TerraTransfer

AQUATOS RADAR · TYPE 0470

# Aquatos Radar

## Radar distance sensor Type 470 / 0470

Measure water levels and distances without contact. Energy-efficient 60 GHz radar sensor with up to three echoes, SDI-12 and Bluetooth. Optionally combinable with LTX data loggers of types 15xx and 17xx.

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## Product profile

The **Aquatos Radar Type 0470** from **TerraTransfer** is a non-contact distance sensor. It measures distances to water surfaces and other suitable reflecting surfaces up to **12 m**. Setup and diagnostics are carried out on site via the **Bluetooth app in the browser**. The **SDI-12 interface V1.3** connects the sensor to a data logger.

| MEASUREMENT | FEATURES |
|---|---|
| Typical accuracy **≤ 2 mm**, resolution **1 mm** | **Up to 3 echoes**, each with distance and signal strength |
| Application range **0.10 to 12 m** | Standard radar lens with **approx. 10° beam angle** |
| Non-contact 60 GHz PCR measuring principle | **SDI-12 V1.3** and **Bluetooth Low Energy** |

**Applications:** gauging stations on streams, rivers and canals; retention basins and tanks; measuring points under bridges or in shafts. Suitable non-conductive tank walls can be measured through. Multiple echoes support the assessment of additional reflections from fixtures or drifting ice.

# Technical data

The following data apply to the **radar sensor Type 0470**. Properties of an optionally connected LTX data logger are described in the section “System operation with Aquatos Web LTX”.

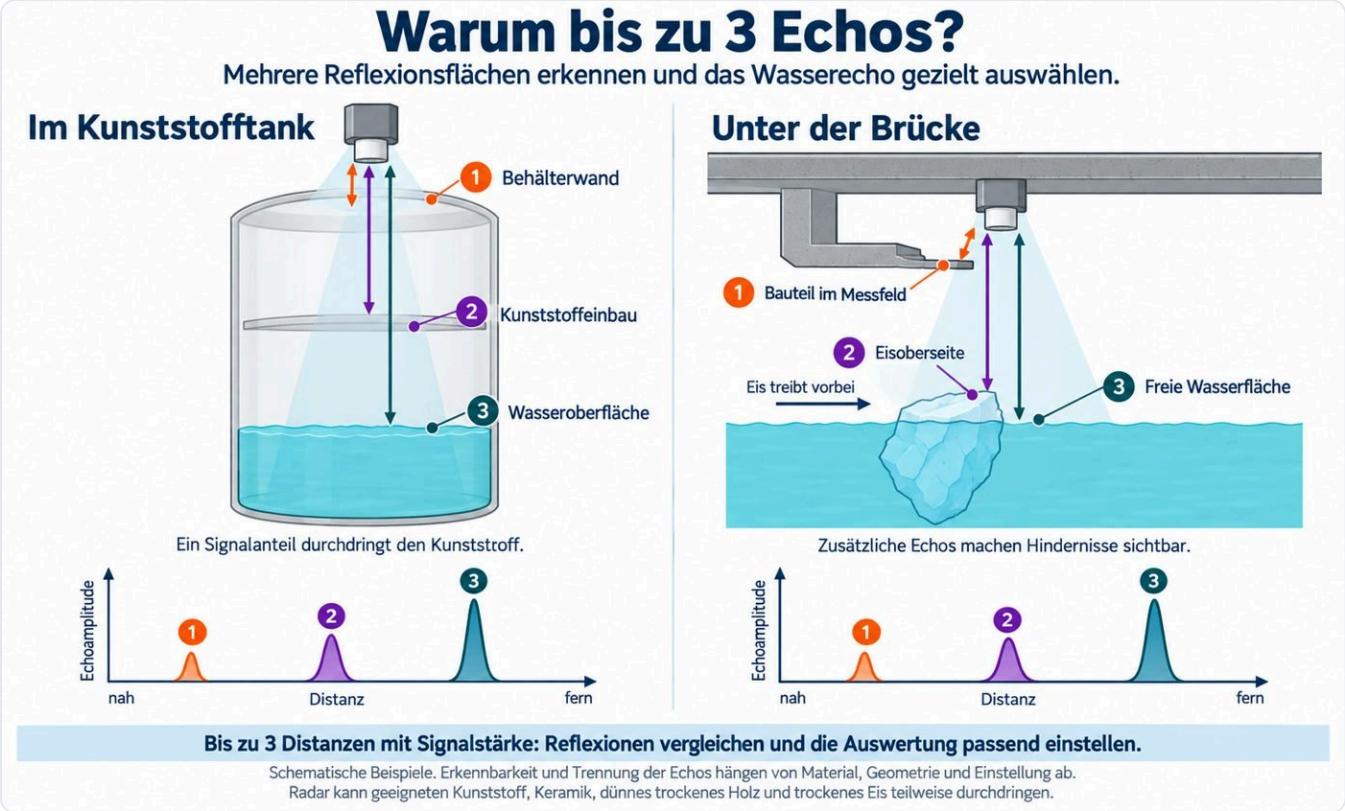
| PARAMETER | RADAR SENSOR TYPE 0470 |
|---|---|
| Measuring principle | 60 GHz radar, Pulsed Coherent Radar (PCR) |
| Application range | 0.10 to 12 m |
| Technical near limit | No detection below 0.05 m; output “ToClose” |
| Near-range setting | Enable LeakCancellation below 0.15 m |
| Typical accuracy / resolution | ≤ 2 mm / 1 mm |
| Factory measuring range | 0.25 to 3.00 m; start and end configurable |
| Radar lens | Standard approx. 10° beam angle; customised lenses on request |
| Echo evaluation | Up to 3 distances, each with signal strength in dB |
| Sorting | Selectable by distance or by signal strength |
| Output | Distance in m; signal strength in dB; optionally supply voltage |
| Interfaces | SDI-12 V1.3; Bluetooth Low Energy; SDI-12 commands via BLE |
| Power supply | 3.6 to 16 V DC; no reverse-polarity protection |
| Current during measurement | Briefly up to 100 mA |
| Quiescent current / BLE connected | < 30 µA at 4 V in deep sleep / < 60 µA at 4 V in connected mode |
| Ready to operate | Approx. 250 ms after power-on; this is not the duration of a radar measurement |
| Operating temperature | -40 °C to +85 °C |
| Electronics / protection class | **IP68**; electronics potted in the TerraTransfer version |
| Conformity / frequency band | CE compliant (RED 2014/53/EU), RoHS; 60 GHz band widely available worldwide |

Housing with radar lens and mounting slots.

The **0.05 m near limit** is the technical detection limit. The recommended application range starts at **0.10 m**. For commissioning, the standard window from **0.25 m** is recommended first. The actual measuring time depends, among other things, on the measuring range and the parameter settings.

# Understanding and using multiple echoes

A radar signal is partially reflected at different material boundaries. A further portion can penetrate suitable materials and be reflected by a surface behind them. This creates echoes with different transit times and signal strengths. The Type 0470 can output **up to three distances at the same time**.




Three reflecting surfaces in a plastic tank and under a bridge with a drifting ice block. Colours and numbers link the surfaces to the respective signal peaks. Diagram labels in German: Behälterwand = tank wall, Kunststoffeinbau = plastic fixture, Wasseroberfläche = water surface, Bauteil im Messfeld = component in the measuring field, Eisoberseite = top of ice, Freie Wasserfläche = open water surface.

## In the plastic tank

In the example drawn, the **tank wall**, an additional **plastic fixture** and the **water surface** each produce one echo. Part of the signal penetrates the plastic and reaches the water. The additional fixture serves to explain a third echo; in practice a tank measurement often shows two echoes, a weak reflection from the PE tank wall and the main reflection from the water.

## Under the bridge with drifting ice

In the example, a **component in the measuring field**, the **top of the ice** and the **open water surface next to the ice block** provide three reflections. Here the water echo is detected next to the ice. Measuring through ice is not a prerequisite in this illustration. The reflections are assessed by their distance and signal strength; the measurement alone does not assign material names to them.

## Benefit for the evaluation

Measuring range, sensitivity and sorting help to select the desired echo. A strong or close echo does not necessarily come from the water surface. The echo numbers in the diagram are **not fixed channel assignments**. Detectability and separation depend on material, distance between the surfaces, geometry and settings. The curves are schematic and not measured data.

# Radar lens, installation and connection

## Measuring principle and material penetration

PCR technology enables highly energy-efficient distance measurement. Metals reflect almost completely, water very strongly; damp soil or vegetation can also deliver clear signals. Suitable **plastic, ceramic, glass or thin, dry wood** attenuate the signal comparatively little and can be measured through. Composition, thickness and moisture affect the actual transmissivity.

Water ice without a liquid water film can also be partially transparent. When measuring through ice, the changed transit time and additional boundary surfaces must be taken into account. A general guarantee of correct level measurement through any kind of ice cannot be derived from this.

The wavelength is approximately **5 mm**. Without a focusing lens, the internal radar emitter produces a wide beam of about **60° to 90°**. The standard lens focuses this to **approx. 10°**. Depending on the version, its exit surface can be flat or dome-shaped. Plastic lenses can additionally radiate in secondary directions; this must be considered when aligning the sensor in confined installations. Customised lenses are available on request.

## Mounting

Mount the sensor vertically above the desired reflecting surface on a bridge, wall bracket or boom. Design the fixing and cable routing so that the alignment does not change. Check walls, fixtures and other objects in the measuring field with the Raw Scan. The beam focusing reduces their influence but does not fundamentally rule out interfering reflections.

When measuring through a suitable tank wall, the radar lens can often be mounted directly on the wall, which is usually beneficial for signal quality. The distance to the tank wall in the examples mainly serves to show its additional echo.

The electronics of the TerraTransfer version are **potted and achieve protection class IP68**. Installation and cable entry must be carried out accordingly. Permanent underwater installation is nevertheless not intended for non-contact level measurement.

## Electrical connection

| WIRE COLOUR | FUNCTION |
|---|---|
| White | Supply 3.6 to 16 V DC |
| Green | SDI-12 data signal |
| Yellow | GND / ground |

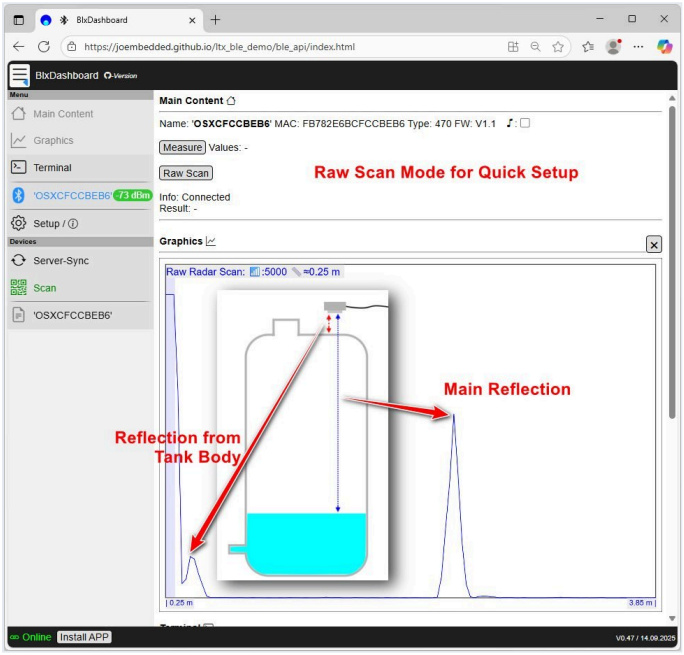
**Not protected against reverse polarity:** check polarity and wire assignment against the type plate before connecting. The Type 0470 requires at least **3.6 V**. The supply must be able to deliver the brief **100 mA** during a measurement.

# Commissioning via Bluetooth

The sensor can be operated via **SDI-12**, **Bluetooth** or **SDI-12 commands via Bluetooth**. The **Bluetooth app in the browser** offers the graphical tools **Raw Scan** and **Live Plot**. Supported are Chrome and Edge on Windows, Chrome on Android and Bluefy on iOS. Alternatively, **BlueShell (Windows)** is available.

## Connection and first reading

1. Check supply and connection, switch the sensor on and wait until it is ready to operate.
2. Open the Bluetooth app in the browser, connect to the sensor and verify its identity.
3. Enter the device-specific **6- to 16-digit PIN** once or scan the enclosed QR code. The PIN is not transmitted in plain text.
4. Display the current coefficients with `k`. Select a suitable measuring window, for example 0.25 to 3 m to start with.
5. Start a measurement and check distance and signal strength. Observe the detected echoes in the Live Plot.
6. Use the Raw Scan for alignment; then check the regular readings and save changed coefficients permanently with `z?XWrite!`.




Weak reflection from the tank wall and pronounced main reflection from the water surface.

## Raw Scan and Live Plot

The **Raw Scan** quickly shows a raw signal and supports coarse alignment. The regular precise measurement processes more data. As a guide for good signals, raw amplitudes from about **500** and regular signal strengths typically **above 1 dB** apply. These are not universal limits; Raw Scan amplitudes are not equivalent to dB values.

Scaling is normally automatic. `.shell raw470scale CNT` sets a fixed value; `.shell raw470scale` without an argument shows the current setting. The **Live Plot** displays the current distance values and is suitable for observing the reflections with changing water level or moving objects.

# SDI-12 commands and measurement output

`a` stands for the sensor address, `n` for the new address or the data block. In the examples for a single sensor, `?` is used as a placeholder. With several devices on the bus, use the specific address.

| COMMAND | FUNCTION |
|---|---|
| `aAn!` | Change SDI-12 address from `a` to `n` |
| `aI!` | Identification; pattern: `a13JE_Radar_0470_OSXxxxxxxxx` |
| `aM!` / `aMC!` | Measurement of one echo without / with CRC; 2 result values: distance and signal strength |
| `aM1!` / `aMC1!` | Measurement of up to 3 echoes plus supply voltage; 7 result values |
| `aD0!` … `aD9!` | Retrieve the stored results of the previous measurement block by block |
| `aXK0!` | Query coefficient; select the digit according to K0 to K11 |
| `aXK1=-0.123!` | Set coefficient; example K1 |
| `aXDevice!` | Query device information |
| `aXWrite!` | Save changed coefficients permanently |
| `aXFactoryReset!` | Restore factory settings |

## Result structure and sorting

The detected echoes are each output as **distance in m and signal strength in dB**. The extended measurement yields three pairs plus the supply voltage: **distance 1, strength 1, distance 2, strength 2, distance 3, strength 3, supply voltage**. The results are initially held in the cache; the logger reads them with the required `D` commands.

The order depends on **K8**: `0` sorts by distance, `1` by signal strength. The position of an echo in the output can change when distances or signal strengths change. Therefore always use the value pair for assessment.

| STATE / CODE | MEANING |
|---|---|
| Distance `0 m`, signal strength `-99 dB` | No echo detected |
| Distance `0 m`, signal strength `-98 dB` | “ToClose”: reflection too close to the sensor |
| Error code `-100` to `-999` | Error in the coefficient setup |
| Error code `-1000` | Internal sensor error / no response; check sensor or internal connection |
| Other errors | Observe the text display in the Bluetooth app or in BlueShell (Windows) |

**Zero values with error identification are not valid level values.** Signal strength and diagnostics must be taken into account when transferring data to the logger.

### Linearisation and reference point

Valid readings are linearised with **VALUE = (MEASURED × K0) - K1**. Factory settings are **K0 = 1.0** and **K1 = 0.0**. The factory reference is chosen so that the upper rectangular housing edge corresponds to **0.01 m**; the round lens surface is not the reference. Document the reference point during calibration. For a level output, the distance must be converted to the desired gauge datum.

## Coefficients and measuring parameters

The BLE command `k` displays the current coefficients and, where available, the memory requirement of the setup. Changes are made via the **SDI-12 `XK` commands**, directly on the bus or with a leading `z` via Bluetooth.

| PARAMETER | MEANING AND SETTINGS |
|---|---|
| **K0** · Raw.Multi | Multiplier of the linearisation; factory setting **1.0** |
| **K1** · Raw.Offset | Subtracted offset; factory setting **0.0** |
| **K2** · LiveSpeed | Automatic measurements in the Live Plot; **0 = off**. Example **16400 = 1 s**, **1640 = 0.1 s** |
| **K3** · Start | Start of the measuring window in m; default **0.25** |
| **K4** · End | End of the measuring window in m; default **3.00** |
| **K5** · MaxStepLength | Step length; **0 = automatic**. Default **2**, for end distances up to about 8 m; for 8 to 12 m the source states **3** |
| **K6** · ConfigProfile | Measuring profile; **0 = automatic**, profiles **1 to 5**. Default **3**; normally keep |
| **K7** · ReflectorShape | **0 = generic**, default for most applications; **1 = planar**, e.g. for flat water surfaces |
| **K8** · PeakSorting | **0 = by distance**, **1 = by signal strength**. In the `k` example output of the source: **1** |
| **K9** · Threshold Sensitivity | Detection sensitivity, range **0 to 1**; default **0.5** |
| **K10** · SignalQuality | Signal quality, range **-10 to 35 dB**; default **20 dB** according to the `k` example |
| **K11** · LeakCancellation | **0 = off**, default; **1 = on**, enable for start distances below about **0.15 m** |

## Measuring window and measuring time

The measuring window is the most important setting. Choose the end distance only as far as the expected distance including the necessary reserve requires. A larger range increases measuring time and energy demand and may include additional reflections in the evaluation.

## Automatic measurements

For K2 the source states values from **1640**. The automatic sequence starts a few seconds after a measurement via Bluetooth. The sensor adjusts the timing so that the pause between measurements is at least **four times the measuring time**, and at least **eight times** with a supply above **7.5 V**. The stated 0.1 s and 1 s are therefore settings and not guaranteed measuring rates for every setup.

## Sensitivity and reflecting surface

K7 can adapt the evaluation to flat surfaces. K9 and K10 influence detection; verify changes with the Raw Scan and regular readings. LeakCancellation improves usability of the near range but extends the measurement.

**Check factory settings:** the output of the command `k` is authoritative for the specific device. The setting values `0` for sorting by distance and `1` for sorting by strength apply regardless.

# Command examples and quick setup

## SDI-12 via Bluetooth

A leading `z` forwards SDI-12 commands via the BLE connection. The following abbreviated example session shows the typical sequence; device identifier and readings are examples.

```
z?I!
013JE_Radar_0470_OSXCFCCBEB6

z?M!
00032
0

z?D0!
0+2.351+8.21
```

The last data record contains, for address `0`, the distance **2.351 m** and the signal strength **8.21 dB**. Between starting the measurement and querying the data, observe the reported measuring readiness or waiting time.

## Changing and saving coefficients

```
k
z?XK3!
z?XK4!
z?XK3=0.25!
z?XK4=3.00!
z?XWrite!
```

The first queries document the previous window. The example then sets **0.25 to 3.00 m**. Only `XWrite` saves the changes permanently. A factory reset restores the factory settings and then requires a renewed check of the measuring-point setup.

## Predefined setups with `.crun`

Ready-made command files are available for common measuring ranges. They can be called via terminal command or via the corresponding setup QR code.

| MEASURING WINDOW | COMMAND IN THE BLUETOOTH APP |
|---|---|
| 0.25 to 3 m | `.crun crun/0470_radar_0m25_3m00.crun` |
| 0.25 to 8 m | `.crun crun/0470_radar_0m25_8m00.crun` |
| 0.25 to 12 m | `.crun crun/0470_radar_0m25_12m00.crun` |

The 3 m setup corresponds to the default after a factory reset. Larger end distances extend the measurement. After calling a setup, check the values with `k` and a measurement; adapt reference point and linearisation to the measuring point if necessary.

# Software, energy and diagnostics

## Further BLE commands

| COMMAND | FUNCTION |
|---|---|
| `bNEW_NAME` | Set the Bluetooth advertising name; 3 to 11 characters |
| `.a` or `.audio` | Show audio settings |
| `.audio 1 1` | Switch on audio / finder function, as in the source example |
| `.firmware` | Select firmware file `*.sec` locally and transfer it via BLE |
| `.shell raw470scale CNT` | Set the Raw Scan scale to a fixed value |
| `.shell raw470scale` | Query the current Raw Scan scaling |

Firmware files for the **Type 0470** are provided by TerraTransfer. After an update, check identification, coefficients and measuring behaviour.

**BlueShell (Windows)** is an alternative tool for sensor access. **SDI12Term** provides access to the SDI-12 bus via a suitable RS232 adapter. The Bluetooth app runs in the browser; no installation is required.

## Energy demand

In idle state the average current is **below 30 µA at 4 V**; retaining the radar RAM adds about **10 µA** compared with the bare sensor module. With an active Bluetooth connection the average is **below 60 µA at 4 V**. During measurement, **up to 100 mA** can briefly occur.

These values describe different operating states. A runtime calculation must additionally consider the duration and frequency of measurements and the connected logger. The readiness after about **250 ms** must not be taken as the fixed duration of a complete measurement. Larger measuring windows and more demanding settings increase the measuring effort.

## Diagnostics at the measuring point

| OBSERVATION | CHECK / ACTION |
|---|---|
| No valid echo | Check supply, alignment, start/end distance and signal strength; use the Raw Scan |
| “ToClose” | Check the distance to the nearest reflecting surface; no measurement possible below 0.05 m |
| Weak echo | Optimise measuring window and alignment; set K7, K9 and K10 appropriately |
| Echo changes its output position | Compare K8 and the distance/strength pairs; check for a possible additional reflecting surface |
| Settings lost after restart | Set the changes again and save with `XWrite` |
| Internal error `-1000` | Check supply as well as sensor and internal connection |

## Further applications with adapted firmware

With **firmware adapted for this purpose**, vibration measurements on distant objects are possible, for example on persons, structures or machines, in the range of approximately **0.2 Hz to 2 kHz**. Presence and speed detection are also possible. These functions are not part of the distance measuring operation described here.

# System operation with Aquatos Web LTX

The sensor Type 0470 can be combined via SDI-12 with **LTX data loggers of types 15xx and 17xx**. In the product context, TerraTransfer refers to these loggers generally as **Aquatos Web LTX**. The radar sensor delivers the readings; the logger handles their time-controlled acquisition, storage and, depending on the version, transmission.

| COMPONENT | TASK IN THE MEASURING SYSTEM |
|---|---|
| Radar Type 0470 | Acquire distance and signal strength; local configuration via BLE |
| LTX logger 15xx / 17xx | Query the sensor via SDI-12; assign channels; store data and transmit it if equipped with radio |
| Sensormanager | Receive, display and evaluate measurement data; remote access depending on logger, firmware and connection |

The radio technology depends on the specific logger. The LTX type overview lists, for example, **LTE-M/NB-IoT for types 1500 and 1710**, **LTE Cat1 for type 1700** and **LoRaWAN EU868 for type 1720**. LTE-M, NB-IoT or a particular battery configuration are therefore not general features of the radar sensor or of all Aquatos Web LTX combinations.

## Measuring channels and level reference

For one echo, **two result values** must be considered, for the extended query **seven result values**. Configure the logger so that it triggers the measurement command and then reads out the associated data blocks. With several sensors, assign unique SDI-12 addresses. Distance, signal strength and error identifications must be evaluated together.

For a water level, the measured distance is converted to the surveyed reference point. Define the conversion consistently in the sensor or logger; do not apply an already performed linearisation a second time. Measuring and transmission intervals as well as the available supply determine the energy demand of the overall system. A blanket multi-year runtime cannot be specified without this information.

## Conformity and supplier

The device is **CE compliant** according to the Radio Equipment Directive **2014/53/EU (RED)** and meets **RoHS 2011/65/EU including (EU) 2015/863**. The **60 GHz band is widely available worldwide**. This description is not a blanket statement on the admissibility of every installation in every country.

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*As of September 2026. Illustrative installation and product image; echo diagram schematic. Subject to change.*