KELLER

OPERATING MANUAL

ARC1

Version 11/2024
Subject to alterations
Company certified according to ISO9001
www.keller-pressure.com

Contents

1 ARC1

The remote data transmission unit ARC1 with logger function is encased in a robust, stainless steel or aluminium housing. This unit records measurements made by external sensors (e.g. a level sensor) and periodically transmits the collected data via 2G, 3G, 4G, NB-IoT, LTE-M or LoRaWAN, depending on the selected radio module. The high-performance battery and sophisticated power management enable autonomous operation for up to 10 years. Typical applications: Pressure monitoring (water and gas pipes), level measurement of surface water and groundwater tanks, and liquid containers.

KELLER provides a range of licence-free software solutions for configuration and data processing. The easiest and most convenient way to access the collected data is via PressureSuite Cloud.

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 ARC1-Box:

Sketch

Connectivity	2G / 3G / 4G / NB-IoT / LTE-M / LoRa
Sensor Interfaces	RS485, SDI-12, analog, digital
Battery Life	Up to 10 years
Dimensions	200 x 100 x 81 mm
Special Characteristics	For wall installation

The remote data transmission unit ARC1-Box is encased in a robust, water-tight aluminium housing.

1.1.2 ARC1-Tube:

Sketch

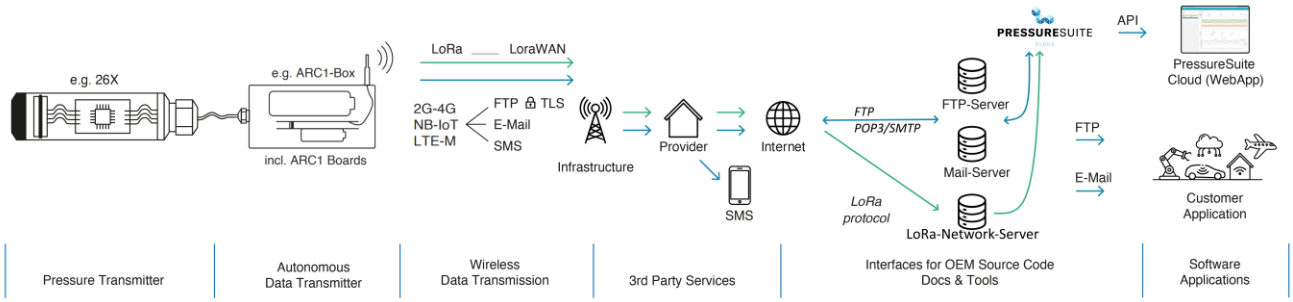
Connectivity	2G / 3G / 4G / NB-IoT / LTE-M / LoRa
Sensor Interfaces	RS485, SDI-12, analog, digital
Battery Life	Up to 10 years
Dimensions	ø 48 mm x 330 mm
Special Characteristics	For 2" monitoring pipes
Battery	Lithium / DD / 3.9 V / 35 Ah
Reading Capacity	56'000

The remote data transmission unit ARC1-Tube is encased in a robust, stainless-steel housing, which is ideally suited to installation in 2" monitoring pipes.

2 General Description

KELLER's solution offers a robust and flexible approach to data handling, spanning from pressure measurement to end-device access, thanks to its modular data chain structure. The ARC1 remote transmitter plays a central role as an intermediary between the pressure transmitter and receiver station, facilitating efficient data transfer. This setup enables seamless integration with existing transmitters and supports highly accurate KELLER level sensors, OEM transmitters, or transducers for specialized needs.

For software integration, KELLER provides well-documented protocols, including LoRaWAN, FTP, Email, and API, enabling smooth connectivity with custom systems. In addition, DLLs and example source codes offer valuable support for developers. While these options increase integration flexibility, KELLER's PressureSuite Cloud remains the simplest way to access collected data, making it an optimal choice for users who prefer ease of use without extensive integration effort.



NOTE:
A detailed description of the ARC1 communication protocol can be found under Communication Protocol ARC1. The protocol documentation is also available on docs.pressuresuite.com, which includes a Live-Editor for real-time configuration and testing. This tool enables users to interactively explore and customize the protocol parameters, enhancing ease of integration and setup for various applications.

2.1 Wireless Data Transmission / Technology

Each technology has its strengths, depending on the use case and available infrastructure.

2.1.1 Cellular communication

Mobile networks have evolved significantly from 2G to 4G, with each generation bringing improvements in speed, data rates, security and coverage. These developments formed the basis for the introduction of Low Power Wide Area Networks (LPWAN) such as NB-IoT (Narrowband Internet of Things) and LTE-M (Long Term Evolution for Machines), which were developed specifically for the requirements of the Internet of Things (IoT).

Thanks to the widespread availability of existing mobile networks, from 2G to 4G, even in less developed countries, NB-IoT and LTE-M offer the particular advantage of ensuring reliable coverage indoors. These technologies are particularly beneficial in challenging environments, such as underground locations or remote areas where traditional cellular coverage is often limited.

2.1.2 LoRa communication (non-cellular)

LoRaWAN®: **Lo**ng **Ra**nge **W**ide **A**rea **N**etwork, is a protocol developed by the LoRa Alliance and is part of Low Power Wide Area Networks (LPWAN). The peculiarity of this protocol is its efficiency, because LoRaWAN® has minimal power consumption, a long range of communication (up to 15km in rural areas and 2km in a dense urban areas), and secure data transmission (with AES-128 encryption).

LoRaWAN® operates in the unlicensed spectrum, which means there are no license fees. This enables a flexible network infrastructure as everyone can set up their own networks. Operating costs are also lower as no spectrum or SIM card fees are required. The absence of mobile network providers increases cost efficiency and offers more independence but can also result in interference with other users in the same frequency range.

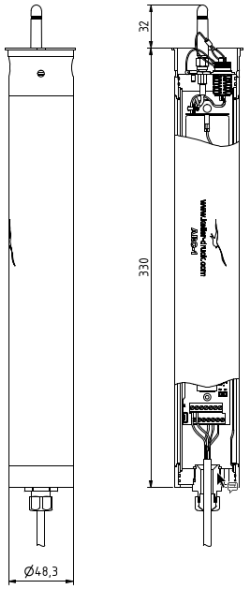
2.2 PressureSuite Cloud

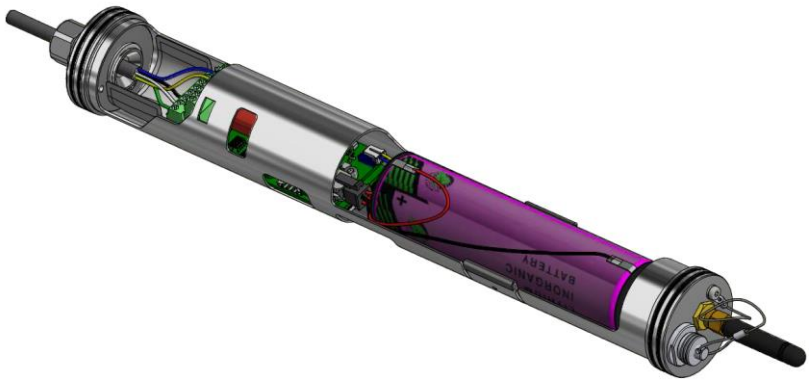
The PressureSuite Cloud from KELLER offers simple and convenient access to your measurement data with your own personal login and SSL encryption. You can enjoy readily available data without the need to set up and maintain a database. The measurements can be displayed as graphs in no time at all and 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 PressureSuite Cloud API allows customer-specific software to call up measurements in a standardised JSON format via HTTPS.

4 Hardware

4.1 ARC1-Tube

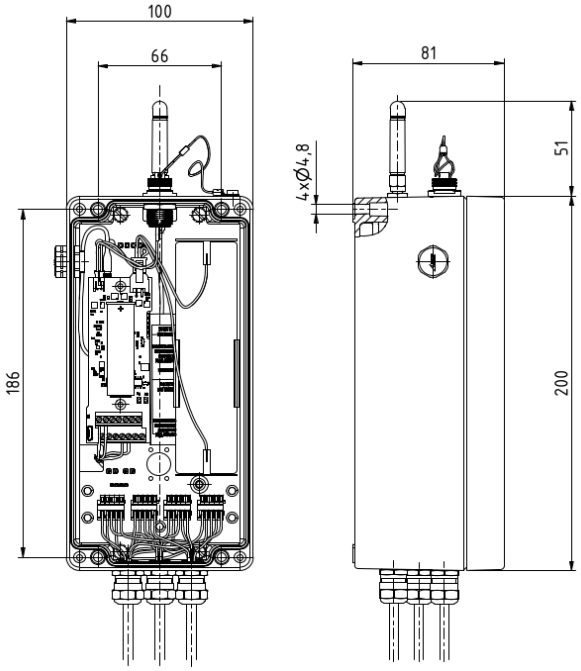
At just 49 mm in diameter, the cylindrical design of the ARC1-Tube can simply be placed into the top of a two-inch-wide sounding tube standard in the groundwater measuring industry. It can be installed in a matter of seconds. The housing is designed to withstand condensation and temporary flooding. The sealed antenna can be covered by a lockable protective cap.

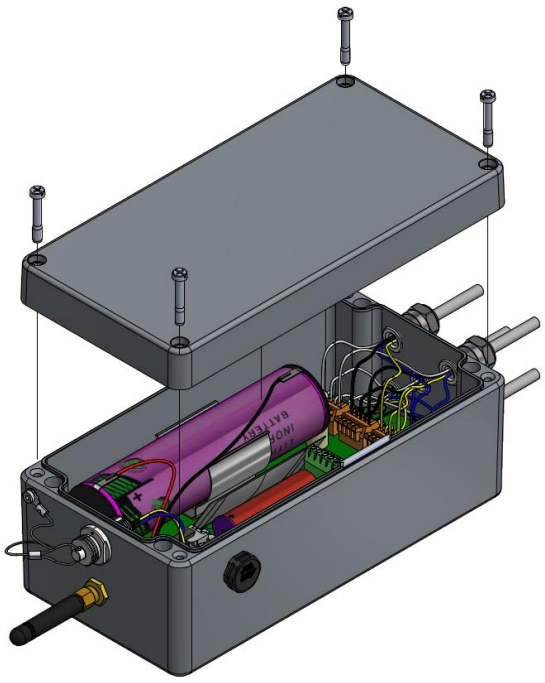




4.2 ARC1-Box

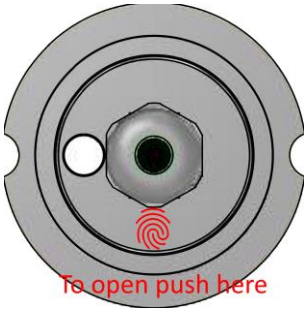
The remote data transmission unit ARC1-Box is encased in a robust, water-tight, impact- and UV-resistant water-tight aluminium enclosure.





4.3 Opening and closing the housing

To open the ARC1-Tube housing, push at the marked positions against the bottom of the housing/piston (see illustration below). The ARC1-Box can be easily opened with a hex key 2.5 mm, unscrew the four screws and carfully open the lid.



Bottom

Top

To close the unit, push with the 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 ARC1 box simply tighten the 4 Allen screws cross-wise alternating pattern. A bag containing silicate desiccant is used to protect the sensitive electronics from humidity. Put this bag into the box or tube. The holes at the top of the ARC1-Tube allow water to drain preventing the pipe from filling up.

CAUTION:
Do not touch the **electronic components (ESDS / Electrostatic sensitive discharge components)**.

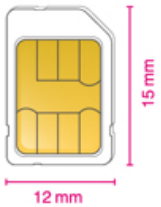
CAUTION:
Do not touch or **remove** the **protective vent**. Keep all sharp or jagged items away from the ePTFE membrane.

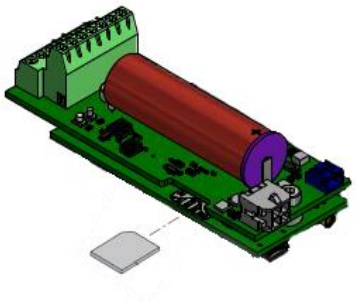
CAUTION:
Keep dry before opening and closing. To maintain the watertight seal, all O-Rings must be **kept free of dirt and debris**. We recommend the use of silica-gel moisture absorbing packets which are reusable after drying out in an oven.

4.4 SIM card (only for cellular version)

For communication via the mobile network, you need a SIM card (3FF / micro SIM).

3FF / micro SIM





NOTE:
We recommend the use of a prepaid card. Thus, in case of an incorrect configuration, only the current credit on the card is used up. Make sure that there is always sufficient credit on the card. Contact your phone provider for information on recharging options and configuration settings (APN, username, password).

4.4.1 Inserting and removing the SIM card

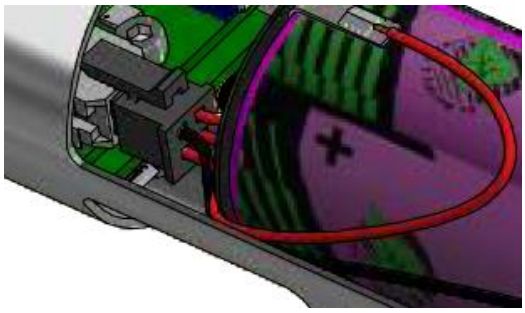
To insert, gently push the SIM card as shown in the illustration (bevelled corner facing left) into the silver SIM card compartment as far as it will go. Make sure that the SIM card is fully inserted. By simultaneously pressing and pulling on the SIM card, it can be pulled out.

CAUTION:
Please ensure that you insert your SIM correctly. Do not touch the gold-coloured contacts of the SIM card when inserting!

4.5 Batterie

The ARC1 is equipped with a premium-quality lithium thionyl chloride battery (3.9 V/35 Ah). In combination with an HLC (Hybrid Layer Capacitor), which is kind of rechargeable battery, on the circuit board, this results in a system with a maximum of energy and power density.

To power the ARC1, connect the black 4-pin battery plug (with reverse polarity protection) to the corresponding socket on the circuit board, ensuring the connector tab faces upwards (see illustration). Once connected, the ARC1 will automatically start operating, as it has no on/off switch. If the battery voltage falls below 3.5 V, or the battery is disconnected, LED1 will flash red (see section 5 Operating Modes).



CAUTION:
Risk of fire and explosion if batteries are handled improperly

- **Do not** charge the battery
- Avoid electrical short circuits
- Avoid mechanical damage
- **Do not** open the battery
- **Do not** throw the battery into a fire and do not expose it to temperatures above +100 °C
- **Do not** carry out any soldering work on the battery
- **Do not** pull, kink or pinch on the battery connection cable
- Protect the battery from moisture

4.5.1 Battery replacement

The ACR1 will operates until the battery voltage drops to **3.4 V**, at which point it is still functional. However, we recommend replacing the battery at **3.6 V** to ensure optimal performance. Both the PressureSuite Desktop and PressureSuite Cloud display the battery capacity as a percentage of the remaining charge, calculated by the ARC1. The actual battery voltage is also displayed. A battery change or disconnection always resets the capacity indicator to **99%**. Therefore, the battery should only be disconnected when replacing it.

CAUTION:
Only the specified Tadiran (TL-6937/3,9V/35Ah) lithium thionyl chloride from KELLER should be used.

Steps to replace the battery:

1. Open the tape fastener of the battery compartment.
2. Connected the battery plug the right way, connector tab must face upwards (see illustration), to the corresponding socket on the circuit board
3. Insert the battery back into the compartment.
4. Close the adhesive tape of the battery compartment tightly around the lithium battery.

NOTE:
Dispose of used batteries according to local regulations; do not discard with household waste

After installation, it may take several hours for the HLC to fully charge, stabilizing the battery voltage at 3.9 V.

NOTE:
When the battery is disconnected, the device will continue to run for approximately 30 minutes (LED1 is flashing red), so that the internal clock can continue to run autonomously without being readjusted. To fully reset the device, remove the battery for at least 30 minutes.

4.5.2 Battery lifetime estimation

The calculated lifetime in the table below indicates how long the battery can last under different conditions. The calculated lifetime values in the table are merely calculations. External factors, such as temperature and storage time, can significantly impact the battery's capacity and overall service life.

4.5.3 ARC1-4G

Device	measure-interval	sending-interval	lifetime estimation
ARC1-4G	1 min	1 min	~ 24 days
ARC1-4G	1 min	10 min	~ 0.6 years
ARC1-4G	1 min	1 h	~ 3.5 year
ARC1-4G	1 h	1 h	~ 3.9 year
ARC1-4G	1 min	2 h	~ 6.3 years
ARC1-4G	1 min	6 h	~ 13 years*

4.5.4 ARC1-M1&NB

Device	measure-interval	sending-interval	lifetime estimation
ARC1-M1&NB	1 min	1 min	~ 40 days
ARC1-M1&NB	1 min	10 min	~ 1.0 years
ARC1-M1&NB	1 min	1 h	~ 5.5 years
ARC1-M1&NB	1 h	1 h	~ 6.4 years
ARC1-M1&NB	1 min	2 h	~ 9 years
ARC1-M1&NB	1 min	6 h	~ 17 years*

4.5.5 ARC1-LR

Device	measure- and sending interval	Spreading Factor	lifetime estimation
ARC1-LR	5 min	SF12	~ 3.8 year
ARC1-LR	5 min	SF11	~ 6 year
ARC1-LR	5 min	< SF10	> 11 years*
ARC1-LR	10 min	SF12	> 12 years*
ARC1-LR	10 min	SF11	> 17 years*
ARC1-LR	10 min	< SF10	> 20 years*

NOTE:
*The batterie is subject to self-discharge over time. To ensure reliable performance, KELLER recommends replacing the battery at least every 10 years, even if it has not yet reached its minimum voltage threshold. This preventative replacement helps maintain optimal operation and prevents unexpected downtime due to gradual battery depletion.

4.6 Connecting the antenna

Screw the stub antenna into the corresponding SMA plug located at the top of the ARC1 and **tighten by hand only**. Make sure it is tight enough.

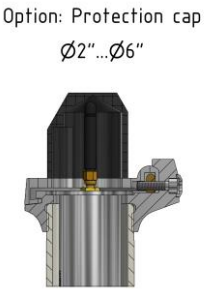
CAUTION:
Please only use the original accessories to prevent injuries and health risks. Only monopole antennas with the specified maximum permissible gain according to 11.6 Antenna, in the respective frequency range may be used. The antenna must be installed at least 0.20 meters away from people and other electrical equipment and antennas.

NOTE:
To ensure reliable data transmission, install the antenna in a location with strong signal coverage for the technology required by your wireless module. The Antenna must not be installed inside metal cases.

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

4.7 Locking unit (Tube only)

The locking unit for the ARC1-Tube with antenna cover is available in sizes ranging 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.



4.8 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.

4.9 Mounting Instructions

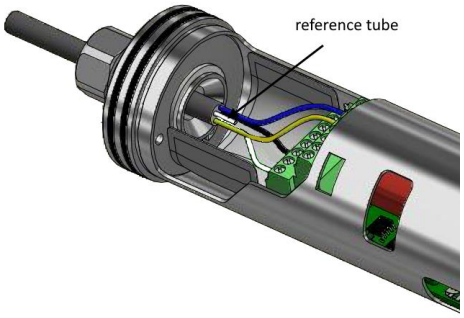
Prefer a mounting location which is protected against rain and direct sun radiation. For best radio performance, install the device upwards with the cable towards ground. Ideally, in such a way that the antenna faces roughly in the direction of the next gateway/antenna. Also, the higher above ground, the better. Avoid metallic object 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 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.

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

4.10 Cable gland / level sensor connection

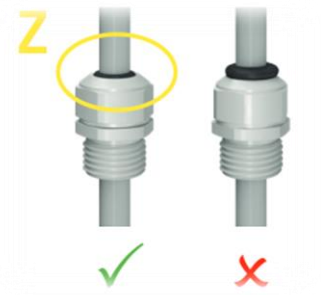
To connect the external sensors, feed the cable through the cable gland and connect the cable ends to the terminals on the connection block. The box version can accommodate up to five sensors, while one sensor can be connected to the tube version. The ARC1 tube has a nut with a wrench width of 22 mm, while the box version has a nut with a wrench width of 15 mm to provide counter-torque when tightening. If a level sensor with a reference tube is used, the reference tube is simply inserted into the housing.



CAUTION:
The cable shall be tightened only over the wrench width and the cable gland.

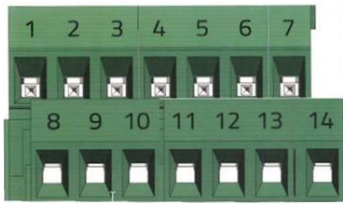
CAUTION:
After opening the ARC1 case, always make sure that the ARC1 case is still tight.

NOTE:
Make sure the cable is mounted securely, e.g. by using an additional retaining cable, for cable lengths > 50 m. Tighten the cable gland until the torque of 5 Nm is reached (depending on many different factors and influences) or the sealing insert forms a bulge that protrudes slightly over the compression nut (see picture)

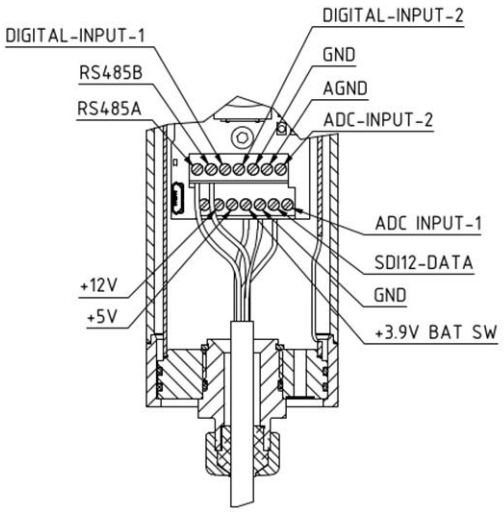


4.11 Connection terminal for the sensors

The ARC1 provides the option to connect various pressure transmitters and level sensors with an RS485 interface from KELLER, as well as sensors from third-party providers that have an analogue output. It also supports the SDI-12 Interface, for example, for multi-parameter sensors.

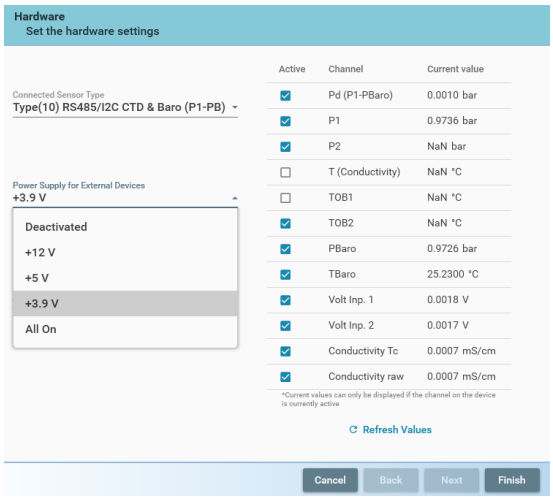


Pin Number	Pin table
1.	RS485-A
2.	RS485-B
3.	Digital Input 1 (alarm input)
4.	Digital Input 2 (counter input)
5.	GND
6.	GND (Voltage Input 1 & 2)
7.	Voltage Input 2 (0...5 VDC)
8.	Not connected
9.	12 V supply (switchable, 100 mA continuous current)
10.	5 V supply (switchable, 100 mA continuous current)
11.	3,9 V supply (switchable, 100 mA continuous current)
12.	GND
13.	SDI12 communication Interface
14.	Voltage Input 1 (0...5 VDC)



4.11.1 Supply

The ARC1 is designed to power external sensors with varying voltage requirements, enabling compatibility with a wide range of sensors. The power supply will be activated only when the unit needs to measure data from the external sensor. Voltage sources can be selected in the "PressureSuite Desktop" program as follows:



4.11.2 Voltage inputs

The voltage inputs (Pin 7 & 14) measure signals from sensors within a 0…5 VDC range. Use the corresponding GND voltage input (Pin 6).

4.11.3 Digital inputs

In addition to their standard function as digital inputs, digital inputs 1 and 2 also have an additional feature Normally, the state of the inputs is displayed only during transmission and is not saved as a measurement value.

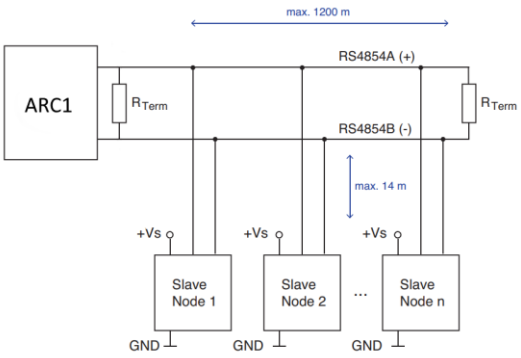
4.11.3.1 Input 1/Pin 3 (alarm)

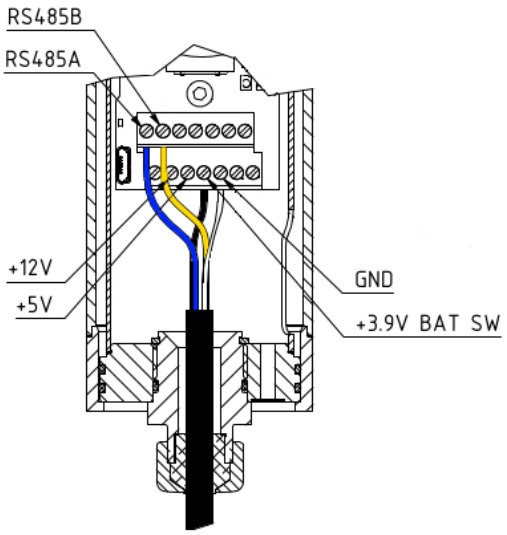
Input 1 (Pin 3) is a normally closed (NC) input used to monitor a switch. If the alarm function is enabled, the ARC1 checks the input every second. When the switch opens, an alarm message is sent immediately. Following this, the switch state is checked at the specified alarm interval.

4.11.3.2 Input 2/Pin 4 (counter)

Input 2 (Pin 4) serves as a counter input for devices with reed relay outputs (e.g., rain catchers). The counter increments when the connected switch closes. Note that the counter can register only one count per second; additional counts within the same second are not recorded. The counter value is saved at each measurement interval, after which it resets to zero, allowing you to measure the count within each interval.

4.11.4 RS485 Interface for X-Line (KELLER bus protocol)

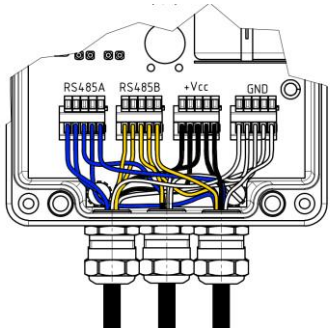




Connect the black wire to the correct supply voltage according to the specification of the KELLER sensor, in this example "+3.9 V" (Pin 11) and the white wire to GND (Pin 12).

The blue wire is the RS485A (Pin 5) and the yellow the RS485B (Pin 6) which serves as the communication interface to the sensor. The RS485 Interface is with a 10kΩ resistor terminated.

NOTE:
If only one transmitter is connected, the communication address is **250**. For configurations with up to five transmitters (Box version), the communication addresses range from **1 to 5**. Each transmitter's communication address must be assigned in advance.



NOTE:
We recommend using KELLER transmitters with the 'low voltage' option to minimize battery consumption. In this case, select the +3.9 V power supply.

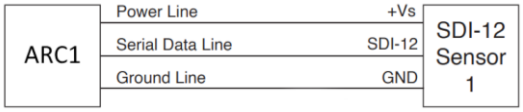
4.11.5 SDI-12 interface

The SDI-12 protocol is based on version 1.3. To ensure proper operation, configure the SDI-12 probe according to the following parameters before connecting it to the ARC1. Verify the compatibility of the SDI-12 probe with the ARC1.

4.11.5.1 Communication parameters

Description	Settings
Data rate	1200 Baud
Byte Frame Format	1 start bit / 7 data bits / 1 parity bit (even) / 1 stop bit
SDI12-Adsresse	0
Channels / Values	max 10
Measurement time (Maximum time for performing a measurement)	max. 300 seconds

4.11.5.2 Connection assignment

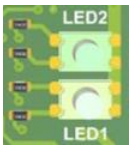
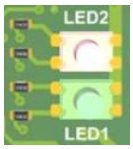


SDI12 probe	ARC-1
VCC	12 V (Pin 9)*
GND	GND (Pin 12)
Data connection	SDI12-Communication interface (Pin 13)

NOTE:
SDI-12 probes with a current consumption of up to 100 mA (1.2W) can be supplied by the ARC1. However, this considerably reduces the battery lifetime (alternative: power the probe externally). Many SDI-12 probes also have a long start-up time until they are initialized (setting the "Pre-On-Time for power supply").

5 Operating Modes

The device has three operating modes:

Operating modes		LED2	LED1
			
Reset:	System (re-)start		
Sleep mode:	no measurements and no data transmissions; no communication		5 sec
Active mode:	no measurements and no data transmissions; communication active		1 sec
Active mode:	During periodic measurements (read sensor)		
	and while registration process		1 sec
	and while data transmission	1 sec	1 sec
	if transmission failed	3x 1 sec	

NOTE:
If the battery voltage falls below 3.5 V the LED1 flashes always red.

5.1 Measurement cycle (Active mode)

During the periodic measurements (sensor reading), the device reads the values from the connected KELLER sensor at a user-defined sampling interval and stores the data in the internal EEPROM (RECORD). To do this, the ARC1 supplies the pressure transmitter with the voltage and channels selected by the user. After reading the values, the power supply is turned off. For KELLER devices, the correct pre-on time is automatically set when the sensor type is defined. For third-party devices, this must be manually selected. The ARC1 then attempts to read the values from the selected interface (up to 5 attempts per interface/sensor). In addition to these values, it is also possible to read the internal barometer's pressure and temperature values, which are also stored in non-volatile memory.

5.1.1 ARC1 with cellular communication

After a user-defined amount of collected measurements the ARC1 sends them. The cellular modem in the ARC1 is powered on, attempts to register with the provider, and transmits the data. Once the transmission is complete, the device powers off the cellular modem. For each measurement, additional internal values, such as signal strength, humidity, battery voltage, and capacity, will also be transmitted.

NOTE:
Establishing the connection and transmitting data are the most energy-intensive processes, even when using energy-efficient technologies such as NB-IoT and Cat-M1. Therefore, it is recommended to set the transmission interval as long as possible to optimize battery life. For more details, please refer to section 4.5.2 Battery lifetime estimation.

5.1.2 ARC1 non-cellular communication (ARC1-LR)

A periodic measurement automatically triggers a transmission, these limitations are a result of the regulatory requirements of LoRaWAN®.

After a random delay of 0 … 6 seconds, the ARC1-LR sends the measurements. If the device has not yet joined the LoRaWAN® network, it will attempt to join up to three times per transmission. Once joined, the data will be transmitted. During each transmission, two receive slots (RX1 and RX2) are opened, and the device is ready to receive data from the network (downlink messages)

For each measurement, additional internal values such as humidity, battery voltage, and capacity can also be transmitted as needed (see “Info” message of Communication Protocol ARC1 LoRaWAN).

NOTE:
The lowest sampling period should not be set below 10 minutes, as shorter intervals may result in packet loss due to the airtime limitations of LoRaWAN® technology, which depends on the spreading factor (SF).

5.2 Sleep Mode

In sleep mode, only the real-time clock remains active. The microprocessor wakes up every second to adjust the time and check for events to react to (LED1 is flashing in a 5 second interval).

When a communication is taking place, the device will automatically switch to active mode (LED flashes every second).

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 ARC1 EEPROM. The memory is organized as a circular memory. This means that always the latest data is available whilst the oldest data is overwritten.

NOTE:
The data can also be remotely requested, for example, through the PressureSuite Cloud.

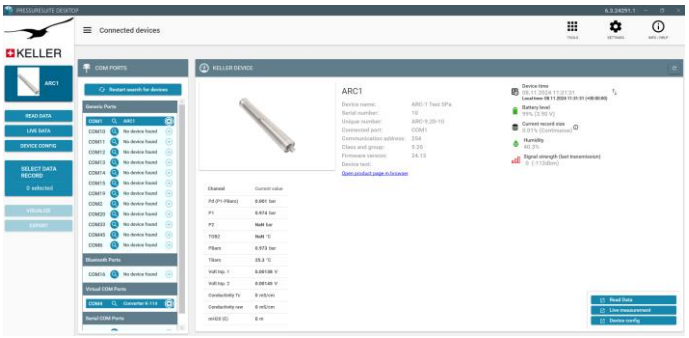
6.1 Storage Capacity

The table below shows you how much data can be stored in the ARC1 memory.

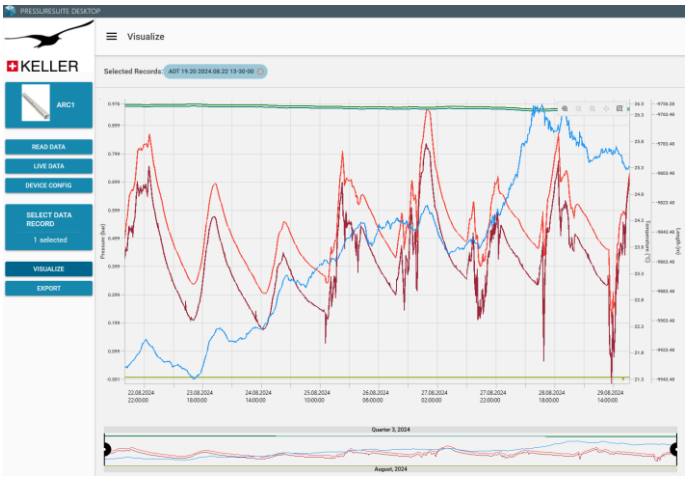
Storage interval	Number of channels	Number of measured values per channel	Recording time
1 min	4	24552	17 days
1min	14	8184	5 days
10 min	4	24552	170 days
10 min	14	8184	56 days
1 h	4	24552	1020 days
1 h	14	8184	340 days

6.2 Read the RECORD data by cable

Connect the ARC1 with the communication interface and start the "PressureSuite Desktop" software. The device should be displayed under “Generic Ports”.



The connection to ARC1 is now established automatically and all available RECORDs appear. Select the desired RECORD and click on the button “Start reading selected record from device”.



7 Configuration

For the configuration of the ARC1 we developed "PressureSuite Desktop". If the device has already been successfully set up for the PressureSuite Cloud, it can also be adapted remotely. 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 the K-114 A converter which establishes a connection from the computer to the ARC1 with the PressureSuite Desktop.
- Downlink command interface: over the air using PressureSuite Cloud downlink messages.

For a full description of this interfaces, please find the specific documents on Communication Protocol ARC1 or on https://docs.pressuresuite.com/.

7.1 Configuring a Cellular device from KELLER

The initial configuration is carried out on-site during installation using the "PressureSuite Desktop" program via the K-114 A, which establishes a cable connection from the PC to the ARC1. The settings are saved on the ARC1 and sent to the FTP or e-mail server. Configuration changes can later be made remotely through the "PressureSuite Cloud" or the user's own application. The updated configuration must be saved on the selected server. The ARC1 checks its FTP or e-mail inbox at a configurable interval, and if a new configuration is available, it will be retrieved and saved.

7.1.1 SIM card and network Access

To use 2G, 3G, 4G, NB-IoT, or LTE Cat M1 networks, you'll need a SIM card that supports the required technology. The SIM card should be activated and have access to the appropriate network of the respective network operator. Some configurations may require additional details depending on the network operator and specific application requirements.

Follow these steps for integration:

1. **Insert the SIM card:** Place the SIM card into the designated slot in the ARC1 with cellular communication (see 4.4 SIM card (only for cellular version)). Ensure that the SIM card is activated with the desired network operator and has an active data plan.
2. **APN configuration:** Depending on the network operator, you need to configure the APN (Access Point Name) via the interface. Some carriers may also require authentication credentials (username and password).

7.1.2 Select transmission protocol and security

An FTP or e-mail server must be configured so that the device can send data. The configuration of FTP or e-mail settings depends on the desired use case. You will receive the specific FTP or SMTP details, like server addresses, ports and authentication credentials from your provider.

NOTE:
We recommend the use of FTP instead of e-mail due to the easier implementation and functionality as this is less prone to errors.

7.2 Configuring a LoRaWAN device from KELLER

The LoRaWAN® module, which can be configured on a country-specific basis, establishes a connection with a LoRaWAN® Gateway to send the measured values to a LoRa network server. The LoRaWAN provider is freely selectable.

The ARC1-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 ARC1-LR is ready to use without any configuration changes.

Nevertheless, the ARC1-LR can be easily reconfigured through the PressureSuite Desktop to other network servers like Actility, Loriot, etc.

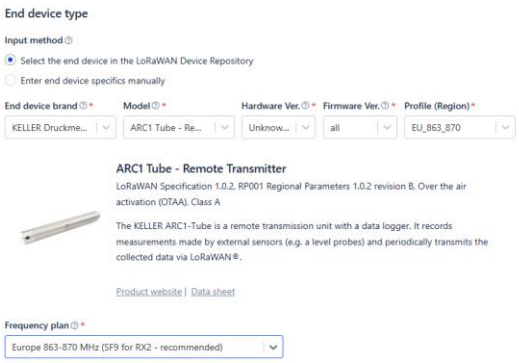
7.2.1 Integration with the Things Network (TTN)

Before a device can communicate via The Things Network you need to register it with an application.

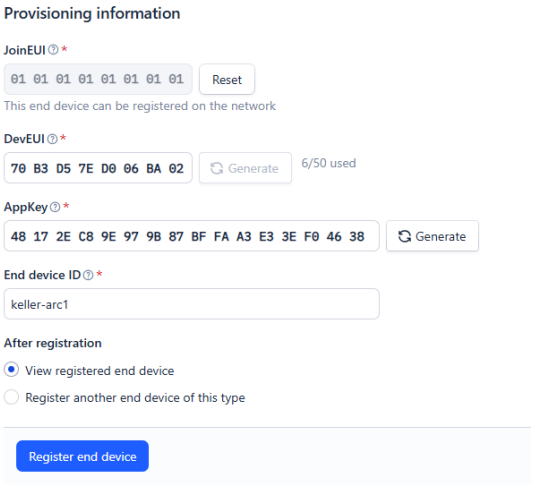
NOTE:
To avoid conflicts or duplicate registrations, it's recommended to change the AppEUI (JoinEUI) if moving the device to a new TTN account or a different server. This step ensures that the device is no longer associated with KELLER's original TTN account and can securely connect to the desired network server.

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)"
- Insert the **App EUI (JoinEUI)**, from the device and press the "Confirm" button.
- For **Device EU and App Key**, copy-paste the one you retrieved from your device.



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

7.2.2 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**.

7.2.2.1 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.

7.2.2.2 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.

7.2.3 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.

7.2.4 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.

7.2.5 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 ARC1-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 ARC1 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 calculation are listed. The focus of the description is for ARC1 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 (fresh water, saltwater, ...), as well as on the temperature of the water. Mostly a value of 998.2 kg/m^3 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 (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 ARC1 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 pressure value for water level calculation.

8.4 Water level calculation types

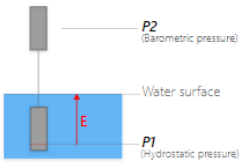
There are essentially 3 different calculation types.

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]

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



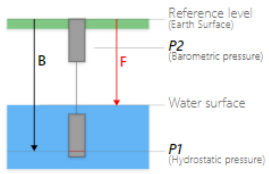
P1 (Hydrostatic pressure)	P1	[Pa]
P2 (Barometric pressure)	PBaro	[Pa]
ρ (Density)	998.2	[kg/m^3]
g (Gravitation)	9.80665	[m/s^2]
Offset	0	[m]

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)

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



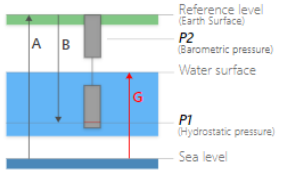
P1 (Hydrostatic pressure)	P1	[Pa]
P2 (Barometric pressure)	PBaro	[Pa]
B (Installation length)	10	[m]
ρ (Density)	998.2	[kg/m^3]
g (Gravitation)	9.80665	[m/s^2]
Offset	0	[m]

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

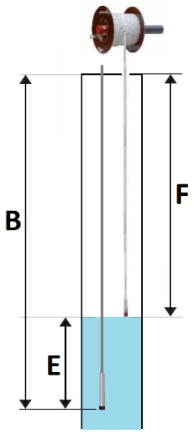
The installation length (B) can be determined by measuring from the upper edge of the remote transmission unit to the level probe (marker) with a tape measure.

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 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

A 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.

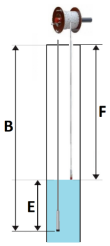
8.8 Determining the installation length with ARC1 remote transmission unit

To determine the installation length with the ARC1 remote transmission unit, here's a possible step-by-step instruction:

8.8.1 Set up the ARC1 device and measure the tap (F):

Install the ARC1 device with connected level probe in the level measuring point.

Measure and note the distance **F** from measuring point to water surface with a electric contact gauge, a tape measure/light plummet or similar.

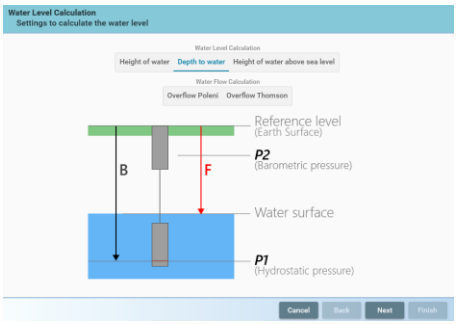


In the example the upper measuring point to the water surface is -> **F** = 0.43 m

NOTE:
The measured installation length is **2.4738 m** and should finally correspond to the calculated installation length B at the end.

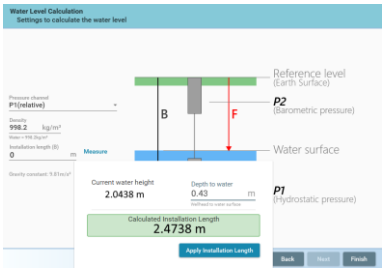
8.8.2 Water level configuration with "PressureSuite Desktop"

Start software "PressureSuite Desktop" and change to "Water level configuration" (assuming all other ARC1 measurement settings are done).



- Select desired calculation method
- Fill in the needed parameters, i.e. density
- 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
- Press the "Measure" button, the current measured value is displayed

To ensure the correct calculation of the installation length B, the distance F, which is the "Depth to water" (measured from the wellhead to the water surface), must be entered.



- 0.43 m

If the "Calculated installation length" matches the measured calculated length, everything has been done correctly.

⇨ 2.4738 m

The connector can now be removed from the interface and the level measuring point closed with the level cap.

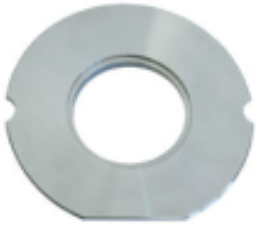
NOTE:
All measured values and parameters should be noted down for safety's reasons, preferably with date and time.

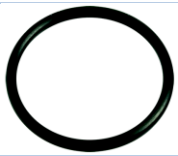
The parameters can now be safed to the device by pressing the "Write Configuration" button. It is possible to transfer the complete settings to the PressuireSuite Cloud by remote transmission, by sending the configuration.

The water level configuration is needed for the PressureSuite Desktop and Cloud to convert pressure to the desired water level. With the PressureSuite Cloud the parameters can be entered or changed. The cloud also receives the parameters, which are transmitted via remote transmission (configuration messages).

9 ARC1 order information

9.1 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	
Battery 3,9 V with Plug Capacity: 35 Ah Type: TL-6937	557005.0019	
K-114 A Interface Converter For communication between the PC and the ARC1 over USB interface Cable length: 0.75m	309010.0075	
Antenna with SMA connection	331005.0005	
Antenna for manhole cover with SMA connection Cable length: 2m	320020.0133	
Closure Cap for Fischer Plug Includes screw (M3 x 6 Inox)	508415.0008	

O-Ring 40 x 1,5 mm (Nitrile) sealing ring for casing (tube)	508620.0007	
Silicagel bag, Box 5 g	702505.0008	
Silicagel bag, Tube 2 g	702505.0007	

10

11 Approvals Compliance

11.1 Americas Approvals

11.1.1 FCC Certification

Model	FCC ID
ARC1-Tube-M1&NB **ARC1-Box-M1&NB** **ARC1-Box-M1&NB-SB**	Contains transmitter module FCC ID: RI7ME910C1WW
ARC1-Tube-4G **ARC1-Box-4G** **ARC1-Box-4G-SB**	Contains transmitter module FCC ID: RI7LE910CXWWX
ARC1-Tube-LR **ARC1-Box-LR** **ARC1-Box-LR-SB**	Contains transmitter module FCC ID: T9JRN2903

The FCC Grants can be found here: https://www.fcc.gov/oet/ea/fccid

11.1.2 IC/ISED Certification

Model / Modèle	ISED Certification Number / Num. de certification ISDE
ARC1-Tube-M1&NB **ARC1-Box-M1&NB** **ARC1-Box-M1&NB-SB**	Contains IC / Contient IC: 5131A-ME910C1WW
ARC1-Tube-4G **ARC1-Box-4G** **ARC1-Box-4G-SB**	Contains IC / Contient IC: 5131A-LE910CXWWX
ARC1-Tube-LR **ARC1-Box-LR** **ARC1-Box-LR-SB**	Contains IC / Contient IC: 6514A-RN2903

The products ISED certified can be found here:
Les produits certifiés ISED peuvent être trouvés ici:
https://sms-sgs.ic.gc.ca/equipmentSearch/searchRadioEquipments?execution=e1s1&lang=en

11.2 FCC/ISED Regulatory notices / Avis réglementaires de FCC et ISED

11.2.1 Modification statement / Déclaration de modification

KELLER Druckmesstechnik AG has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authority to operate the equipment.

KELLER Druckmesstechnik AG n'approuve aucune modification apportée à l'appareil par l'utilisateur, quelle qu'en soit la nature. Tout changement ou modification peuvent annuler le droit d'utilisation de l'appareil par l'utilisateur.

11.2.2 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.

11.2.3 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 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.

11.3 Brazil ANATEL

Agência Nacional de Telecomunicações (ANATEL) of Brazil

"Este equipamento não tem direito à proteção contra interferência prejudicial e não pode causar interferência em sistemas devidamente autorizados"

"This equipment is not entitled to protection against harmful interference and must not cause interference in duly authorized systems"

LE910C1-WWX Homologation # 08491-22-02618
ME190C1-WW Homologation # 06163-19-02618
RN2903A Homologation # 06998-21-08759

11.4 EMEA Approvals

11.4.1 EU RED Declaration of Conformity

KELLER Druckmesstechnik AG declares that the equipment is in compliance with the Directive 2014/53/EU.

The full text of the EU declaration of conformity is available at the following internet address:
https://www.keller-pressure.com/en/downloads?types=Declaration-of-Conformity

Text of 2014/53/EU Directive (RED) requirements can be found here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0053

11.4.2 UK UKCA Declaration of Conformity

KELLER Druckmesstechnik AG declares that the equipment is in compliance with the Radio Equipment Regulations 2017 for UKCA.

The full text of the UKCA declaration of conformity is available at the following internet address:
https://www.keller-pressure.com/en/downloads?types=Declaration-of-Conformity

The UKCA requirements can be found here: https://www.gov.uk/guidance/using-the-ukca-marking

11.5 APAC Approvals

11.5.1 Australia RCM Declaration of Conformity

KELLER Druckmesstechnik AG declares that the equipment is in compliance with Regulatory Compliance Mark (RCM) of Australia.

NOTE: The equipment listed may not work when main power fails

11.5.2 Taiwan NCC Regulatory Notices (ARC1-X-4G only)

According to NCC Taiwan requirements, the module and the packaging shall be identified as described in the following lines. Shall be added also the specified safety warning statement.

Brand name: Telit

Model name: LE910C1-WWXD

Equipment name: WWAN module

NCC logo: 

NCC ID: CCAK22Y00021T4

NCC safety warning statement: “減少電磁波影 響，請妥適使用 ”

11.6 Antenna

This radio transmitter has been approved under RED, UKCA, 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 RED, UKCA, FCC and ISED 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
ARC1-Tube-M1&NB **ARC1-Box-M1&NB** **ARC1-Box-M1&NB-SB**	Omnidirectional Antenna Gain 2.14 dBi Omnidirectionelle Gain de l’antenne 2.14 dBi
ARC1-Tube-4G **ARC1-Box-4G** **ARC1-Box-4G-SB**	Omnidirectional Antenna Gain 4.00 dBi Omnidirectionelle Gain de l’antenne 2.14 dBi
ARC1-Tube-LR **ARC1-Box-LR** **ARC1-Box-LR-SB**	Omnidirectional Antenna Gain 2.00 dBi Omnidirectionelle Gain de l’antenne 2.00 dBi

12 Version History

Version	Date	Description
11/2024	**13.11.2024**	Update layout New and revised content
10/2021	04.10.2021	New document

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