PULSE COUNTER DEVICES

DATASHEET

Revision history

Revision	Author	Date	Approved by	Changes
R1	Tihomir Protulipac	09.2022.		First release
R2	Tihomir P	04.2023		Updated tamper byte with input states

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

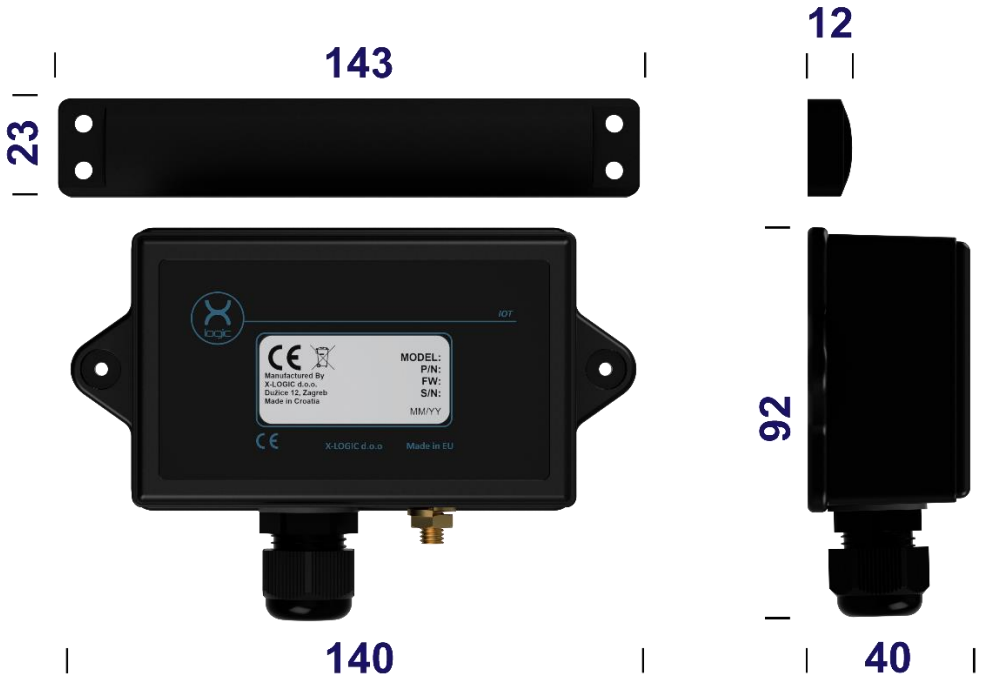
3 Product variants and options

PRODUCT TYPE	COMMUNICATION	INPUTS	POTTING	MOVEMENT TAMPER	INTERNAL TEMP. SENSOR
PC – PULSE COUNTER	**LR** - LoRaWAN	**1** – one input for pulse counting, 2 tamper inputs **2** – two inputs for independent pulse counting, 1 tamper input	**P** – potted, completely sealed electronics for applications in wet or moist environments. Non-removable battery and antenna. **IP54** – not sealed. For applications in dry environment. Removable battery and antenna.	**MVY** – accelerometer chip included **MVN** – accelerometer chip NOT included	**TY** – temp sensor included **TN** – temp sensor not included
	SF – Sigfox				
	NB – NB-IoT		**IP68** - For applications in moist environment. Removable battery and antenna.		

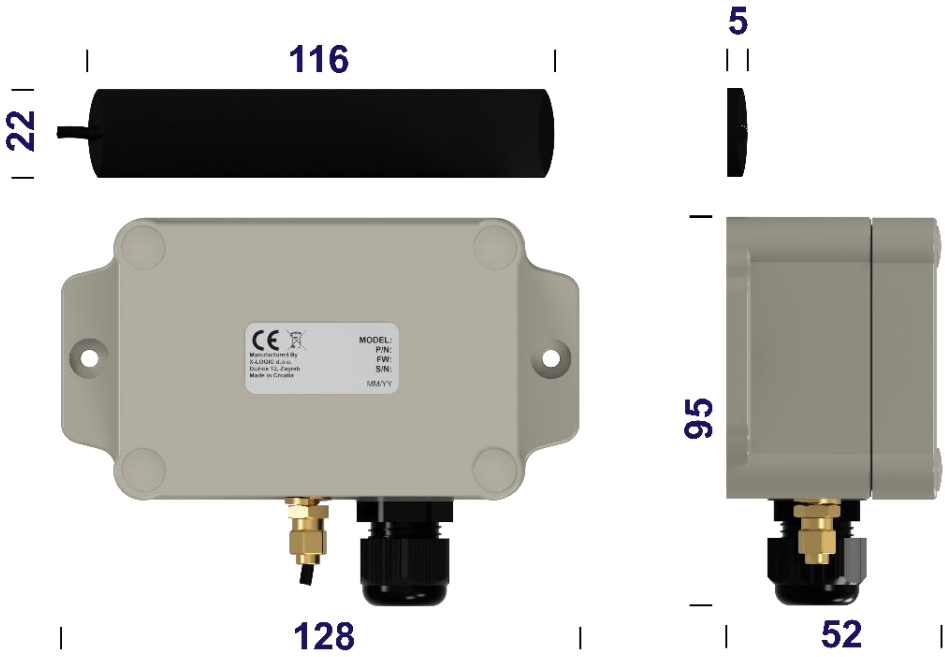
Example:
PC-LR-1-P-MVY-TY represents pulse counter with *LoRaWAN* communication, 1 pulse input and 2 tamper inputs (switch inputs), potted electronics and with accelerometer and temperature sensor on board.

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	3.6V Lithium, high quality, standard widely available size (for future battery replacements by the user)
Operating temperature	-30°C to +70°C
Operating environment *Water & humidity*	IP54 variants are suitable only for dry environment Potted and IP68 variants are suitable for moist environment. 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. Battery holders are used, providing for reliable connection and solder free battery replacement.
Impulse counter backup	Internal EEPROM of the device and reset-proof RAM. Pulse counts are hard backed-up to internal EEPROM periodically and are continuously kept in a battery backed and reset proof RAM.
Real Time Clock	Built in, enables message sending at defined times of the day

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. In hibernation minimal power is consumed and CPU only checks for activation signal. RF communication, tamper detection and internal sensors are disabled.

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.

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:

- Regular message
- Tamper message

Regular messages are sent in regular, defined intervals. Available intervals are 1h, 2h, 4h, 8h, 12h, 24h and 48h. If so configured, message sending can be initiated in a specific time of a day, and subsequent messages are sent afterwards in defined time interval. If time of the day to send message is not defined, interval is calculated from the device activation.

Tamper message is sent immediately after tamper detection. This message is independent from regular messages.

Uplink message format is defined in a later chapter.

6.7 Device configuration

Device can be configured by downlink or by using 3.3V UART port on the device itself (potting makes UART not accessible). Downlink configuration is possible only after device activation.

Relevant operating parameters are configurable, i.e., message sending period. To configure devices contact X-LOGIC support for instructions.

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 Communication

LoRaWAN devices are configured as class A with OTAA join. Keys are provided from 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. Default band is EU868. Other bands can be provided at a request to X-LOGIC.

NB-IoT devices are provided with EMEA band coverage. Other bands can be provided at request to X-LOGIC. Transfer protocol used is raw UDP. TCP port and IP address to connect are configurable over UART. SIM card can be user-replaced. uSIM format is used. To configure devices contact X-LOGIC support for instructions.

Typical usage:

For Sigfox devices no configuration is needed, 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

Pulse counter device has three pairs of inputs that can be used for pulse counting or tampers depending on device type.

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.

Input pin functions for devices with one pulse counter:

Function	PCB Mark/Input	Description
Impulse Counter	IN2+	Impulse counter input
	IN2-	Impulse counter ground
Tamper #1	IN1+	External sensor #1 input
	IN1-	External sensor #1 ground
Tamper #2	IN3+	External sensor #2 input
	IN3-	External sensor #2 ground

Input pin functions for devices with two pulse counters:

Function	PCB Mark/Input	Description
Impulse Counter 2	IN2+	Impulse counter input
	IN2-	Impulse counter ground
Impulse Counter 1	IN1+	Impulse counter input
	IN1-	Impulse counter ground
Tamper	IN3+	External sensor #2 input
	IN3-	External sensor #2 ground

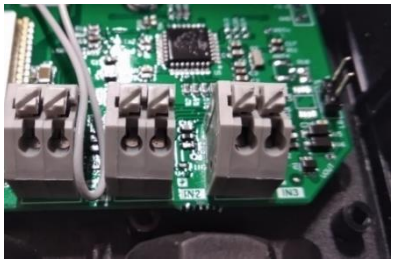
7.1 Potted and non-potted version

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.
To connect, it is recommended to have a small flat-blade screwdriver to press the levers on the terminal block or to screw down terminal blocks if that terminal-block type is used on your device.
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.**

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:
M0**R**1**T**1603448475**S**46800

Setting	Description
M	Message frequency
R	Reset tamper flag
T	UNIX time (*uint32*)
S	Time of the day for sending (*uint32*)
C	Reset impulse counter to 0
X	Factory reset

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 (decimal)	Sending interval
0	1h
1	2h
2	4h
3	8h
4	12h
5	24h *(default)*
6	48h

8.1.2 R – Reset flag

R setting is reaction of network server on a tamper message sent by the device.
In given example above, device receives command to reset tamper flag and new tamper detection will be enabled.

As a backup option, here also server can reset entire device.

8.1.3 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*

Value	Action
0	No action
1	Tamper flag reset
2	Device reset

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

8.1.4 S – Time of the day for uplink message sending (uint32)

S setting configures 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 0-86400 seconds.

Example: 51300 will set *time for send* at 14:15 since that is number of seconds passed from midnight.

8.1.5 C – Reset impulse counter to 0 (uint16)

C setting reset impulse counter to 0. This command format starts with *C* in hex ASCII followed by code *7235* in hex little endian format.

Example: hex array 43431C resets input 1, 43431C resets input 2.

8.1.6 X – Factory reset (*uint16*)

X setting reset impulse counter to 0 and restarts device. This command format starts with *X* in hex ASCII followed by code *2403* in hex little endian format.

Example: 586309

8.1.7 F – Factory reset with delay for network server change

This setting does the same as X setting, with added delay of 1 minute after reset and before device attempts LoRaWAN network join.

It is used in case when device needs to be moved from one LoRAWAN network server to another while using OTAA join procedure. After character F in ASCII format 46, it is neccesary to add code *9168* in hex little endian format *D023*.

8.2 Uplink message

Uplink message is message sent by the device to a network server/system. Device will send the message:

- Every *X* hours (*M* setting)
- At a certain time of the day (*S* setting)
- After tamper detection

Basic message length is 10 bytes for a device with one pulse counter and 12 bytes for a device with 2 pulse counters. For NB-IoT version, ID part is added to basic message „*\r\nIMEI: XXXXXXXXXXXXXXX\r\nIMSI: XXXXXXXXXXXXXXX*“. Because of that, the basic message with one impulse is 56 bytes long for NB-IoT device, for two impulses is 58.

Byte	0	1	2	3	4	5	6	7	8	9
Data	impulse_cnt				voltage			mode	tamper	temperature
Coding	*uint – little-endian*				*char(ASCII) - little-endian*			*uint – little-endian*		*int – little-endian*

Byte	0	1	2	3	4	5	6	7	8	9	10	11
Data	impulse_cnt2				impulse_cnt1				batt. voltage	mode	tamper	temperature
Coding	*uint – little-endian*				*uint – little-endian*				*uint – little-endian*			*int – little-endian*

- **impulse_cnt:** Number of impulses counted from the device activation
- **voltage:** Battery voltage – 0-255 centivolts (0,1V steps) + add offset 2V to get real battery voltage. i.e 0xFF in battery voltage represents 2.55V + 2V = 4.55V, 0x00 represents 0V + 2V = 2V Normal battery voltage level is 3.6V
- **mode:** Sending interval as in table

Value	Sending interval
0	1h
1	2h
2	4h
3	8h
4	12h
5	24h *(default)*
6	48h

- **tamper:** Tamper flag. Multiple tamper flags are possible

Bit	7	6	5	4	3	2	1	0
Desc.	Purpose	Input state				Movement	Tamper 2	Tamper 1

  - **Purpose:** Bit is set to 1 if the message is sent because of tamper detection, immediately after detection.
  - **Movement:** Bit is set to 1 if device movement is detected by internal accelerometer
  - **Tamper 1/2:** Bit is set to 1 if external tamper contact open is detected
  - **Input state:** Bit 3 logical level of IN1, Bit4 logical level of IN2, Bit 5 Logical level of IN3 input on PCB

- **temperature**: temperature in °C, internal sensor on the device, 0 when sensor not mounted

8.3 Start message

After device power-up/reset, *ASCII* start message is sent – „*STARTx*“ where *X* is one byte representing cause of reset.

Start message example: **535441525404.** Cause of reset in this case is **04**. This code can be used by X-LOGIC for debug.

8.4 Tamper message

Device can have one or two digital inputs for tamper detection using various switch devices (i.e detector of magnetic tamper, detector of water level, detector of open hatch). As additional tamper source device can have accelerometer built in to detect device movement.

If tamper is detected, device sends messages with 7th bit set to 1.
Device will reset tamper 30 minutes after detection (separately for every tamper) or if received downlink message contains *R* setting.

New tampers are ignored for a configured period, messages are not sent (separately for every tamper) for battery saving purposes. Default period is 30 minutes.

Tamper byte examples:
10000101 – Message is sent because of tamper detection, active tampers are: movement and tamper 1
00000011 – Regular message, active tampers are: tamper 1 and tamper 2

9 Battery endurance

Long-life, high-quality lithium battery of 3.6V is used. LoRaWAN and Sigfox devices use one 18505 size battery. NB-IoT devices use 2 AA size batteries. In non-potted devices, batteries are replaceable without soldering.

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

Pulse counting influences power consumption slightly, examples are given with one 50ms duration pulse per minute on one input. Pulse input consumes about 3.5uA when continuously pulled low.

Low and high ambient temperatures influence endurance.

Sending interval	Expected endurance [years]		
	LoRaWAN	**Sigfox**	NB-IoT
48h	45.6	52.8	17.6
24h	41.4	43.9	14.5
12h	34.8	32.8	10.7
8h	30.1	26.2	8.5
4h	21.3	16.3	5.3
2h	13.5	9.3	3.0
1h	7.8	5.0	1.6

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. Dužice 12, 10 000 Zagreb, Croatia
Proizvođač: ***Manufacturer:***	X-LOGIC d.o.o. Dužice 12, 10 000 Zagreb, Croatia
Primijenjene norme: ***Related standards:***	EN 62368-1:2014+A11:2017 EN 62311:2008 EN 301 489-1 V2.2.3:2019 Draft EN 301 489-52 V1.1.2:2020* 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. Dužice 12, 10 000 Zagreb, Croatia
Proizvođač: ***Manufacturer:***	X-LOGIC d.o.o. Dužice 12, 10 000 Zagreb, Croatia
Primijenjene norme: ***Related standards:***	EN 62368-1:2014+A11:2017 EN 62311:2008 EN 301 489-1 V2.2.3:2019 Draft EN 301 489-52 V1.1.2:2020* EN 301 908-1 V13.1.1:2019 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. Dužice 12, 10 000 Zagreb, Croatia
Proizvođač: ***Manufacturer:***	X-LOGIC d.o.o. Dužice 12, 10 000 Zagreb, Croatia
Primijenjene norme: ***Related standards:***	EN 62368-1:2014+A11:2017 EN 62311:2008 EN 301 489-1 V2.2.3:2019 Draft EN 301 489-52 V1.1.2:2020* 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.