KELLER

OPERATING MANUAL

ADT1-LR

Version 12/2023
Subject to alterations
Company certified according to ISO9001
www.keller-druck.com

Contents

1 ADT1-LR

The ADT1-LR is a maintenance-free, battery-operated (three conventional, high-quality lithium AA batteries), autonomous IoT pressure gauge with a battery life of up to 5 years. The robust, waterproof housing allows outdoor use in all places where pressure or a level must be monitored. Typical applications: Pressure monitoring (water and gas pipes), level measurement of surface water and groundwater, tanks, and liquid containers.

This device can be linked with digital level sensors and pressure transmitters with the KELLER “D” and “X” low voltage product lines. With its wide range of water level sensors and pressure transmitters, KELLER can offer the right solution for any measuring situation. The device records the pressure and temperature (and optionally conductivity as well) of the connected sensor as well as the internal measured values like barometer and temperature.

The sensor data are transmitted in real-time using LoRaWAN® radio technology. LoRaWAN® enables encrypted radio transmission over a long distance while consuming very little power. The user can obtain sensor data through KOLIBRI Cloud from KELLER, or through the user`s infrastructure. Visit KOLIBRI Cloud for insight into the data cloud service.

1.1 Overview

The remote data transmission unit is offered in two different housings (Box and Tube) that accommodate different installation requirements in the locations where it is to be used.

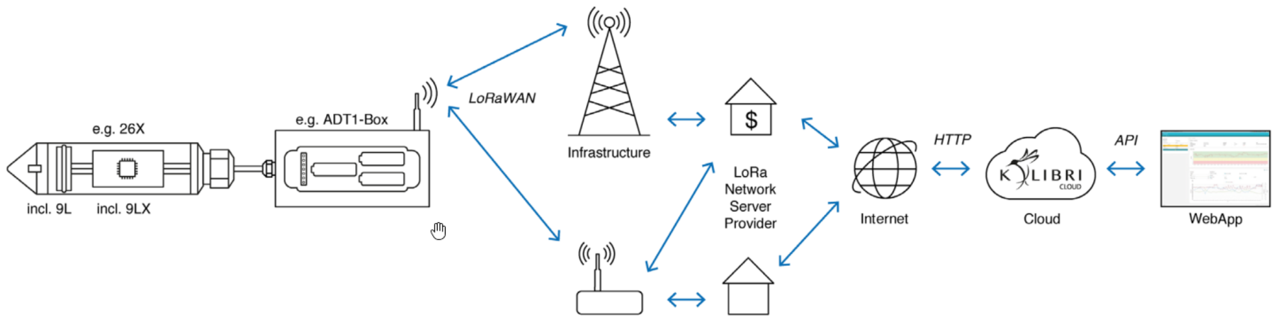
1.1.1 ADT1-Box-LR:

The remote data transmission unit ADT1-Box-LR is encased in a robust, water-tight polycarbonate housing.

1.1.2 ADT1-Tube-LR:

The remote data transmission unit ADT1-Tube-LR is encased in a robust, stainless-steel housing, which is ideally suited to installation in 2" monitoring pipes.

2 General Description / ADT1-LR Communication



The LoRaWAN® module, which can be configured on a country-specific basis, establishes a connection with a LoRaWAN® Gateway makes it possible to send the measurements to a LoRa network server. The LoRaWAN provider can be selected freely. The easiest and most convenient way to access the collected data at the end of the transmission chain is via KOLIBRI Cloud from KELLER.

2.1 Pre-Configuration

The ADT1-LR is preconfigured on the open-source, decentralized network called "The Things Network" on our KELLER TTN account. TTN is a contributor member of the LoRa Alliance and provides a set of open tools and a global, open network to connect things. This means the ADT1-LR is ready to use without any configuration changes.

Nevertheless, the ADT1-LR can be easily reconfigured through the USB interface to other network servers like Actility, Loriot, etc.

NOTE:
If you use another network server than TTN or you would like to register the devices under your TTN Account we recommend changing at least the AppEUI (JoinEUI), so that the device is not registered on the old TTN account anymore.

2.2 Data Transmission / Technology

LoRaWAN®: **Lo**ng **Ra**nge **W**ide **A**rea **N**etwork, is a protocol developed by the LoRa Alliance.

The peculiarity of this new protocol is its efficiency; because LoRaWAN® has minimal power consumption, a long range of communication (up to 15km in rural areas), and secure data transmission (with AES-128 encryption).

The range of communication is around 2km in a dense urban area, and up to 15km in rural areas and is influenced by the position of the ADT1-LR and of the gateway, if the gateway is mounted in a high place the cover will be major than it is mounted in a low place.

LoRaWAN® is part of a bigger category of technologies named LPWAN, which stands for Low Power Wide Area Network, this technology was born for the necessity of sending and receiving messages from a sensor that operates on a battery, using the smallest amount of energy available to preserve the battery energy.

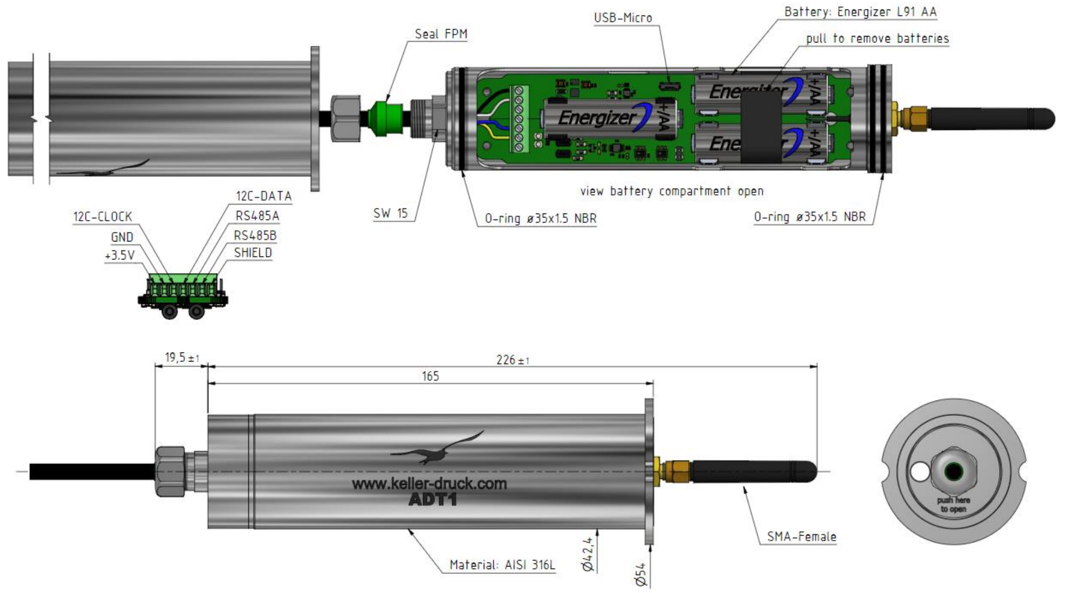
2.3 KOLIBRI Cloud

The KOLIBRI Cloud from KELLER offers simple and convenient access to your measurement data with your own personal login and SSL encryption. You can enjoy readily available data without the need to set up and maintain a database. The measurements can be displayed as graphs in no time at all and the export function allows you to download your data as Excel or CSV files. Measuring points are effortlessly and efficiently monitored with the integrated alarm system. For instance, a warning can be triggered via e-mail if there is an increase in water level or a battery is running low. The KOLIBRI Cloud API allows customer-specific software to call up measurements in a standardized JSON format via HTTPS.

3 Hardware

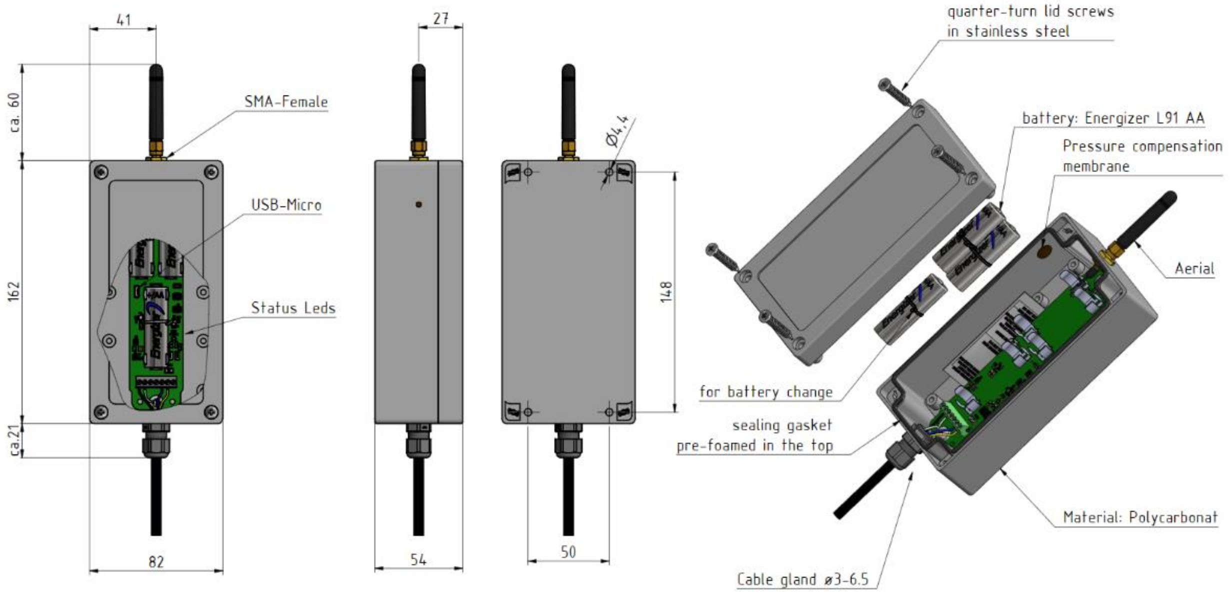
3.1 ADT1-Tube-LR

At just 43 mm in diameter, the cylindrical design of the ADT1-Tube-LR can simply be placed into the top of a two-inch-wide sounding tube standard in the groundwater measuring industry. It can be installed in a matter of seconds. The housing is designed to withstand condensation and temporary flooding. The sealed antenna can be covered by a lockable protective cap.



3.2 ADT1-Box-LR

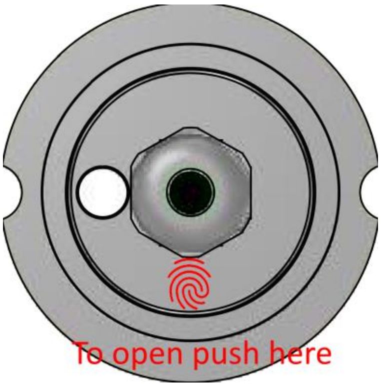
The remote data transmission unit ADT1-Box-LR is encased in a robust, water-tight, impact- and UV-resistant polycarbonate enclosure.

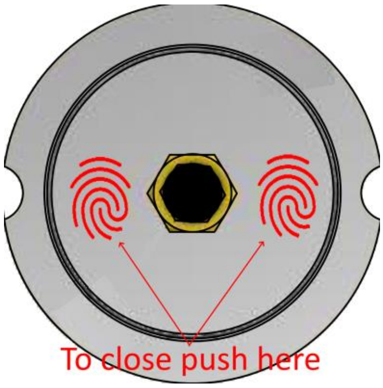


<u>CAUTION:</u>
Do not touch or **remove** the **protective vent**. Keep all sharp or jagged items away from the ePTFE membrane.

3.3 **How to open and to close the housing**

To open the ADT1-LR Tube housing, push at the marked positions against the bottom of the housing/piston (see illustration below). The ADT1-LR Box can be easily opened with a Screwdriver PZ1, unscrew the four screws and carefully open the lid.





To close the unit, push with two fingers against the top of the housing/piston until it stops. Be sure that the piston is completely inserted. Keep dry before opening and closing. To close the ADT1-LR Box you just squeeze the screws together and make a quarter turn.

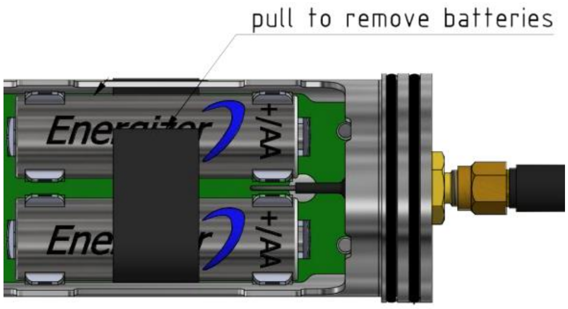
A bag containing silicate desiccant is used to protect the sensitive electronics from humidity. Put this bag into the box or tube.

CAUTION:
Do not touch the electronic components (ESD / Content static sensitive) and the ePTFE membrane.

CAUTION:
Keep dry before opening and closing. To maintain the watertight seal, all O-Rings must be kept free of dirt and debris. We recommend the use of silica-gel moisture absorbing packets which are reusable after drying out in an oven.

3.4 **Replacing batteries**

The cable twists or the tape allows the batteries to be easily removed from the holder (no tools required). Just turn the cable twist upwards and pull on the two balls to take the batterie out (see illustration below). They can then be clipped back onto the new batteries.



Insert 3 high-quality lithium AA batteries (**Energizer Ultimate Lithium / L91 (Lithium/Iron Disulfide (Li/FeS_2) / 1.5 V / 3.3 Ah)**) into the battery holders. Always replace all three batteries simultaneously with identical and new ones. Makes sure you insert the batteries the right way as shown in the picture. The device operates until the voltage drops to 3.5 V

NOTE:
When the battery is changed, the timekeeping function is working for about 4min, which has the advantage that the time does not need to be readjusted.

3.5 **Connecting the antenna**

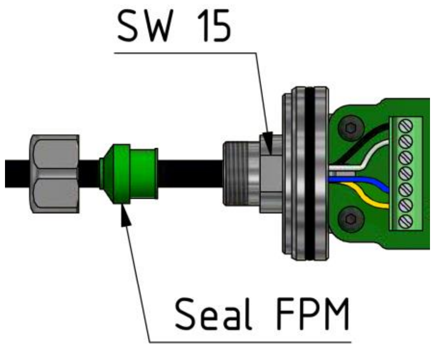
Screw the stub antenna into the corresponding SMA plug located at the top of the ADT1-LR and **tighten it by hand only**. Make sure it is tight enough.

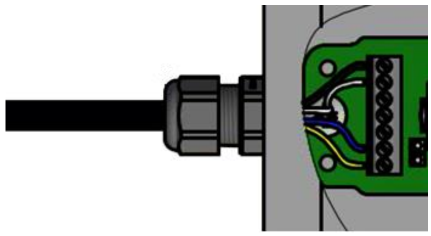
<u>CAUTION:</u>
Please only use the original accessories to prevent injuries and health risks. The Monopole antenna may have an amplification of a maximum of 1.04 dBi in the relevant frequency range.

<u>NOTE:</u>
The antenna is provided with a seal. If you use other antennas or connectors, make sure that they are also equipped with a seal.

3.6 **Cable gland / level sensor connection**

The cable gland is required to connect a level sensor. Feed the sensor cable through the cable gland and connect the cable ends to the corresponding terminal strip. The ADT1-Tube-LR has a nut with a wrench width of 15 to provide a counter torque. The cable diameter must be in the range of 3.5 to 6.4 mm.

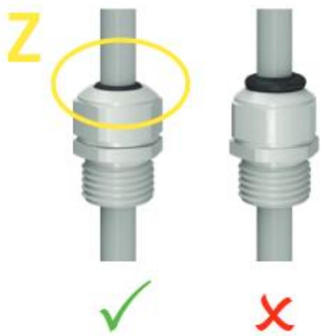




<u>CAUTION:</u>
The cable shall be tightened only over the wrench width and the cable gland. Never use the PCB as a counterpart to tighten the cable gland.

<u>CAUTION:</u>
After opening the ADT1-LR case, always make sure that the ADT1-LR case is still tight.

<u>CAUTION:</u>
The entire weight of the level sensor must be carried by the adapter socket. Make sure you tighten it well. The torque for the plastic cap nut of the box version is typically 1.7Nm and for the steel tube 5Nm.



<u>NOTE:</u>
The torques depend on many different factors and influences. The example and numbers shown are therefore intended as an optical aid.

NOTE:
If a level sensor with a reference tube is used, the reference tube is simply inserted into the housing as shown in the figure.

CAUTION:
For cable diameters in the range of 3.5 to 6.4 mm only

CAUTION:
The maximum cable length for the I^2C interface is limited due to the datasheet of the respective sensor and is usually only a few meters (typically up to 3m).

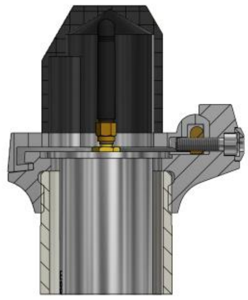
The maximum cable length (typically max. 100 m) for the RS485 interface is limited by the voltage drop of the power supply. This must be determined from the data sheet of the corresponding sensor (current consumption, line impedance, and min. supply voltage).

3.7 **Locking unit (Tube only)**

The locking unit for the ADT1-LR Tube with antenna cover is available in sizes from 2 up to 6 inches. The sealed antenna can be covered by a lockable protective cap made of robust plastic. This protects the data logger against theft and damage by people or wild animals when level measurements are being taken in the open countryside.

Option: Protection cap

Ø2"...Ø6"



3.8 **Humidity / Ventilation element**

The units are equipped with a pressure compensation element which ensures that the housing is sufficiently ventilated inside the unit so that constant pressure compensation takes place and condensation is reduced to a minimum. At the same time, the penetration of liquids and dirt is prevented. In addition, the use of silica gel (moisture absorption bag) inside the housing is recommended (included in the device), which absorbs the residual moisture. These should be replaced regularly. The internal humidity sensor, which transmits the current humidity inside the device by radio, provides an additional indication of the current humidity status of the device.

3.9 **Mounting Instructions**

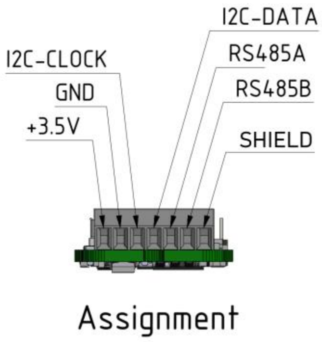
Prefer a mounting location that is protected against rain and direct sun radiation.

For best radio performance, install the device upwards with the cable towards the ground. Ideally, in such a way that the antenna faces roughly in the direction of the next gateway. Also, the higher the above ground, the better. Avoid metallic objects close to the device.

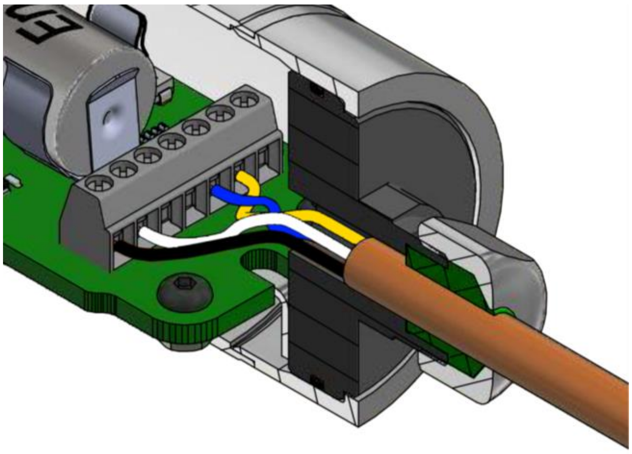
NOTE:
For outdoor installations, it is advisable to install the units so that they are protected from the weather. If this is not possible, consider self-built weather protection. If you build weather protection, use a material such as plastic that does not affect the wireless signal too much.

3.10 Connection Terminal for the Sensors

The ADT1-LR offers the possibility to connect a low-cost I^{2}C or a more precise RS485 Sensor of KELLER. The pin assignment of the ADT1-LR is shown as follows:



3.10.1 Connection for X-Line (RS485-Interface) “low voltage” type only



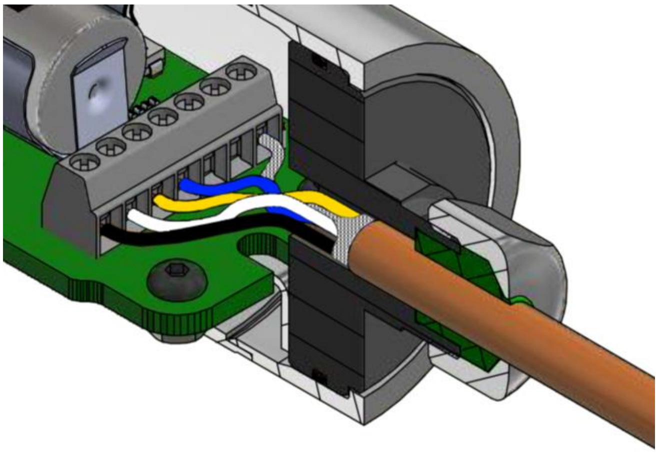
Connect the black wire to the +3.5V supply voltage and the white wire to the GND pin.

The blue wire is the RS485A (Pin 5) and the yellow is the RS485B (Pin 6) which is the communication interface to the sensor.

The RS485 Interface is with a 10kΩ resistor terminated.

NOTE:
The communication address is 250 if only one transmitter is connected. For a configuration with up to 5 transmitters, the communication address is 1 … 5. However, the communication address must be assigned in advance.

3.10.2 Connection for D-Line (I^{2}C-Interface)



Connect the black wire to the +3.5V supply voltage and the white wire to the GND pin.

The yellow wire must be connected to the clock pin (Pin 3) and the blue wire to the data pin (Pin 4). The red wire (EOC) is not required.

CAUTION: The I^{2}C interface is very sensitive to external interferences. Therefore, we recommend connecting the CASE of the Sensor to the SHIELD pin of the ADT1-LR.

NOTE:
The communication address is 0x40 if only one transmitter is connected. For configuration with up to 5 transmitters, the communication address is 0x40, 0x41, 0x43, 0x47 and 0x4F. However, the communication address must be assigned in advance

4 Operating Modes

The device has three operating modes:

Operating modes		LED1	LED2
Reset:	System (re-)start	green	red
Sleep Mode:	no measurements and data transmissions; no USB connected	green 5 sec	
Active Mode:	no measurements and data transmissions; USB connected	green 1 sec	
Active Mode:	During periodic measurements (read sensor)	green	
	and while data transmission	green 1 sec	green 1 sec
	if transmission failed		red 3x 1 sec

CAUTION: During USB connection the power consumption of the ADT1-LR is much higher (10 mA). USB does not supply or charge the ADT1-LR.

4.1 Measurement Cycle (Active Mode)

During the periodic measurements (read sensor), the device reads the values of the connected KELLER sensor with sampling period T_{SX} = 30 minutes (default, configurable) and stores the data in the internal EEPROM (RECORD). Therefore, the ADT1-LR supplies the pressure transmitter and reads the user-selected channels, when the values have been read out the power supply is switched off again. The device tries automatically to read the values on the I^2C Interface if that fails on the RS485 Interface (maximum 3 attempts per Interface/sensor), so the user does not have to care about the connected sensor. Besides these values it is also possible to read out the internal barometer with its pressure and temperature value with will be saved also in the non-volatile memory. A periodic measurement triggers automatically a transmission.

After a random delay of 0 … 6 seconds, the ADT1-LR sends the measurements. If the device has not joined the LoRaWAN® network yet, it will try to join until it succeeds (maximum 3 attempts per transmission). Afterward, it will transmit the data. In each transmission, two receive slots are opened (RX1 and RX2). During these time slots, the device is ready to receive data from the network (downlink message).

For each measurement, internal values such as humidity, battery voltage, and capacity can also be transmitted as required (see Info message).

NOTE: The lowest sampling period should not be lower than 10min, if you do so it can be, that some packets get lost, due to the airtime limitation of the LoRaWAN® technology (depends on the spreading factor (SF)).

4.2 Sleep Mode

The unit is in sleep mode; only the real-time clock is active. In this mode, the microprocessor wakes up every second to adjust the time and check if there is an event to react (LED1 is flashing in a 5-second interval).

When the USB interface is connected, the device will automatically switch to active mode (LED flashes every second).

NOTE: The power consumption with a connected USB interface is very high and discharges the battery rapidly.

4.3 Battery lifetime estimation

The value displayed in the “ADT1-LR Configuration” and the “KOLIBRI Cloud“ is the battery capacity calculated by the ADT1-LR as a percentage of remaining capacity. It is recommendable to change the battery if the value is less than **20%**. Once the battery has been changed the value is once again shown as **99%**.

NOTE:
Firmware Version < 23.38
Please note that a battery voltage change or disconnection of the battery always results in resetting the capacity indication to 99%! For this reason, the battery should be disconnected for battery replacement only.

Firmware Version >= 23.38
Please note that’s only battery voltage change of > 0.3V leads to a resetting of the capacity indication to 99%! For this reason, the battery can also be disconnected when the ADT1 is taken out of operation without losing the remaining capacity.

The calculated lifetime in the table below indicates how long the battery can last in different conditions.

Device	measure- and sending interval	Spreading Factor	lifetime estimation
ADT1-LR	10 min	SF12	> 1.7 year
ADT1-LR	10 min	SF7	> 5 year
ADT1-LR	60 min	SF12	> 7 year
ADT1-LR	60 min	SF7	> 14 year

NOTE:
The calculated lifetime values in the table are merely calculations. External conditions (like temperature and storage time) influence the battery capacity and its lifetime.

5 Configuration

The user can configure a rich set of device parameters, such as measuring interval, LoRaWAN® band, data rate, ADR Settings, power level, and many more. The parameter will be stored permanently in the internal non-volatile memory. The user can configure the device via two interfaces:

- Command line interface: via a Micro USB (Type B) cable connected to a computer with the KOLIBRI Desktop program which can be downloaded from our website https://keller-druck.com/?d=vNHsw8GWe3pFgCCe7Zifgk
- Downlink command interface: over the air using LoRaWAN® downlink messages.

For a full description of the command line interface and the downlink command interface, please find the specific documents on www.keller-druck.ch or https://docs.kolibricloud.ch/.

6 RECORD Data Storage

The record data storage offers the advantage that the measuring data doesn't get lost if the data transfer (connection to the gateway) is temporarily out of function, the data can also be read out on site. All measured values are stored in the ADT1-LR's EEPROM. The memory is organized as a circular memory. This means that always the latest data is available whilst the oldest data is overwritten.

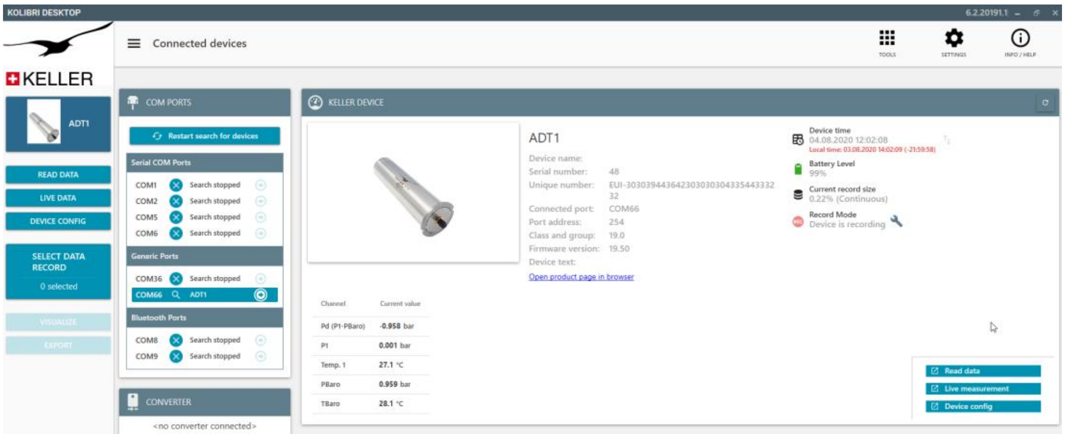
6.1 Storage Capacity

The table below shows you how much data can be stored in the ADT1-LR memory.

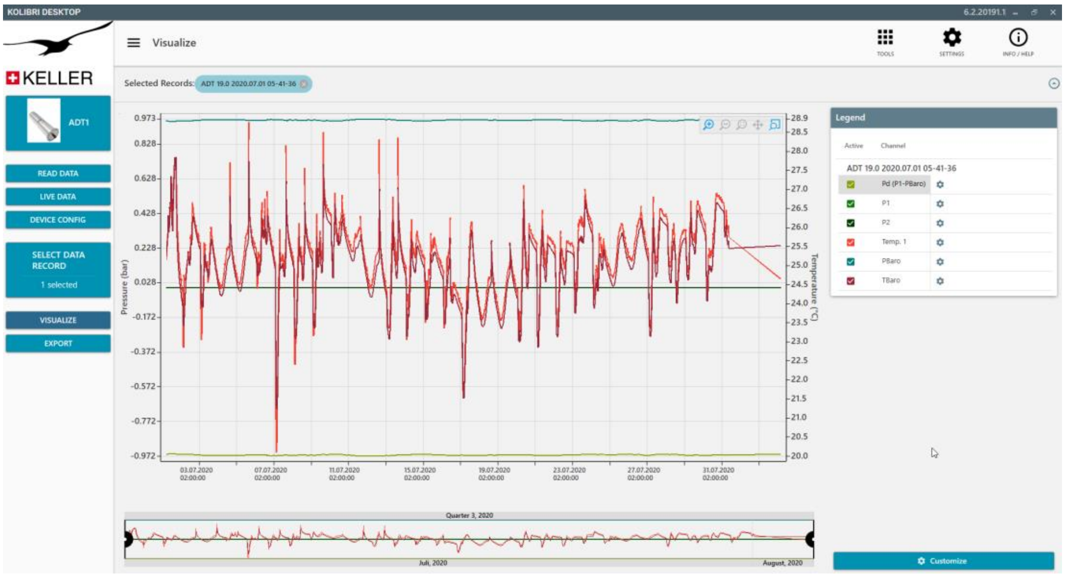
Storage interval	Number of channels	Number of measured values per channel	Recording time
10 min	4	24552	85 days
10 min	14	8184	28 days
1 h	4	24552	510 days
1 h	14	8184	170 days

6.2 Read the RECORD data by USB

Connect the ADT1-LR with the USB interface and start the "KOLIBRI Desktop" software. The device should be displayed under "Generic Ports".



The connection to ADT1-LR is now established automatically and all available RECORDs appear. Select the desired RECORD and click on the button "Start reading a selected record from device".



7 Device Registration

Before a device can communicate via The Things Network you need to register it with an application. **The ADT1-LR is preconfigured on the open-source, decentralized network called "The Things Network" on our KELLER TTN account**. TTN is a contributor member of the LoRa Alliance and provides a set of open tools and a global, open network to connect things. This means the ADT1-LR is ready to use without any configuration changes.

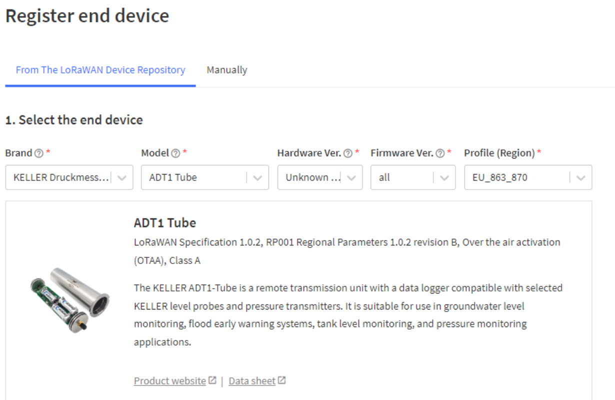
Nevertheless, the ADT1-LR can be easily reconfigured through the USB interface to other network servers like Actility, Loriot, etc.

NOTE:
If you use another network server than TTN or you would like to register the devices under your own TTN Account we recommend changing at least the AppEUI (JoinEUI), so that the device is not registered on the old TTN account anymore.

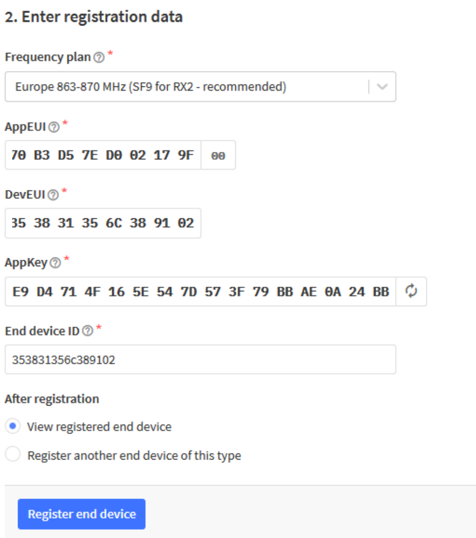
7.1 Integration with the Things Network (TTN)

To use the default **Over the Air Activation** (OTAA) you will need to register your device with its Device EUI:

1. Access the TTN portal https://www.thethingsnetwork.org/. An account is free, and the entry page is https://console.thethingsnetwork.org/If you don't have an application yet, you need to create one. For more information on how to do this have a look at the network server information.
2. Open the application to which you wish to add a device and click **add end device**. Select "KELLER Druckmess-technik AG" as a Brand and select the model according to our device. Set the Profile parameter of our region.



   - Choosing a **frequency plan**. In Europe choose **"**Europe 863-870 MHz (SF9 for RX2 - recommended)"
   - For **Device EUI**, copy-paste the one you retrieved from your device.
   - Leave the **App Key** to be generated.
   - For **App EUI (JoinEUI)**, enter the AppEUI from the device.



3. Click **Register end device** to finish.

7.1.1 **Activation**

LoRaWAN devices have a 64-bit unique identifier “Device EUI” that is assigned to the device by the chip manufacturer. However, all communication is done with a dynamic 32-bit device address “Device Address” a procedure called **Activation**.

7.1.1.1 Over-the-Air Activation (OTAA / default)

Over-the-Air Activation (OTAA) is the preferred and most secure way to connect with the LoRa network. Devices perform a join-procedure with the network, during which a dynamic Device Address is assigned, and security keys are negotiated with the device.

7.1.1.2 Activation by Personalization (ABP)

In some cases, you might need to hardcode the Device as well as the security keys in the device. This means activating a device by personalization (ABP). This strategy might seem simpler because you skip the join procedure, but it has some downsides related to security.

7.1.2 **LoRaWAN Security**

When a device joins the network (this is called a join or activation), an application session key and a network session key are generated. The network session key is shared with the network, while the application session key is kept private. These session keys will be used for the duration of the session.

The **Network Session Key** is used for interaction between the Node and the Network Server. This key is used to validate the integrity of each message by its Message Integrity Code (MIC check). This MIC is like a checksum, except that it prevents intentional tampering with a message. For this, LoRaWAN uses AES-CMAC. In the backend of The Things Network, this validation is also used to map a non-unique device address to a unique Device EUI and Application EUI.

The **Application Session Key** is used for encryption and decryption of the payload. The payload is fully encrypted between the Node and the Handler/Application Server component of The Things Network (which you will be able to run on your own server). This means that nobody except you can read the contents of messages you send or receive.
These two session keys (network and application session keys) are unique per device, per session. If you dynamically activate your device (OTAA), these keys are re-generated on every activation. If you statically activate your device (ABP), these keys stay the same until you change them.

The **Application key** is only known by the device and by the application. Dynamically activated devices (OTAA) use the **Application Key** to derive the two session keys during the activation procedure.

7.1.3 **Data Rate**

There are some knobs you can turn: **transmission power** and **spreading factor**. If you lower the transmission power, you’ll save battery, but the range of the signal will obviously be shorter. The other knob is the data rate. This determines how fast bytes are transmitted. If you increase the data rate you can transmit those bytes in a shorter time. For those, the calculation is approximate as follows: Making the spreading factor 1 step lower (from SF10 to SF9) allows you to send 2x more bytes at the same time. Lowering the spreading factor makes it more difficult for the gateway to receive a transmission, as it will be more sensitive to noise.

7.1.4 **LoRaWAN Adaptive Data Rate**

Adaptive Data Rate (ADR) is a mechanism for optimizing data rates, airtime, and energy consumption in the network. ADR should be enabled for static devices, like the ADT1-LR.

To determine the optimal data rate, the network needs some measurements (uplink messages). The network calculates the so-called “margin”, which is used to determine how much the network can increase the data rate or lower the transmit power, which means more airtime- and energy efficiency. The network could even lower the transmit power to save more energy and cause less interference.

8 Perform water level configuration with ADT1-LR devices

8.1 Description

This document is intended to show how to determine the installation parameters needed for the calculation of the water level, especially the installation length. At the same time, the different types of water level calculations are listed. The focus of the description is for ADT1-LR data transmission units with a level probe and the determination of the installation length.

8.2 Basics for level measurement with pressure sensors

Level probes detect water levels based on a pressure measurement. If a pressure probe (level probe) is immersed in water, the pressure acting on the pressure probe increases in proportion to the immersion depth with the water level. Per 1cm water height a pressure of about 1 mbar (0.001 bar) results.

The pressure signal of the level probe can be read out via the digital interface. The read-out pressure value can then be converted into one of the three levels explained in more detail below.

Pascal's law $p = r \times g \times h$ $h = \frac{p}{r\, x\, g}$

p = Hydrostatic pressure as a function of height [m] r = density of water (~ 998.2 kg/m^3) g = acceleration due to gravity (~ 9.80665 m/s^2)

The density of the water depends on the type of water (freshwater, saltwater, ...), as well as on the temperature of the water. Mostly a value of 998.2 kg/m^2 is used for the density. The acceleration of gravity varies depending on the place on earth where you are. Usually, a value of 9.81 m/s^2 is used for the calculation. With these parameters the following results are obtained for 1 bar = 10.212 mWS or 1 mbar = 1.0212 cmWS.

8.3 Air pressure dependence

When using a relative pressure sensor for level measurement, the air pressure compensation is done through the reference opening to the pressure sensor. Measured and output from the pressure sensor (P_1), the air pressure is thus independent of the air pressure.

When measuring with an absolute pressure sensor, the air pressure (barometer) (P_2/P_{Baro}) must also be recorded. This air pressure must be subtracted from the recorded pressure measurement P_1 (water level). This eliminates air pressure fluctuations. For this reason, our ADT1-LR devices are equipped with a barometer that measures and can record the barometric air pressure (P_2/P_{Baro}).

For the calculation, the pressure difference P_1-P_2 or P_1-P_{Paro} is then used instead of P_1, as a pressure value for water level calculation.

8.4 Water level calculation types

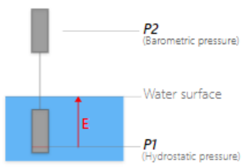
There are essentially 3 different calculation types.

8.4.1 Water height above probe

At water height above probe (E), the water column/water height above the probe is measured.

Water height [E]

$$E = \frac{P1 - P2}{\rho * g} + Offset$$



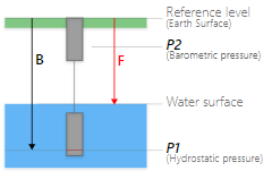
P1 (Hydrostatic pressure)	P1	[Pa]
P2 (Barometric pressure)	PBaro	[Pa]
ρ (Density)	998.2	[kg/m^3]
g (Gravitation)	9.80665	[m/s^2]
Offset	0	[m]

8.4.2 Depth to water

At depth to water (F), the distance from the upper edge of the measuring point to the water surface is determined. For the calculation of the depth upper edge of the measuring point to the water surface, the installation length B must be known.

Depth to water (F)

$$F = B - \frac{P1 - P2}{\rho * g} + Offset$$



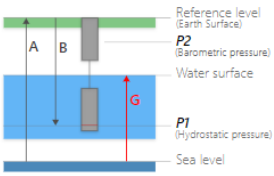
P1 (Hydrostatic pressure)	P1	[Pa]
P2 (Barometric pressure)	PBaro	[Pa]
B (Installation length)	10	[m]
ρ (Density)	998.2	[kg/m^3]
g (Gravitation)	9.80665	[m/s^2]
Offset	0	[m]

8.4.3 Water height related to sea level

At water level related to sea level (G) the water level/water level related to sea level is calculated. With this information, the measured values from different locations can be compared with each other. For this calculation, the installation length B and the height above sea level of the upper edge of the measuring point are required.

Height of water ASL (G)

$$G = A - B + \frac{P1 - P2}{\rho * g} + Offset$$



P1 (Hydrostatic pressure)	P1	[Pa]
P2 (Barometric pressure)	PBaro	[Pa]
A (Reference level above sea)	500	[m]
B (Installation length)	10	[m]
ρ (Density)	998.2	[kg/m^3]
g (Gravitation)	9.80665	[m/s^2]
Offset	0	[m]

8.5 Determining the installation length by measuring with a tape measure

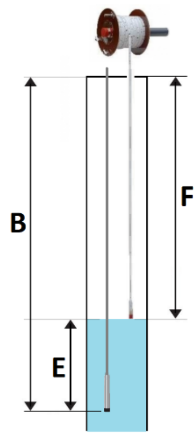
The installation length (B) can be determined by measuring from the upper edge of the remote transmission unit to the level probe (marker) with a tape measure.

For this purpose, the level probe must be mounted to the remote transmission unit and then laid out on the ground. Make sure that the cable of the level probe is taut, so that measurement errors are avoided. The length is measured from the upper edge of the remote transmission unit to the marking of the level probe. This measured value corresponds to the installation length (B).

This method for determining the installation length is only suitable for shorter cables because the stretching of the level probe cable is difficult to manage with a long cable and an appropriate space must also be available.

We recommend determining the installation length (B) at the measuring point, as explained below. The advantage of this method is that all influences such as a not completely stretched cable etc. are corrected and during the installation, it can be checked whether the water level calculation is correct with the determined parameters.

8.6 Determining the installation length (B) at the measuring point



The installation length B is most easily determined on-site at the measuring point by measuring the distance F from the upper edge of the measuring point to the water surface with a tape measure/light plummet.

The water level E is read out by the pressure sensor/level sensor.

B = E + F

By the addition of distance upper edge to water surface F and water height E, the installation length B results, which is needed for the water level calculation depth to water (tap) F and water height related to sea level G.

8.7 Electric contact gauge

An electric contact gauge is a tape measure on a roll, which is lowered into the measuring point with a weight. As soon as the weight, which also includes an electrical contact, touches the water surface, a sound is generated. When the sound is heard, the exact distance to the water surface can be read off the measuring tape at the upper edge of the measuring point.

8.8 Determining the installation length with ADT1-LR remote transmission unit

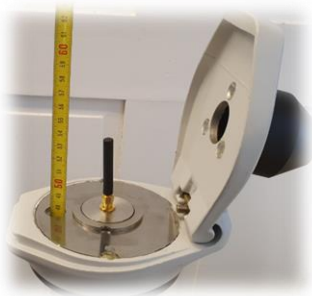
Since the ADT1-LR remote transmission unit has no external connector for the interface, the level measurement e must be performed with the housing open.

Note that the housing length must then be added to the measurement result to obtain the correct installation length.

Install the ADT1-LR device with a level probe in the level measuring point.

Measure and note the distance **B** from the measuring point to the water surface.

In the example, the upper measuring point to the water surface is B = 0.48 m



Connect the ADT1-LR device to the PC. To get access to the internal USB interface the ADT1-LR device must be opened.

The housing sleeve can remain in the measuring point, place the inner part with the electronics on the housing sleeve.

Now the height of the water column **e** above the sensor can be measured via the interface.

As the inner part of the ADT1-LR is pulled out, the position of the level probe changes by 16.5 cm, i.e., the length of the inner part.

This 16.5 cm must be added later to the measured level over probe e so that the correct installation length can be determined.

Start software "ARC/GSM/ADT Configuration" and change to the Tab "Water level configuration" (assuming all other ADT1-LR measurement settings are done).

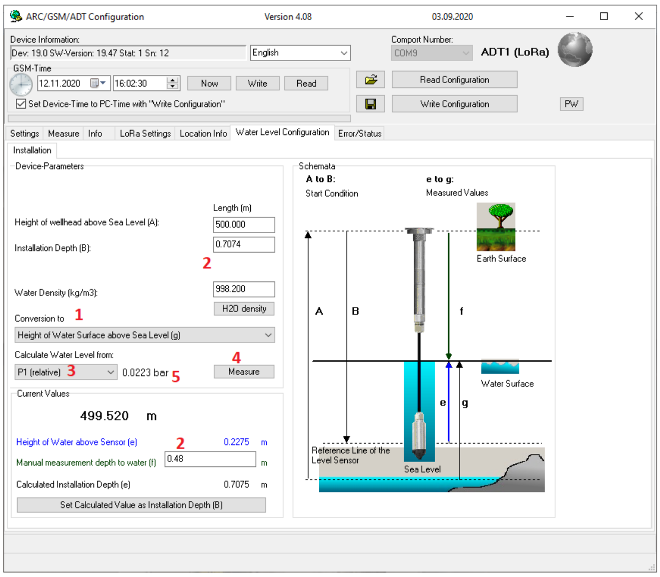
(1) Select desired calculation method

(2) Fill in the parameters

(3) Select the measuring channel that is responsible for the water level measurement. For absolute pressure measurement select P_1-P_{Baro}, for relative pressure measurement select P_1(relative). In this example, a relative sensor is used

(4) Press the "Measure" button, and the current measured value is recorded

(5) The measuring value P_1(relative) is displayed, in this example 0.0223 bar which corresponds to 0.2275 m



Thus, the height of the water column **e** above the sensor is 0.7075 m. To this value must now be added the length of the inner part of the ADT1-LR housing, 16.5 cm.

Water column e = 0.2275 m + 0.165 m = 0.3925 m

By adding the distance of the upper edge to the water surface **F** and water height **e**, the installation length **B** is obtained.

Installation length B = F + e = 0.48 m + 0.3925 m = 0.8725 m

All measured values and parameters should be noted down for safety reasons, preferably with date and time.

The parameters can now be transferred to the device by pressing the "Write Configuration" button. It is possible to transfer the complete settings to the receiving station by remote transmission, by sending the configuration.

The water level configuration is needed at the receiving center to convert pressure to the desired water level. With the KOLIBRI Cloud the parameters can be entered or changed. The cloud also receives the parameters, which are transmitted via a remote transmission (configuration messages).

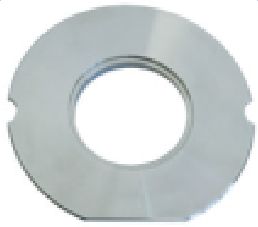
The plug can now be removed from the interface, the remote transmission unit reassembled, and the level measuring point closed with the level cap.

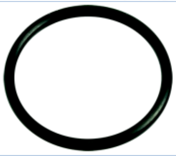
9 ADT1-LR order information

9.1 Variants and options

Description	Product number	Picture
ADT1-Tube, LoRa, stub antenna, batteries	ADT1-Tube-LR 320060.0004	
ADT1-Box, LoRa, stub antenna, batteries	ADT1-Box-LR 320060.0001	

9.2 Accessories

Description	Product number	Picture
Locking Unit 2'' 3'' 4'' 5'' 6''	 509210.0001 509210.0002 509210.0003 509210.0004 509210.0005	
Adapter ring suitable for the locking unit 3'' 4'' 5'' 6''	 506810.0118 506810.0119 506810.0102 506810.0120	
Micro USB cable (B-Type)	309010.0134	

Antenna	331005.0005	
Antenna for manhole cover with SMA connection Cable length: 2m	320020.0133	
O-Ring 35x1.5 mm (cable gland side)	508620.0023	
Silicagel bag, 5 g	702505.0007	

10 Ingrees Protection – IP

10.1 Humidity / Ventilation element

The units are equipped with a pressure compensation element which ensures that the housing is sufficiently ventilated inside the unit so that constant pressure compensation takes place and condensation is reduced to a minimum. At the same time, the penetration of liquids and dirt is prevented. In addition, the use of silica gel (moisture absorption bag) inside the housing is recommended (included in the device), which absorbs the residual moisture. These should be replaced regularly. The internal humidity sensor, which transmits the current humidity inside the device by radio, provides an additional indication of the current humidity status of the device.

10.2 Application / Assembly

For outdoor installations, it is advisable to install the units so that they are protected from the weather. If this is not possible, consider a self-built weather protection. If you build a weather protection, use a material such as plastic that does not affect the wireless signal too much.

Note: The unit is not intended to be used underwater. The IP protection is only to be understood as a short-term flood protection (IPX7 / IPX8).

10.3 Test condition (IPX7 / IPX8)

The devices have been subjected to a type test at KELLER AG, where they are completely submerged in an immersion basin. The immersion depth as well as the test duration are carried out according to the specified definitions. **Devices with optional IPX7/IPX8 protection are subjected to a final test in a water bath. The unit is immersed in water at a depth of 1 m for 1 h, after which it is optically evaluated whether water has penetrated the unit.**

10.4 Note

The test conditions are met if no water or water in a non-harmful quantity has penetrated within the specified time of the test. Since the tests of the protection class do not take aging into account, the maintenance of the protection class over the lifetime of the device is not guaranteed. Similarly, temperature changes, such as those which may occur in open air weather, are not considered. If the ventilation is blocked, such temperature changes lead, among other things, to negative pressure in the housing, and under certain circumstances, moisture can be sucked in through the sealing areas.

10.5 What is an "IP" rating?

The "IP" rating tells you how resistant the equipment is to dust and liquids. It is simple code that covers a range of international standards for enclosure and electronic equipment. This code was developed to provide customers with more information about how weatherproof an enclosure is, rather than just claiming that it is weatherproof.

10.6 What does the numbers 65, 67 and 68 stand for?

The first digit of the IP code represents the level of protection against dust. While 0 indicates "no protection", the number 6 stands for "dustproof". The second digit represents the level of protection against water. The higher the number, the stronger the level of protection.

- IPX5: Protection against water jets (nozzle) from any angle
- IPX7: Protection against temporary immersion (1 m @ 30 min)
- IPX8: Protection against permanent immersion (as defined by the manufacturer but > IPX7)

10.7 What does the IP certification mean for my device?

- IPX5: defines on the one hand that the device is dustproof and on the other hand that it is protected against precipitation.
- IPX7: defines on the one hand that the device is dustproof and on the other hand protection against temporary immersion in water up to a maximum depth of 1 meter for a maximum of 30 minutes.

- IPX8: defines on the one hand that the device is dustproof and on the other hand protection against continuous immersion in water up to a maximum depth of 2 meters for a maximum of 24 hours (requirement defined by KELLER AG)

Note: The information given refers to clear water; other liquids, e.g., salt water, soapy water, alcohol, or heated liquids, do not provide protection. In addition, care must be taken to ensure that all covers/screw connections of the unit are always fully tightened and closed. It must also be ensured that the seals are free of dirt and well-greased (vacuum grease) so that no water can penetrate.

11 Regulatory Statements of the radio module

11.1 FCC and ISED Regulatory notices / Avis réglementaires de FCC et ISDE

Model	FCC ID
ADT1-Tube-LR **ADT1-Box-LR**	Contains transmitter module FCC ID: VPYCMABZ

Model / Modèle	ISED Certification Number / Num. de certification ISDE
ADT1-Tube-LR **ADT1-Box-LR**	Contains IC / Contient IC: 772C-CMABZ

11.1.1 Modification statement / Déclaration de modification

Any changes or modifications could void the user's authority to operate the equipment.

Tout changement ou modification peuvent annuler le droit d'utilisation de l'appareil par l'utilisateur.

11.1.2 Interference statement / Déclaration d'interférence

This device complies with Part 15 of the FCC Rules and Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions:
(1) this device may not cause interference, and
(2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :
(1) l'appareil ne doit pas produire de brouillage, et
(2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

11.1.3 Wireless notice / Wireless avis

This device complies with FCC/ISED radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines and RSS-102 of the ISED radio frequency (RF) Exposure rules. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. The antenna should be installed and operated with a minimum distance of 20 cm between the radiator and your body.

Le présent appareil est conforme à l'exposition aux radiations FCC / ISED définies pour un environnement non contrôlé et répond aux directives d'exposition de la fréquence de la FCC radiofréquence (RF) et RSS-102 de la fréquence radio (RF) ISED règles d'exposition. L'émetteur ne doit pas être colocalisé ni fonctionner conjointement avec à autre antenne ou autre émetteur. L'antenne doit être installée de façon à garder une distance minimale de 20 centimètres entre la source de rayonnements et votre corps.

11.2 Antenna

This radio transmitter has been approved by FCC and ISED to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

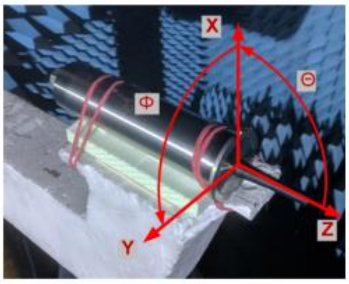
Le présent émetteur radio a été approuvé par FCC and ISDE pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Model / Modèle	Antenna Type / Type d'Antenne
ADT1-Tube-LR **ADT1-Box-LR**	Omnidirectional Antenna Gain 1.04 dBi Omnidirectionelle Gain de l'antenne 1.04 dBi

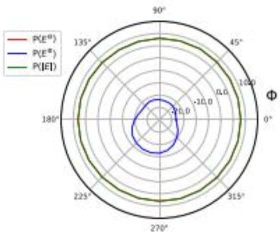
12 RF Performance measurements

12.1 ADT1-Tube-LR

UL-Frequency:	863099890 Hz
TRP:	10.1 dBm
max. EIRP (Θ):	14.4 dBm at (Θ=120.0°, Φ=0.0°)
max. EIRP (Φ):	-8.6 dBm at (Θ=180.0°, Φ=-90.0°)
max. EIRP (abs):	14.4 dBm at (Θ=120.0°, Φ=-165.0°)



(a) Device under Test



(b) xy-plane

Channel	max. EIRP (dBm) P(E^{Θ})	P(E^{Φ})	P($\|E\|$)	TRP (dBm)
LOW	14.4	-8.6	14.4	10.1
MID	14.4	-8.5	14.4	10.1
HIGH	14.4	-7.9	14.4	10.1
HIGH (RX2)	14.4	-8.0	14.4	10.1

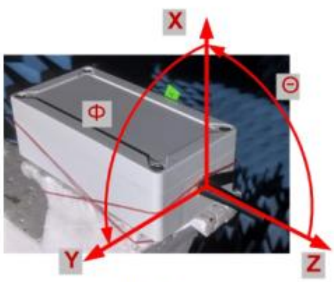
Table 4.1: Tx Power Measurement Result Summary

Channel	max. EIS (dBm) S^{Θ}	S^{Φ}	S^{eff}	TIS (dBm)
LOW-SF7BW125	-126.0	-103.0	-126.0	-121.6
LOW-SF12BW125	-140.0	-117.0	-140.0	-135.7
MID-SF7BW125	-125.3	-102.4	-125.3	-121.0
MID-SF12BW125	-140.4	-117.5	-140.4	-136.0
HIGH-SF7BW125	-125.0	-102.7	-125.0	-120.7
HIGH-SF12BW125	-139.5	-117.2	-139.5	-135.2
HIGH (RX2)-SF7BW125	-125.3	-102.9	-125.3	-121.0
HIGH (RX2)-SF12BW125	-139.4	-117.0	-139.4	-135.1

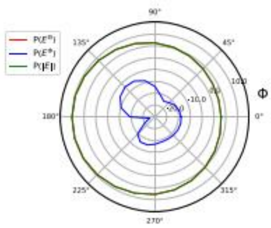
Table 4.2: Rx Sensitivity Result Summary

12.2 ADT1-Box-LR

UL-Frequency:	863100000 Hz
TRP:	9.6 dBm
max. EIRP (Θ):	14.3 dBm at (Θ=120.0°, Φ=-165.0°)
max. EIRP (Φ):	-2.3 dBm at (Θ=180.0°, Φ=-255.0°)
max. EIRP (abs):	14.3 dBm at (Θ=120.0°, Φ=-180.0°)



(a) Device under Test



(b) xy-plane

Channel	max. EIRP (dBm) P(E^{Θ})	P(E^{Φ})	P($\|E\|$)	TRP (dBm)
LOW	14.3	-2.3	14.3	9.6
MID	14.2	-2.3	14.2	9.5
HIGH	14.0	-2.4	14.0	9.3
HIGH (RX2)	14.0	-2.4	14.0	9.3

Table 4.1: Tx Power Measurement Result Summary

Channel	max. EIS (dBm) S^{Θ}	S^{Φ}	S^{eff}	TIS (dBm)
LOW-SF7BW125	-124.9	-108.3	-124.9	-120.2
LOW-SF12BW125	-140.0	-123.4	-140.0	-135.2
MID-SF7BW125	-125.4	-108.9	-125.4	-120.7
MID-SF12BW125	-139.4	-122.9	-139.4	-134.7
HIGH-SF7BW125	-125.1	-108.7	-125.1	-120.4
HIGH-SF12BW125	-139.7	-123.3	-139.7	-134.9
HIGH (RX2)-SF7BW125	-125.5	-109.1	-125.5	-120.8
HIGH (RX2)-SF12BW125	-139.6	-123.2	-139.6	-134.8

Table 4.2: Rx Sensitivity Result Summary

13 Version History

Version	Date	Description
12/2023	**11.12.2023**	Update layout Update torque for 3.6 Cable gland / level sensor connection Add 4.3 Battery lifetime estimation Update 5 Configuration Add 10 Ingrees Protection – IP
03/2023	28.03.2023	Remove 9.2 Accessories / O-Ring 37x1.5 mm (Antenna side) PN: 508620.0022
10/2022	20.10.2022	Update Company name Update product pictures Update chapter 3.4 Replacing batteries. Add chapter 3.8 Humidity / Ventilation element. Update chapter 3.9 Mounting Instructions
05/2021	26.05.2021	Update the chapter " Integration with the Things Network (TTN)"
02/2021	16.02.2021	Add RF Performance measurements
11/2020	18.11.2020	Add Regulatory Statements of the radio module. Add level measurement. Add a description of the new function rejoin and link check in the settings (6)
08/2020	07.08.2020	New document

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