# PULSE COUNTER DEVICES

DATASHEET

## Revision history

| Revision | Author | Date | Approved by | Changes |
|---|---|---|---|---|
| **R1** | T.P. | 09.2022. | | First release |
| **R2** | T.P. | 04.2023 | | Updated tamper byte with input states |
| **R3** | M.J. | 05.2023. | | Added more downlinks and alarm message |
| **R4** | D.Z. | 11.2024. | | Added timestamp to alarm message; Update w.r.t. v2.0.0. Grammar check. |
| **R5** | M.V. | 05.2026. | | Downlinks Updated |

## Firmware Versions Supported by this Datasheet

- **3.x.x**

# Contents

1 Summary ....4
2 Copyright & Disclaimer ....4
3 Product variants and options ....5
4 Mechanical & mouting....6
5 Technical characteristics....8
6 Device operation ....9
6.1 Principle ....9
6.2 Startup....9
6.3 Activation....9
6.4 Impulse counting ....9
6.5 Tamper detection ....10
6.6 Uplink message sending ....10
6.7 Device configuration....11
6.8 Temperature measurement ....11
6.9 Battery monitoring ....11
6.10 Alarms....12
6.11 Communication....12
7 Input connection....12
7.1 Potted and non-potted version....13
8 Message format ....14
8.1 Downlink message ....14
8.1.1 M – Message interval configuration....15
8.1.2 Y – Pulse reading period ....15
8.1.3 R – Reset....15
8.1.4 T – UNIX time (uint32)....16
8.1.5 S – Time of the day for uplink message sending (uint16)....16
8.1.6 m – Send Randomizer Interval....16
8.1.7 C – Reset impulse counter to 0 (uint16)....16
8.1.8 V – Set Initial State ....16
8.1.9 F – Set k-factor ....17
8.1.10 I – Tamper ban interval (uint32) ....17
8.1.11 B – Burst Alarm parameters ....17
8.1.12 L – Leak Alarm parameters ....17

8.1.13 U – Input configuration ....18
8.1.14 u – Update Enable ....18
8.1.15 X – Factory reset (*uint16*) ....18
8.1.16 A – Period for requesting ACK response from server (uint32) ....18
8.1.17 D – LoRa Data Rate ....18
8.1.18 W – Set server IP address (see Note 1) ....19
8.1.19 D – Set server URL (see Note 1) ....19
8.1.20 P – Set server port (see Note 1) ....19
8.1.21 O – Set network operator ....19
8.1.22 G – Set network operator APN ....20
8.1.23 K – Select device sleep mode ....20
8.2 Uplink message ....21
8.2.1 START message ....21
8.2.2 Regular message ....23
8.2.3 Tamper message ....26
8.2.4 ALARM message ....29
9 Battery endurance ....30
10 Regulatory compliance ....31
11 Environmental ....32

# 1 Summary

Document contains technical characteristics of pulse counting devices designed and manufactured by X-LOGIC. Devices with LoRaWAN, Sigfox and NB-IoT interfaces with available options are covered in this document.

# 2 Copyright & Disclaimer

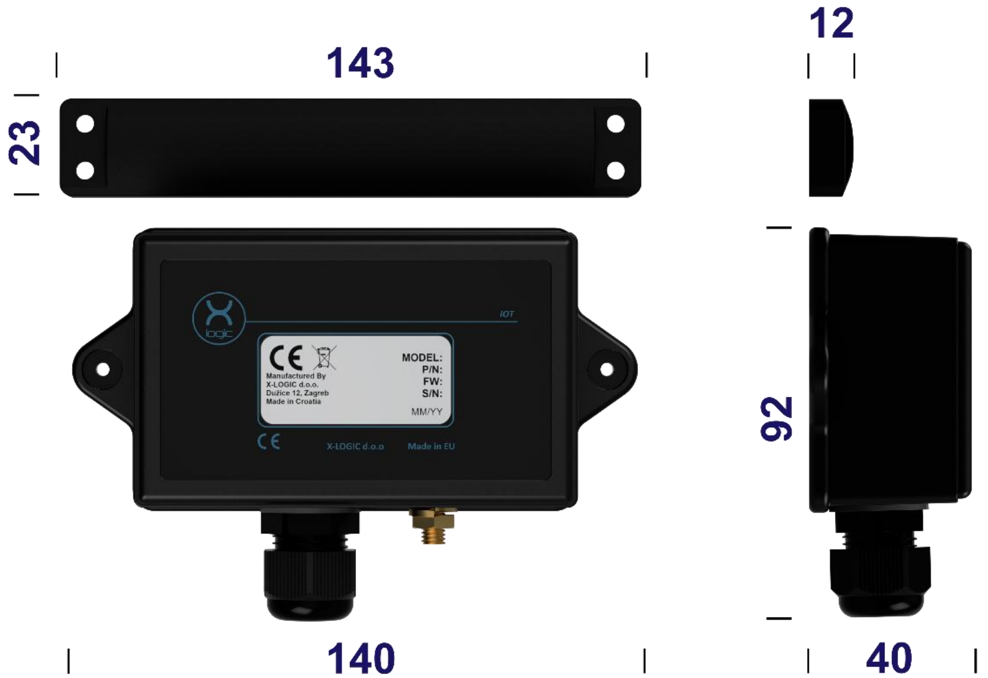
## 3 Product variants and options

<table>
<tr><th>PRODUCT TYPE</th><th>COMMUNICATION</th><th>INPUTS</th><th>POTTING</th><th>MOVEMENT TAMPER</th><th>INTERNAL TEMP. SENSOR</th></tr>
<tr><td rowspan="3">PC – PULSE COUNTER</td><td>LR - LoRaWAN</td><td rowspan="3">22 –two inputs for independent impulse counting, 2 tamper inputs<br><br>40 - four inputs for independent impulse counting, 0 tamper inputs<br><br>42 – four inputs for independent impulse counting, 2 tamper inputs<br><br>24 – two inputs for independent impulse counting, 4 tamper inputs<br><br>xx – configurable inputs</td><td rowspan="2">P – potted, completely sealed electronics for applications in wet or moist environments. Non-removable battery and antenna.<br><br>IP54 – not sealed. For applications in dry environment. Removable battery and antenna.</td><td rowspan="3">MVY – accelerometer chip included<br><br>MVN – accelerometer chip NOT included</td><td rowspan="3">TY – temp sensor included<br><br>TN – temp sensor not included</td></tr>
<tr><td>SF – Sigfox</td></tr>
<tr><td>NB – NB-IoT</td><td>IP68 - For applications in moist environment. Removable battery and antenna.</td></tr>
</table>

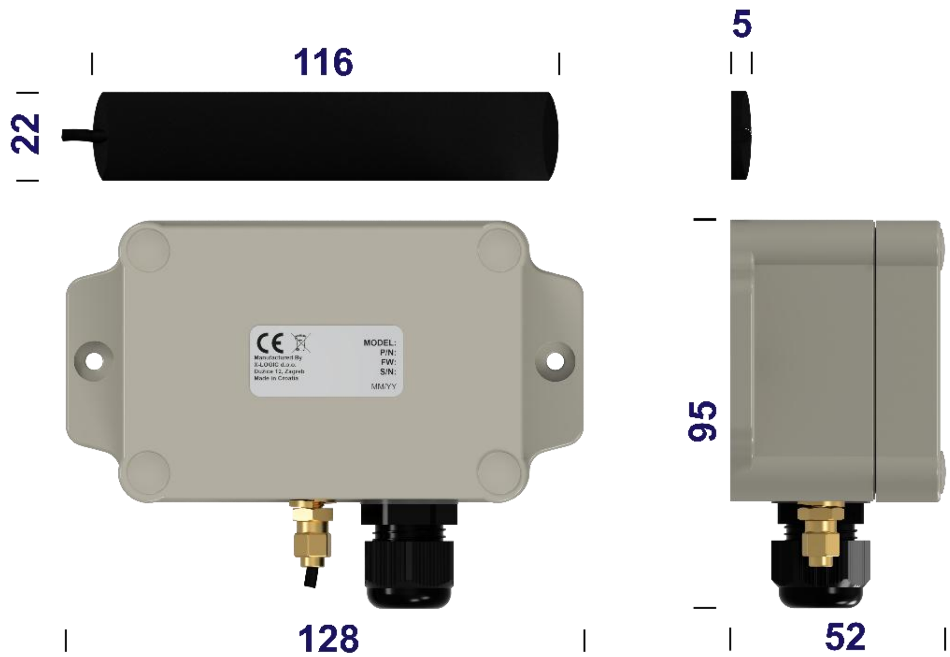
**Example:**
PC-LR-1-40-P-MVY-TY represents pulse counter with *LoRaWAN* communication, 4 pulse input and 0 tamper inputs (switch inputs), potted electronics and with accelerometer and temperature sensor on board.

# 4 Mechanical & mouting

**LoRaWAN and Sigfox devices (in mm):**




**NB-IoT device(in mm):**




Devices are intended for wall mounting using integrated mounting flanges. Provided antenna is sealed and can be used in a moist environment. Antenna can be attached to a wall. Attention must be given to ensuring proper RF signal level for the antenna. Provided antenna is good performing, but some common applications still present a very low signal environment for the antenna and limit or disable message sending.
Common example is using antenna inside a reinforced concrete utility access hole with metal lid. This environment strongly blocks RF transmission.

In such cases, it is necessary to extract antenna from this environment, i.e., through a drilled hole position the antenna close to the surface of the hatch.

Recommended antenna positioning is on the earth surface, with line of sight to the gateway/base station, covered with a compound that allows for RF transmission, i.e., PU, acrylic, silicone, some rubbery compounds.

# 5 Technical characteristics

| GENERAL PROPERTIES | |
|---|---|
| **Battery** | LoRaWAN and Sigfox version – 3.6V Li battery from a high-quality manufacturer, with standard dimensions. Replaceable, using battery holders.<br>NB-IoT version – 3.6V Li high-current battery from a high-quality manufacturer, size D, replaceable. |
| **Operating temperature** | -30°C to +70°C |
| **Operating environment**<br>*Water & humidity* | IP54 variants are suitable only for dry environment<br>Potted and IP68 variants are suitable for moist environment.<br>Only potted variants provide robust long-term protection against high humidity and temperature cycling. |
| **Input protection** | ESD diode and RC filter on all inputs |
| **Input type** | Voltage free – Contact input, max. voltage generated from the pulse counter device on the input is 3.65V through pull-up resistor |
| **Maximum resistance of pulse generator** | 1kOhm |
| **Minimum impulse times** | 10ms on – 10ms off |
| **Battery endurance** | Designed for over 10 years with 1 message per day, depends on various factors. Consult table in this document or contact X-LOGIC support for detailed calculations. |
| **Battery replacement** | Possible on all non-potted variants.<br>LoRaWAN and Sigfox variant - Battery holders are used<br>NB-IoT – Possible replacement |
| **Impulse counter backup** | The pulse count is periodically stored in a section of working memory, with the ability to retain the last 96 records (the most recent data is stored).<br>Before each message is sent, the current pulse count is saved to the internal EEPROM (non-volatile memory) and is continuously stored in a section of working memory that is not erased during a device reset, provided that the power supply (battery) remains connected. |
| **Real Time Clock** | Built in, enables message sending at defined times of the day |
| **Device Configuration** | Wireless NFC configuration |

# 6 Device operation

## 6.1 Principle

Device accepts pulse switch contact from pulse sending device. Pulse sending device is connected directly to a meter (water, gas, electricity...) and uses some means of detecting medium flow and converting metered quantities into pulses.

i.e connected to a water meter, pulse sender can create a short circuit pulse on X-LOGIC's pulse counter input with for each liter of water passed through the meter. Pulse sender device is usually provided by the manufacturer of a meter as it needs to be adapted to a specific meter.

If special cases need to be covered, please contact X-LOGIC.

## 6.2 Startup

If device is rebooted, i.e. after battery change, CPU runs specific startup code. This is intended to signal regular startup and also to provide information if startup happens due to some issue, i.e. battery too low for regular operation.

If device was activated prior to reboot, message with ASCII payload "START" is sent and with additional information about device startup.

If device was not activated prior to reboot, no message is sent.

## 6.3 Activation

Device is delivered in hibernation mode or without the battery connected. In hibernation minimal power is consumed and CPU only checks for activation signal. RF communication, tamper detection and internal sensors are disabled. In case the battery is not already connected, the device isn't consuming any power and it is necessary to first connect the battery.

Activation is done simply by providing an impulse on counter input. i.e user can create a short circuit on the input before installation.

After activation, device starts counting pulses and sending messages according to the default schedule (every 24h). If device has LoRaWAN communication, OTAA join will be performed at this point (contact X-LOGIC if ABP join is the only choice for you). If not successful join will be attempted 2 times, and afterwards paused 24h until next attempt.

NB-IoT device will after activation try to connect to a mobile network and send first message. If successful, it will immediately go to sleep and wake up for sending periodically. If connection is not successful, modem will be reset and try repeated. If unsuccessful still device will try again at a time of next message sending.

## 6.4 Impulse counting

Device counts short circuit (resistance lower than minimal pulse sender resistance in technical characteristics table) events on counter input(s). Pulses are counted from the activation. One total number of pulses is recorded for one pulse counter input. This total number is included in the message payload.

Device includes hardware RC filter and additional software filter to prevent counting short disturbances or noise as pulses.

Maximum possible number of pulses is 4 294 967 295, after which device starts counting from 0.
Pulse numbers are periodically stored in nonvolatile memory (*EEPROM*) and are additionally kept in reset-proof RAM locations. Time interval between saving number of impulses is called *"Read Mode"* and can be changed by the user. Available intervals are 15min, 30min, 1h, 2h, 3h, 4h, 6h, 8h, 12h and 24h.

The meter state which is send in the uplink message is calculated with following formula:

***meter_state = impulses*k-factor + initial_state***

By default, the device is configured so that the initial state equals 0 L and the k-factor is 1 (1 pulse = 1 liter). If these settings are retained, the meter state sent in the message will correspond to the number of pulses counted since the device began operating.

If the k-factor or the initial state is changed via the NFC application or downlink messages, the meter state sent in the message will correspond to the formula above.

It is possible to modify all variables via downlink or the NFC application.

## 6.5 Tamper detection

Device contains tamper input(s) to connect external tamper switch(es). It reports state of tamper input and sends message immediately after tamper input changes state from normal to a tamper active state. This feature can be used to connect various switches, i.e switch from magnetic tamper detection, door switch to detect hatch opening, water level switch to detect flooding etc.

Hardware tamper input detects transition from closed to open state of the switch.

Device has an option of internal accelerometer that provides information for tamper of movement. When device is moved or impacted, tamper message is sent.

Information about tamper is transmitted also as a part of regular messages sent in defined intervals. Tamper event can be cleared by a downlink message and if not cleared by a downlink, it will be reset 30 minutes after detection.

After tamper is detected, further detections are blocked for a configured period of time (default 30 minutes). This is to prevent excessive message sending.

## 6.6 Uplink message sending

Uplink message is sent from pulse counter device, through available RF infrastructure to a server platform (further in this text – platform)

**Message types:**

- START message
- Regular message
- Tamper message
- Alarm message (for impulse inputs)

Regular messages are sent at fixed intervals. Available intervals are 1h, 2h, 4h, 8h, 12h, and 24h. The default is 24h.

When the send time expires, the device will connect to the network and send as many regular messages as there were readings. For example, if the reading interval is set to 15 minutes and the transmission interval to 1 hour, the device will send 4 consecutive messages every hour. In the event of an unsuccessful modem connection to the network, the device will, upon the next successful connection, send all messages that had not yet been transmitted (up to the last 96 records).

If configured accordingly, a message can be sent at a predefined time of day, after which subsequent messages are sent at the configured interval. If the exact time is not defined, after the first interval from activation has elapsed, the device will send messages at times relative to 00:00 UTC (for example, if the transmission interval is set to every 8 hours, the device will send messages at 00:00, 08:00, and 16:00). To avoid a large number of devices connecting to the network simultaneously, there is a configurable interval within which the device transmits at a random time (Send Randomizer interval). By default, this interval is 5 minutes (the device transmits between 00:00 and 00:05).

Tamper messages are sent immediately after a tamper event is detected, regardless of the schedule for regular messages.

Alarm messages are sent immediately after detection of the configured pulse count threshold being exceeded. This is described in the following chapters.

The message format is defined in the following chapters.

## 6.7 Device configuration

Depending on the type of device, configuration can be performed via downlink messages, through NFC communication using the X-LOGIC NFC application, or via the 3.3V UART interface. Downlink messages are accepted after device activation. The 3.3V UART interface requires physical access to the device's printed circuit board.

A range of device parameters is available for configuration, such as the message transmission interval, RTC time, and others.

The primary configuration interface is through downlink messages. The configuration procedure is described in the following chapters.

Configuration via the NFC application is described in separate documents, which must be requested from X-LOGIC.

## 6.8 Temperature measurement

Pulse counter can contain integrated temperature measurement sensor. Measured temperature is sent in each sent message. This temperature corresponds well with the ambient temperature on the device's location.

## 6.9 Battery monitoring

Pulse counter continuously measures battery voltage and sends this information in each sent message. Battery voltage can be used as an indicator of a remaining capacity or battery health. This provides early-enough warning to replace battery, but due to the used lithium battery technology for the most part of the battery life cycle, voltage is almost constant.

### 6.10 Alarms

Pulse counters contain two types of alarms:

1. Burst alarm
2. Leakage alarm

The burst alarm has configurable parameters consisting of a time interval in minutes (1–255) and the number of pulses that must not be exceeded within that interval. If the pulse count is exceeded, alarm message 1 is sent.

The leakage alarm has configurable parameters consisting of the measurement start hour (0–24), measurement end hour (0–24), and the number of pulses that must not be exceeded within that interval. If the pulse count is exceeded, alarm message 2 is sent.

### 6.11 Communication

LoRaWAN devices are configured as class A with OTAA join. Keys are provided by X-LOGIC for each device at delivery. LoRaWAN devices are by default provided in EU868 band. Other bands can be provided at a request to X-LOGIC.

Sigfox devices are provided with ID and PAC on the device label. The default band is EU868. Other bands can be provided at a request to X-LOGIC.

NB-IoT devices are delivered with at least EMEA bands supported (including LTE Cat NB1/2 Band 20). The data transmission protocol is UDP. The UDP port and the IP address of the server to which messages are sent are configured via NFC or can be preconfigured during production. The SIM card is in nanoSIM format and is provided by the user, i.e. it is not included with the device.Typical usage:

For Sigfox devices no configuration is needed, the device is registered with printed ID and PAC codes.

For LoRaWAN devices no configuration is needed, device is registered with device ID and keys provided at delivery.

For NB-IoT user needs to configure IP address to send data, and APN if devices are used in roaming mode. This is typical for global low-cost SIMs. This can be also preconfigured at delivery, contact X-LOGIC for this service.

After devices are connected to a server platform, future configuration changes can be done over downlink.

## 7 Input connection

Depending on the device, pulse counter has four to six pairs of inputs that can be used for pulse counting or tampers depending on the device configuration.

**Warning:** If pulse sender or external sensor has polarity (e.g., active transistor impulse senders), it is necessary to connect positive line to positive and negative to negative to receive pulses.

The first n inputs are pulse inputs, while the remaining inputs are used as tamper inputs. For example, in a device with 6 inputs, IN1–IN4 are typically used as pulse inputs, while IN5 and IN6 are “normally closed” inputs used for tamper detection.

By default, the inputs are configured as follows:

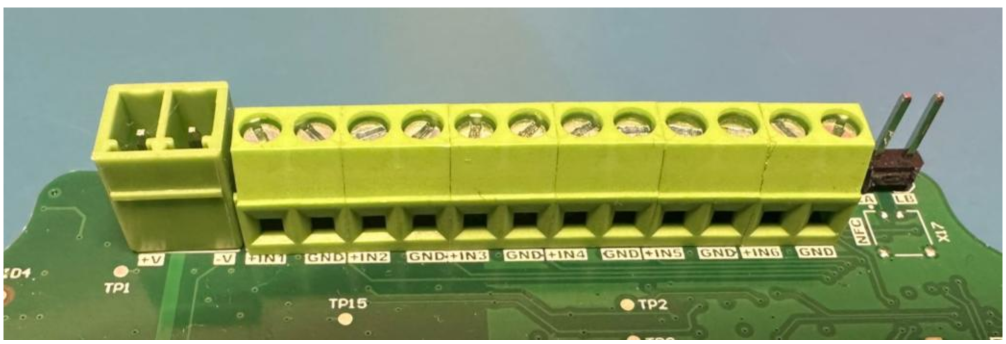
| | |
|---|---|
| **IN1** | Pulse input |
| **IN2** | Pulse input |
| **IN3** | Pulse input |
| **IN4** | Pulse input |
| **IN5** | Tamper input |
| **IN6** | Tamper input |

## 7.1 Potted and non-potted version

Device with potted module uses a cable of 0.5m length that is connected to the PCB before potting. This cable connects to a pulse generating switch(es) and tamper switch using sealed solder sleeves.

Recommended part: CWT-3 by TE Connectivity/Raychem.

Solder sleeve application is done in the field using heat gun or other applicable tool.




Device with non-potted electronic module does not have cable connected. Impulse generator and/or external sensors connect directly to the electronic module via terminal blocks.

Maximum wire thickness is 0.75mm2(22-18AWG).

# 8 Message format

## 8.1 Downlink message

Downlink message is a message sent by network server to the device for configuration purposes. In case of a Sigfox device request for downlink message is sent by the device every seven days or on each tamper detection message, while LoRaWAN and NB-IoT devices can receive downlink after each uplink message is transmitted.

General message format is: ***A**x* – where *A* represents ASCII character setting and x represents ASCII parameter value (except for the two uint32 time parameters and two uint16 reset codes, everything else is ASCII coded) Settings order in the message can vary, but **length of the downlink message must not be longer than eight(8) bytes for Sigfox devices and fifty(50) for other devices.**

If message is shorter than 8 bytes, null-bytes(*0*) padding will be automatically added on device until message is 8 bytes long.

**Downlink message example:**
**M**0**R**1**T**1603448475**S**46800

| Setting | Description |
|---|---|
| **M** | Message sending period |
| **Y** | Pulse reading period |
| **R** | Reset tamper flag or device |
| **T** | UNIX vrijeme (*uint32*) |
| **S** | Time of day for sending messages (uint32) |
| **m** | Send Randomizer interval |
| **C** | Reset pulse counter |
| **V** | Set Initial State |
| **F** | Set k-factor |
| **I** | Tamper ban period |
| **B** | Parameters for burst alarm |
| **L** | Parameters for leak alarm |
| **U** | Input configuration |
| **u** | Update Enable |
| **X** | Factory reset |
| **A** | Period for requesting ACK response from server * |
| **D** | LoRa Data Rate* |
| **W** | Set server IP address ** |
| **D** | DNS setting** |
| **P** | Set server Port ** |
| **O** | Set network operator ** |
| **G** | Set network operator APN ** |
| **K** | Select device sleep mode ** |

*LoRa specific settings
**NB-IoT specific settings

### 8.1.1 M – Message interval configuration

***M*** setting selects interval of time between 2 uplink messages. In example above, device will send message every hour.

| Value (ASCII) | Sending interval |
|---|---|
| **0** | 1h |
| **1** | 2h |
| **2** | 4h |
| **3** | 8h |
| **4** | 12h |
| **5** | 24h *(default)* |

**Example:** Change send period to 2 hours. Message M1 (ASCII) needs to be converted to hex format. 0x4D is ASCII for character M and 31 is ASCII for character 1. Message that needs to be sent is 4D31.

### 8.1.2 Y – Pulse reading period

***Y*** setting choses time interval between reading and saving number of impulses to storage

| Value(decimal) | Pulse reading period |
|---|---|
| **255** | 15 min |
| **254** | 30 min |
| **253** | 1h |
| **252** | 2h |
| **251** | 3h |
| **250** | 4h |
| **249** | 6h |
| **248** | 8h |
| **247** | 12h |
| **246** | 24h *(default)* |

*Pulse reading period cannot be larger than message sending period.

**Example:** Change pulse reading period to 2 hours. Message Y252 (ASCII) needs to be converted to hex format. 0x59 is ASCII for character Y and 2 5 2 is converted to 32 35 32 in hex. Message that needs to be sent is 59323532.

### 8.1.3 R – Reset

***R*** setting can reset the tamper flag after receiving a tamper message or reset the device entirely.

In the example above, tamper flag is being reset which will enable sending of new tamper messages.

| Value | Action |
|---|---|
| **0** | No action |
| **1** | Tamper flag reset |
| **2** | Device reset |

**Example:** To reset tamper flag, message R1 needs to be sent. Message R1 (ASCII) needs to be converted to hex format. 0x52 is ASCII for character R and 1 is converted to 31 in hex. Message that needs to be sent is 5231.

### 8.1.4 T – UNIX time (uint32)

***T*** setting contains UNIX time – number of seconds passed from 1st of January 1970.
Example UNIX time is: **1606134075** - *23rd of October 2020, 12:21:15*

This option sets the time in internal *RTC* (Real Time Clock) of the device.

**Example:** Unix timestamp 1651747265 wants to be set – in uint32 hex little endian format: C1 A9 73 62 -> message to be sent is: 54 C1 A9 73 62. 0x54 is hex format of ASCII character T.

### 8.1.5 S – Time of the day for uplink message sending (uint16)

***S*** setting configures the time of the day when device will send uplink message. Reference point is 00:00(midnight).

If the device never receives this setting, uplink messages will be sent in intervals configured with setting *M*.
Range is 0-1440 minutes.

**Example:** 855 will set *time for send* at 14:15 since that is number of seconds passed from midnight - in uint16 hex little endian format: 57 03 -> message to be sent is: 53 57 03. 0x53 is hex format of ASCII character S.

### 8.1.6 m – Send Randomizer Interval

***m*** setting is used to configure the Send Randomizer interval. After the character m, the interval duration in minutes is sent as a single byte. The value can range from 0 to 60 minutes.

**Example**: If we want to set the Send Randomizer interval to 5 minutes->the message to be sent in hex format:

0x6D is the hexadecimal representation of the ASCII code for the character m; 5 minutes in hex format is 0x05.
The message to be sent is: 6D 05.

### 8.1.7 C – Reset impulse counter to 0 (uint16)

***C*** setting sets impulse counter input to desired number of impulses. It is necessary to send a RESET code as a confirmation of intentional impulse change along with number of impulses that wants to be set. Message is sent in hex little endian format.

| Input | RESET code (hex) |
|---|---|
| **IN1** | 0x1C43 |
| **IN2** | 0x2C43 |
| **IN3** | 0x3C43 |
| **IN4** | 0x4C43 |
| **IN5** | 0x5C43 |
| **IN6** | 0x6C43 |

**Example:** Input 4 is being set to 1245 impulses. 0x43 is hex format of character C (ASCII) and 1245 converted to hex format is 0x04DD. Message to be sent is: 43 43 4C DD 04 00 00 (4 bytes for impulse number).

### 8.1.8 V – Set Initial State

***V*** setting sets the wanted initial meter state into the device. It is necessary to send the RESET code as confirmation of the intentional transmission of the setting, followed by the value to which the input initial state should be set, expressed in liters. Transmission is performed in hexadecimal little-endian format.

| Input | RESET code (hex) |
|---|---|
| **IN1** | 0x67C1 |
| **IN2** | 0x67C2 |

| | |
|---|---|
| **IN3** | 0x67C3 |
| **IN4** | 0x67C4 |
| **IN5** | 0x67C5 |
| **IN6** | 0x67C6 |

**Example:** The initial state for IN3 should be set to 43694 liters.

0x56 is the ASCII code for the character V, and 43694 (decimal) in hexadecimal format is 0xAAAE.
Accordingly, the following message is sent: 56 67 C3 AE AA 00 00 (4 bytes for the initial value).

### 8.1.9 F – Set k-factor

***F*** setting is used to configure the k-factor of an individual pulse input. After the character F, the number of the input for which the k-factor is to be changed is sent (1 byte), followed by the k-factor value (4 bytes).

**Example**: If we want to set the k-factor to 500 for input 3, the message to be sent in hexadecimal format is:

0x46 is the hexadecimal representation of the ASCII code for the character F; input 3 in hexadecimal format is 0x03; k-factor 500 is 000001F4.
The message to be sent is: 46 03 00 00 01 F4***.***

### 8.1.10 I – Tamper ban interval (uint32)

***I*** setting adjusts the tamper ban period. After a tamper event occurs, a specified period must pass before the tamper can be reactivated. The minimum value is 5 minutes. The value is sent in minutes in hex little-endian format.

**Example**: Setting the tamper prohibition period to 10 minutes.
0x49 is the ASCII code for the character I in hex, 10 in hex is 0x0A.
The message to be sent is: 49 0A

### 8.1.11 B – Burst Alarm parameters

***B*** setting sets the parameters for the burst alarm. It consists of 4 bytes. The number of pulses is sent in hex big-endian format.

1. Byte: time interval in minutes (1-60)
2. and 3. Byte: the number of pulses representing the limit
4. Byte: input number

**Example**: Setting that the number of pulses on input 3 (IN3) in 5 minutes must not exceed 10000.

0x42 is the ASCII code for the character B in hex. 5 minutes = 05 in hex. The number of pulses 10000 = 2710 in hex. The message to be sent is: 42 05 27 10 03.

### 8.1.12 L – Leak Alarm parameters

***L*** setting sets the parameters for the leak alarm. It consists of 7 bytes. The number of pulses is sent in hex big-endian format.

1. and 2. Byte: Start hour of measurement in minutes (0-1440) in UTC+00 timezone
3. and 4. Byte: End hour of measurement in minutes (0-1440) in UTC+00 timezone
5. and 6. Byte: the number of pulses representing the limit
7. Byte: input number

**Example**: Setting that on the input 3 the number of pulses from 02:00 (120 minutes) to 04:00 (240 minutes) must not exceed 10,000.

0x4C is the ASCII code for the character L in hex. 120 = 0x78 in hex. 240 = 0xF0 in hex. The number of pulses 10,000 = 2710 in hex. The message to be sent is: 4C 00 78 00 F0 27 10 03.

### 8.1.13 U – Input configuration

***U*** setting is used to configure the inputs of the SMANCO device as either impulse or tamper inputs (where at least one input must be impulse). After the character U, two bytes are sent in HEX format.

1. Byte: Indicates the type of input. 0 indicates a tamper input, and 1 indicates an impulse input.
2. Byte: Indicates whether the input will trigger on the rising or falling edge. 0 indicates triggering on the falling edge, and 1 indicates triggering on the rising edge.

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| **Desc.** | 0 | 0 | IN6 | IN5 | IN4 | IN3 | IN2 | IN1 |

**Example**: If we want to set inputs IN1 and IN3 as impulse inputs triggered on the falling edge, and the rest of the inputs as tamper inputs triggered on the rising edge: 0x55 is the ASCII code for the character U in hex.

1st byte: 0000 0101 in hex format is 0x05. 2nd byte: 0011 1010 in hex format is 0x3A.
The message to be sent is: 55 05 3A.

### 8.1.14 u – Update Enable

***u*** setting enables device firmware updates. If updates should be disabled, it is necessary to send the message U0 in hexadecimal format; if updates should be enabled, it is necessary to send the message U1 in hexadecimal format. By default, device updates are enabled.

**Example**: If we want to enable device updates, the message to be sent in hexadecimal format is:

0x75 is the hexadecimal representation of the ASCII code for the character u; ASCII 1 in hexadecimal format is 0x31.
The message to be sent is: 75 31.

### 8.1.15 X – Factory reset (*uint16*)

**X** setting resets all settings to default and pulse counters to 0, the letter must be followed by the number 2403, all in hex little-endian format.

**Example**: 0x58 is the ASCII code for the character X in hex. 2403 in hex is 0963 (little-endian: 63 09). The message to be sent is: 58 63 09.

### 8.1.16 A – Period for requesting ACK response from server (uint32)

***A*** setting sets the number of messages between requests for an ACK response from the LoRa server. This is used in LoRa SMANCO devices. The value is sent in hex little-endian format.

**Example**: Setting to request an ACK response after every 50 messages. 0x41 is the ASCII code for the character A in hex. 50 messages in hex is 32 (00 00 00 32, little-endian: 32 00 00 00). The message to be sent is: 41 32 00 00 00.

### 8.1.17 D – LoRa Data Rate

***D*** setting adjusts the Data Rate on LoRa SMANCO devices. To set it, three characters are sent: the first is 0, and the other two correspond to the desired Data Rate. To set an automatic Data Rate, the characters 2 5 5 are sent.

**Example**: Setting the Data Rate to 5. 0x44 is the ASCII code for the character D in hex. The first character is 0 (ASCII) which in hex is 30, and for setting Data Rate 5, the next two characters are 05 which in hex are 30 35. The message to be sent is: 44 30 30 35.

The message to be sent for automatic Data Rate is: 44 32 35 35

### 8.1.18 W – Set server IP address (see Note 1)

***W*** setting is used for NB-IoT SMANCO devices to set the IP address of the UDP server to which the device sends messages. After the character W, the IP address of the UDP server is sent by converting each part into one byte in HEX format. The device continues to send to the previously defined server until the change is confirmed by resetting the device with the command R2.

**Example**: If we want to set the IP address to 192.168.15.1: 0x57 is the ASCII code for the character W in hex. 192 = C0; 168 = A8; 15 = 0F; 1 = 01. The message to be sent is: 57 C0 A8 0F 01.

### 8.1.19 D – Set server URL (see Note 1)

***D*** setting is used for NB-IoT pulse counters to configure the server URL. After the character D, the URL is sent character by character in hexadecimal format. The maximum URL length is 44 characters.

**Example**: If we want to set the URL to test.net, the message to be sent in hexadecimal format is:

0x44 is the hexadecimal representation of the ASCII code for the character D; the URL t e s t . n e t in hexadecimal format is 74 65 73 74 2E 6E 65 74.
The message to be sent is: 44 74 65 73 74 2E 6E 65 74.

### 8.1.20 P – Set server port (see Note 1)

***P*** setting is used for NB-IoT SMANCO devices to set the UDP server port to which the device sends messages. After the character P, the UDP server port is sent in HEX little-endian format. After sending the downlink message to change the port, the device needs to be reset by sending the command R2.

**Example**: If we want to set the port to 38560: 0x50 is the ASCII code for the character P in hex. Port 38560 in hex is 96A0 (little-endian: A0 96). The message to be sent is: 50 A0 96.

Note 1

To change the IP/URL and the port to which the device sends data, it is necessary to send a single downlink containing both the IP/URL and the port in the same downlink message, in order to avoid sending an incorrect server configuration. To set the IP address to 192.168.15.1 and the port to 38560, you need to send the hex code 57C0A80F0150A0965232.

### 8.1.21 O – Set network operator

***O*** setting is used for NB-IoT SMANCO devices to set the Mobile Network Operator (MNO) code in numerical format (MCC/MNC). After the character O, the operator's name is sent character by character in HEX format. After sending the downlink message to change the operator's name, the device needs to be reset by sending the command R2.

**Example**: If we want to set "HT" as the operator, its code is 21901: 0x4F is the ASCII code for the character O in hex. The code 2 1 9 0 1 in hex format is 32 31 39 30 31. The message to be sent is: 4F 32 31 39 30 31.

### 8.1.22 G – Set network operator APN

***G*** setting is used for NB-IoT SMANCO devices to set the Access Point Name (APN) of the mobile network operator. After the character G, each character of the APN is sent in HEX format. After sending the downlink message to change the APN, the device needs to be reset by sending the command R2.

**Example**: If we want to set the APN to "internet": 0x47 is the ASCII code for the character G in hex. The APN "internet" in hex format is 69 6E 74 65 72 6E 65 74. The message to be sent is: 47 69 6E 74 65 72 6E 65 74.

### 8.1.23 K – Select device sleep mode

***K*** setting is used for NB-IoT SMANCO devices to select the device's sleep mode. After the character K, either PM or SM (depending on the desired mode) is sent character by character in HEX format.

**Example**: If we want to set the poweroff sleep mode (PM): 0x4B is the ASCII code for the character K in hex. PM in hex format is 50 4D. The message to be sent is: 4B 50 4D.

### 8.2 Uplink message

Uplink message is a message that is beint sent from the device to the server.

Uplink message can be:

1. START message
2. Regular message
3. Tamper message
4. ALARM message

#### 8.2.1 START message

The START message is sent after the device has been activated and when the previously activated device is reset.

**START message format:**

| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| **Data** | 'S' | 'T' | 'A' | 'R' | 'T' | reset cause | config |
| **Data Type** | ASCII hex | | | | | uint8 | uint8 |

| Byte | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Data** | impulse_cnt4 | | | | impulse_cnt3 | | | | impulse_cnt2 | | | | impulse_cnt1 | | | |
| **Data Type** | uint – little-endian | | | | uint – little-endian | | | | uint – little-endian | | | | uint – little-endian | | | |

For NB-IoT devices, the ID part is added at the end of the start message: *"\r\nIMEI: XXXXXXXXXXXXXXX\r\nIMSI: XXXXXXXXXXXXXXX*".

*The length of the START message will depend on the number of pulse inputs. The example provided refers to the case with 4 pulse inputs. If the device has 3 pulse inputs, there is no impulse_cnt4, but instead, impulse_cnt3 takes its place, and the message is 4 bytes shorter.

**Data description:**

- **reset cause:** cause of the device reset according to the table

| Value | Reset Cause |
|---|---|
| **0** | Unknown Cause |
| **1** | Low Power Reset |
| **2** | Window Watchdog |
| **3** | Independant Watchdog |
| **4** | Software Reset |
| **5** | Power On Power Down Reset |
| **6** | External Reset (Pin/Button) |
| **7** | Option Bytes Loading |
| **8** | Firewall Reset |

- **config:** Configuration of the device's physical inputs, either pulse or tamper input. If the bit is 0, the input is for tamper, and if it is 1, the input is pulse.

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| **Desc.** | 0 | 0 | IN6 | IN5 | IN4 | IN3 | IN2 | IN1 |

- **impulse_cnt:** Meter state in litres.

### 8.2.2 Regular message

Regular messages are sent at specified time intervals. The interval can be changed using the *M* (*Send Mode*) setting. These messages contain the number of pulses and the time at which the pulses were logged.

Besides the interval, it is also possible to set these messages to be sent at a specific time (*S* setting).

**Regular message format** of a device with 4+ impulse inputs:

| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Data** | impulse_cnt4 | | | | impulse_cnt3 | | | | impulse_cnt2 | | | | impulse_cnt1 | | | | timestamp | | | |
| **Data Type** | uint – little-endian | | | | uint – little-endian | | | | uint – little-endian | | | | uint – little-endian | | | | uint – little-endian | | | |

| Byte | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|
| **Data** | send mode | read mode | tamper | input states | voltage | temperature | config | RSRQ* | SNR* |
| **Data Type** | uint8 | uint8 | uint8 | uint8 | uint8 | int8 | uint8 | int8 | int8 |

For NB-IoT devices, the ID part is added to the message: *"\r\nIMEI: XXXXXXXXXXXXXXX\r\nIMSI: XXXXXXXXXXXXXXX*".

*only for NB-IoT devices

**Data description:**

- **impulse_cnt:** Meter state in litres
- **timestamp:** The time at which the number of pulses was counted (in Unix format)
- **voltage:** Battery voltage – 0-255 centivolts (0.1V steps) + 2V offset. For example, 0xFF represents 2.55V + 2V = 4.55V, and 0x00 represents 0V + 2V = 2V. The normal battery voltage is 3.5 - 3.65V.

- **mode/send mode:** Send period according to the table

| Value (decimal) | Send period |
|---|---|
| **0** | 1h |
| **1** | 2h |
| **2** | 4h |
| **3** | 8h |
| **4** | 12h |
| **5** | 24h *(default)* |

- **read mode:** Read period according to the table

| Value (decimal) | Read period |
|---|---|
| **255** | 15 min |
| **254** | 30 min |
| **253** | 1h |
| **252** | 2h |
| **251** | 3h |
| **250** | 4h |
| **249** | 6h |
| **248** | 8h |
| **247** | 12h |
| **246** | 24h *(default)* |

- **tamper:** Tamper flag; it is possible to have more tampers activated at once

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| **Desc.** | Purpose | 0 | IN6 | IN5 | IN4 | IN3 | IN2 | IN1 |

  - **Purpose:** Bit set to 1 if the message is sent due to tamper
  - **IN1-IN6:** Bit set to 1 depending on which input the tamper was detected

- **input states:** Bit 0 represents the logic level at input IN1 (0 or 1), Bit 5 represents the logic level at input IN6, and the rest represent other inputs.
- **temperature**: temperature in °C
- **config**: Configuration of the device's physical inputs, either pulse or tamper input. If the bit is 0, the input is for tamper, and if it is 1, the input is pulse.

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| **Desc.** | 0 | 0 | IN6 | IN5 | IN4 | IN3 | IN2 | IN1 |

- **RSRQ**: *Reference Signal Received Quality* – signal quality parameter

| RSRQ (dB) | Connection Quality |
|---|---|
| > -7 | Excellent |
| -7 do -11 | Medium |
| < -11 | Bad |

- **SNR**: *Signal-to-Noise Ratio* – signal quality parameter

| SNR (dB) | Connection Quality |
|---|---|
| >= 20 | Excellent |
| 13 do 20 | Good |
| 0 do 13 | Medium |
| <= 0 | Bad |

### 8.2.3 Tamper message

When a tamper event is detected, a tamper message is sent, identifiable by the eighth bit set to 1 in the tamper byte. The device will reset the internal tamper flag after 30 minutes (default) for each tamper source. The flag reset occurs immediately upon receiving a downlink message for resetting the tamper flag.

No new tamper messages are sent while the internal tamper flag is active.

**Tamper message format**:

| Byte | 0 1 2 3 | 4 5 6 7 | 8 9 10 11 | 12 13 14 15 | 16 17 18 19 |
|---|---|---|---|---|---|
| **Data** | impulse_cnt4 | impulse_cnt3 | impulse_cnt2 | impulse_cnt1 | timestamp |
| **Data Type** | uint – little-endian | uint – little-endian | uint – little-endian | uint – little-endian | uint – little-endian |

| Byte | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|
| **Data** | send mode | read mode | tamper | input states | voltage | temperature | config | RSRQ* | SNR* |
| **Data Type** | uint8 | uint8 | uint8 | uint8 | uint8 | int8 | uint8 | int8 | int8 |

For NB-IoT devices, the ID part is added to the message: *"\r\nIMEI: XXXXXXXXXXXXXXX\r\nIMSI: XXXXXXXXXXXXXXX*".

*only for NB-IoT devices

**Tamper byte examples:**
10000101 – Tamper message, tamper flag is active for inputs 1 and 3

00000011 – Regularna message, tamper flag is active for inputs 1 and 2

**Data description:**

- **impulse_cnt:** Number of pulses counted since activation or counter reset
- **timestamp:** The time at which the tamper was detected (in Unix format)
- **voltage:** Battery voltage – 0-255 centivolts (0.1V steps) + 2V offset. For example, 0xFF represents 2.55V + 2V = 4.55V, and 0x00 represents 0V + 2V = 2V. The normal battery voltage is 3.5 - 3.65V.

- **mode/send mode:** Send period according to the table

| Value (decimal) | Send period |
|---|---|
| **0** | 1h |
| **1** | 2h |
| **2** | 4h |
| **3** | 8h |
| **4** | 12h |
| **5** | 24h *(default)* |

- **read mode:** Read period according to the table

| Value (decimal) | Read period |
|---|---|
| **255** | 15 min |
| **254** | 30 min |
| **253** | 1h |
| **252** | 2h |
| **251** | 3h |
| **250** | 4h |
| **249** | 6h |
| **248** | 8h |
| **247** | 12h |
| **246** | 24h *(default)* |

- **tamper:** Tamper flag; it is possible to have more tampers activated at once

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| **Desc.** | Purpose | 0 | IN6 | IN5 | IN4 | IN3 | IN2 | IN1 |

  - **Purpose:** Bit set to 1 if the message is sent due to tamper
  - **IN1-IN6:** Bit set to 1 depending on which input the tamper was detected

- **input states:** Bit 0 represents the logic level at input IN1 (0 or 1), Bit 5 represents the logic level at input IN6, and the rest represent other inputs.
- **temperature**: temperature in °C
- **config**: Configuration of the device's physical inputs, either pulse or tamper input. If the bit is 0, the input is for tamper, and if it is 1, the input is pulse.

| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| **Desc.** | 0 | 0 | IN6 | IN5 | IN4 | IN3 | IN2 | IN1 |

- **RSRQ**: *Reference Signal Received Quality* – signal quality parameter

| RSRQ (dB) | Connection Quality |
|---|---|
| > -7 | Excellent |
| -7 do -11 | Medium |
| < -11 | Bad |

- **SNR**: *Signal-to-Noise Ratio* – signal quality parameter

| SNR (dB) | Connection Quality |
|---|---|
| >= 20 | Excellent |
| 13 do 20 | Good |
| 0 do 13 | Medium |
| <= 0 | Bad |

### 8.2.4 ALARM message

Alarm messages are sent when consumption thresholds set in the device are exceeded.

**Alarm 1 message format (Burst alarm):**

| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12-13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Data** | 'F' | 'l' | 'o' | 'w' | ' ' | 'a' | 'l' | 'a' | 'r' | 'm' | ' ' | '1' | threshold | input index |
| **Data Type** | ASCII hex | | | | | | | | | | | | uint – little-endian | uint8 |

| Byte | 15-18 |
|---|---|
| **Data** | timestamp |
| **Data Type** | uint – little – endian |

For NB-IoT devices, the ID part is added to the message: "*\r\nIMEI: XXXXXXXXXXXXXXX\r\nIMSI: XXXXXXXXXXXXXXX*".

**Alarm 2 message format (Leak alarm):**

| Byte | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12-13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Data** | 'F' | 'l' | 'o' | 'w' | ' ' | 'a' | 'l' | 'a' | 'r' | 'm' | ' ' | '2' | threshold | input index |
| **Data Type** | ASCII hex | | | | | | | | | | | | uint – little-endian | uint8 |

| Byte | 15-18 |
|---|---|
| **Data** | timestamp |
| **Data Type** | uint – little – endian |

For NB-IoT devices, the ID part is added to the message: "*\r\nIMEI: XXXXXXXXXXXXXXX\r\nIMSI: XXXXXXXXXXXXXXX*".

**Data description:**

- **threshold:** pulse threshold set in the device
- **input index:** index of the input which triggered the alarm
- **timestamp:** The time at which the the alarm was detected (in Unix format)

# 9 Battery endurance

The device uses a high-quality lithium battery with a nominal voltage of 3.6V. LoRaWAN and Sigfox devices use one battery of size 18505. NB-IoT devices use one D-size battery. The batteries are mounted in holders and can be replaced without soldering.

For precise endurance calculation for your specific use-case please contact X-LOGIC. Endurance examples for typical cases are given below.

Example lifetime values are given for typical cases in the table below. One input is included for counting with a 50 ms pulse duration (active pulse transmitter) and one pulse per minute. For reed relay transmitters, the consumption for counting will be higher and typically amounts to 1.65 µA per input on average. Device firmware updates are disabled.

Low and high ambient temperatures influence endurance along with signal strength.

| Send Mode for NB-IoT i Sigfox, Read Mode LoRaWAN | Battery Life Expectancy [years] | | |
|---|---|---|---|
| | LoRaWAN | Sigfox | NB-IoT |
| **48h** | 45.6 | 52.8 | 109.17 |
| **24h** | 41.4 | 43.9 | 85.6 |
| **12h** | 34.8 | 32.8 | 70.5 |
| **8h** | 30.1 | 26.2 | 46 |
| **4h** | 21.3 | 16.3 | 27.1 |
| **2h** | 13.5 | 9.3 | 14.9 |
| **1h** | 7.8 | 5.0 | 8.2 |

# 10 Regulatory compliance

X-LOGIC pulse counter devices are fully CE certified by an independent notified lab.

| | |
|---|---|
| **Tip/model:** ***Type/model*** | PC-LR-1 |
| **Komercijalni naziv:** ***Brand name:*** | - |
| **Podnositelj zahtjeva:** ***Applicant:*** | X-LOGIC d.o.o.<br>Dužice 12, 10 000 Zagreb, Croatia |
| **Proizvođač:** ***Manufacturer:*** | X-LOGIC d.o.o.<br>Dužice 12, 10 000 Zagreb, Croatia |
| **Primijenjene norme:** ***Related standards:*** | EN 62368-1:2014+A11:2017<br>EN 62311:2008<br>EN 301 489-1 V2.2.3:2019<br>Draft EN 301 489-52 V1.1.2:2020*<br>EN 300 220-2 V3.2.1:2018 |
| **Broj izvještaja prijavljenog tijela:** ***Notified Body Evaluation Report No:*** | 80210013RED |

| | |
|---|---|
| **Tip/model:** ***Type/model*** | PC-NB-3 |
| **Komercijalni naziv:** ***Brand name:*** | - |
| **Podnositelj zahtjeva:** ***Applicant:*** | X-LOGIC d.o.o.<br>Dužice 12, 10 000 Zagreb, Croatia |
| **Proizvođač:** ***Manufacturer:*** | X-LOGIC d.o.o.<br>Dužice 12, 10 000 Zagreb, Croatia |
| **Primijenjene norme:** ***Related standards:*** | EN 62368-1:2014+A11:2017<br>EN 62311:2008<br>EN 301 489-1 V2.2.3:2019<br>Draft EN 301 489-52 V1.1.2:2020*<br>EN 301 908-1 V13.1.1:2019<br>EN 301 908-13 V13.1.1:2019 |
| **Broj izvještaja prijavljenog tijela:** ***Notified Body Evaluation Report No:*** | 80210010RED |

| | |
|---|---|
| **Tip/model:** ***Type/model*** | PC-SF-1 |
| **Komercijalni naziv:** ***Brand name:*** | - |
| **Podnositelj zahtjeva:** ***Applicant:*** | X-LOGIC d.o.o.<br>Dužice 12, 10 000 Zagreb, Croatia |
| **Proizvođač:** ***Manufacturer:*** | X-LOGIC d.o.o.<br>Dužice 12, 10 000 Zagreb, Croatia |
| **Primijenjene norme:** ***Related standards:*** | EN 62368-1:2014+A11:2017<br>EN 62311:2008<br>EN 301 489-1 V2.2.3:2019<br>Draft EN 301 489-52 V1.1.2:2020*<br>EN 300 220-2 V3.2.1:2018 |
| **Broj izvještaja prijavljenog tijela:** ***Notified Body Evaluation Report No:*** | 80210011RED |

## 11 Environmental

Pulse counter devices shall be disposed and recycled following all applicable rules in your region.
Attention was given in product design to allow for a safe battery removal for disposal/recycling.

Please remove battery after the use and dispose it appropriately.
If product is potted, used compound is soft and can be cut to open the space around battery for removal.