7: <br> Bits 7-2: RFU <br> Bits 1-0: RF POWER LEVEL (1 to 3, where 1 equals LOW POWER, 2 equals MEDIUM POWER and 3 equals HIGH POWER) |
| 08 | MODE SELECTOR | UINT8, see chapter 2.4.1 for more details |
| 09-X | DOWNLINK MODE | See chapter 2.4.1 for more details |

**Note that changes in the settings will not take effect until the next uplink (due to Class A, RX only after TX).**

**GET CFG STRUCTURE**

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00 | GET CFG | VALUE MUST BE TRUE -> any value != 0x00 |

**Note that changes in the settings will not take effect until the next uplink (due to Class A, RX only after TX).**

## 2.4.3  Downlink Port 100 configuration examples

**SET CFG MODE 0 (RAW):** 0A3412FE0827100300000F01F8A17F7FFFFF00066000

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00-03 | 0A3412FE | DEV Pin Code: must match internal device pin code (First 2 and last 2 bytes of appKEY) |
| 04-07 | 08271003 | LoRa CFG:<br>UNCONFIRMED Uplinks, CONFIRMED Tries 1 (DON'T CARE), ADR ON, default DR 0 (SF12, DON'T CARE)<br>Rejoining Trigger → 10000 counts<br>TX Power level HIGH |
| 08 | 00 | MODE 0 |
| 09-10 | 000F | Measurement Interval → 15 minutes |
| 11 | 01 | TX/RX Trigger → 1 |
| 12 | F8 | ACTIVE SENSORS → BUTTON ON, REED ON, TEMP ON, HUM ON, MOTION ON |
| 13 | A1 | REED Options → Detection RISING, REED Event OFF, REED Counter ON, REED Debounce 100ms |
| 14-15 | 7F7F | TEMPERATURE Options:<br>TEMP HIGH Thres → 127 → OFF<br>TEMP LOW Thres → 127 → OFF |
| 16-17 | FFFF | HUMIDITY Options:<br>HUM HIGH Thres → 255 → OFF<br>HUM LOW Thres → 255 → OFF |
| 18 | 00 | TEMPERATURE/HUMIDITY History Options:<br>TEMP History OFF, HUM History OFF |
| 19-21 | 066000 | MOTION Options:<br>MOTION Thres. → 6 → 6 * 16 mg → 96mg<br>MOTION Event OFF, MOTION TX RAW ON, MOTION COUNTER ON<br>DELTA X AXIS OFF, DELTA Y AXIS OFF, DELTA Z AXIS OFF |

**SET CFG MODE 1 (RAW):** 0A3412FE0827100301000A0C06

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00-03 | 0A3412FE | DEV Pin Code: must match internal device pin code (First 2 and last 2 bytes of appKEY) |
| 04-07 | 08271003 | LoRa CFG:<br>UNCONFIRMED Uplinks, CONFIRMED Tries 1 (DON'T CARE), ADR ON, default DR 0 (SF12, DON'T CARE)<br>Rejoining Trigger → 10000 counts<br>TX Power level HIGH |
| 08 | 01 | MODE 1 |
| 09-10 | 000A | Measurement Interval → 10 minutes |
| 11 | 0C | Motion Check Multiplicator:<br>12 → 12 * 10 minutes → 120 minutes |

**GET CFG (RAW):** 01

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 01 | Get CFG TRUE |

## 2.4.4    Downlink Port 101 INFO

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00 | GET DEVICE INFO | VALUE MUST BE TRUE → any value != 0x00 |

**Note that changes in the settings will not take effect until the next uplink (due to Class A, RX only after TX).**

## 2.4.5    Downlink Port 101 INFO examples

**Get Device INFO (RAW):** 01

| Byte-Nr | HEX | Meaning |
|---------|-----|---------|
| 00 | 01 | GET DEVICE INFO TRUE |

## 2.4.6    Downlink Port 102 remote rejoin

Some special cases (account migration, debugging, device relocation with ADR on) might require your device to restart and rejoin.

| Byte Nr | Function | Remarks |
|---------|----------|---------|
| 00 | REJOIN SET | VALUE MUST BE TRUE -> any value != 0x00 |

**Note that changes in the settings will not take effect until the next uplink (due to Class A, RX only after TX).**

### 2.4.7    Downlink Port 102 example

**REMOTE REJOIN (RAW):** 01

| Byte Nr | HEX | Remarks |
|---------|-----|---------|
| 00      | 01  | REJOIN SET TRUE |

**Note that changes in the settings will not take effect until the next uplink (due to Class A, RX only after TX).**

## 2.5.    Payload decoder

JavaScript payload decoder can be downloaded here.

# 3. Introduction to LoRaWAN coverage

Here is a very quick guidance to understand how the network coverage of the sensors works with the Swisscom LPN network (LoRaWAN). More detailed information can be obtained by contacting Support.LPN@swisscom.com or by visiting our LoRaWAN bootcamp, for example.

The main advantages of the LoRaWAN technology in this context are:

- **Easy onboarding:** Wherever the device is activated, it connects to the same network. No complicated on-site pairing or configuration process is needed.

- **Good penetration:** Compared to IoT technologies like BLE and Zigbee, the penetration in the building is much better, which is due to the sensitivity of the LoRa modulation.

- **Flexible coverage:** The Swisscom LPN network already covers 97% of the Swiss population. This includes light indoor coverage in most urban areas. However you can easily improve the coverage by using our plug-and-play indoor gateway. This will improve the battery lifetime of your devices, and it can generate coverage in difficult circumstances (building with thick walls, basements, …)

## 3.1. Outdoor coverage

A detailed coverage map for Google Earth can be downloaded here: You can install the overlay in Google Earth Pro, and you will see 3 colors to estimate the coverage in different regions. Another option to check coverage is via https://iot-maps.swisscom.com

**Important**: Every building is different. Therefore we cannot make a statement for indoor coverage. Also please note that this is only a model and some deviations might occur. Before a productive installation, the coverage should be measured on-site (see 3.4).
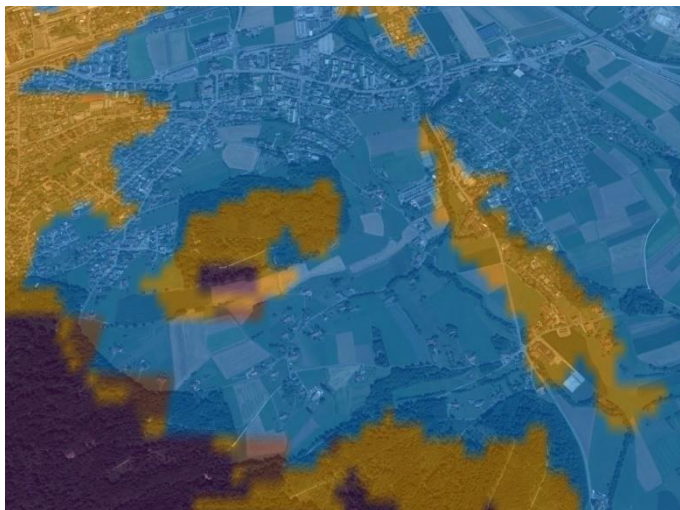


**Blue (125 dBm pathloss)**
The outdoor coverage is good and will also penetrate 1-2 walls if the building is not shielded too much.

**Orange (135 dBm pathloss)**
This is still a good outdoor coverage and might also reach indoor installations.

**Purple (141 dBm pathloss)**
Outdoor coverage is available, but indoors will be difficult.

## 3.2.    Indoor gateways

Wherever the coverage needs to be extended, we offer a plug-and-play indoor gateway. It connects to our Network Server over 4G, the SIM-card is already included. Therefore you just need to plug it in and place it somewhere in your building where Swisscom 4G coverage is available. Usually one gateway covers multiple floors and only a few gateways are needed, even for a large office building.

## 3.3.    Battery lifetime of the device

In the pre-defined mode descriptions (1.3), you will find battery lifetime indications based on the LoRaWAN Spreading Factor (SF). Spreading factors from SF7 to SF12 are available, where SF7 offers the best battery lifetime and SF12 the best sensitivity (distance and building penetration).

Multisense uses the LoRaWAN Adaptive Data Rate algorithm and automatically adapts the SF according to the network coverage. If you see SF7 values in your data, you have probably installed an indoor gateway or your device is placed close to an outdoor gateway. If you see values like SF11 or SF12, the device will still work, but the battery lifetime is impacted.

The decision to install an indoor gateway or not, will probably depend on the number of devices installed in a certain place. In a smart office context, hundreds or thousands of devices are installed in the same building. Installing an indoor gateway to get 10 years of battery life will be probably the most cost-effective option.

When only few sensors are installed in a building, it might be better to use a different method to fine-tune the battery life (e.g. sending data less frequently).

## 3.4.    Field test device



To measure the coverage in the field before or during installation, this Field Test Device is available for purchase. It costs CHF 250.- including lifetime connectivity and can be ordered from IoT.SPOC@swisscom.com.