

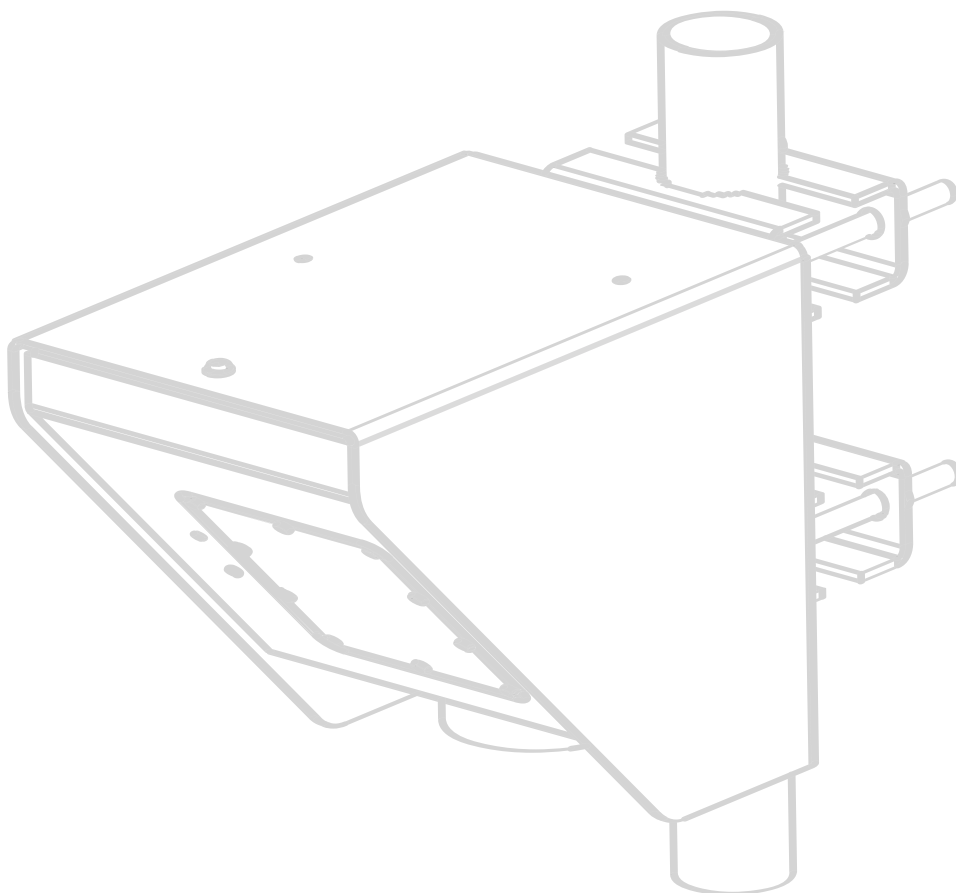


# GLX-RSS-2-300 WL

Non-Contact Flow Meter

*User Manual*

v6.4.8



# Starting Point

Thank you for purchasing Geolux RSS-2-300 WL non-contact open channel flow meter! We have put together the experience of our engineers, the domain knowledge of our customers, the enthusiasm of our team, and the manufacturing excellence to deliver this product to you.

You may freely rely on our field-proven radar technology. The use of top-quality components and advanced signal processing algorithms ensures that Geolux level meter can be used in various applications and environments.

We have created this User Manual to assist you in setting up and using the Geolux instrument.

Should there be any questions left unanswered, please feel free to contact us directly:

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# 1 Introduction

Geolux RSS-2-300 WL flow meter uses radar technology to provide precise contactless measurement of surface flow velocity and precise distance (level) measurement from the sensor to the water surface. Fully contactless radar technology enables quick and simple sensor installation above the water surface and requires minimum maintenance.

Surface velocity measurement functionality is achieved by transmitting an electromagnetic wave in 24 GHz frequency range (K-band) and measuring the frequency shift of the electromagnetic wave reflected from the flowing water surface. The frequency shift is caused by the Doppler effect of the moving surface on the electromagnetic wave. As the relative speed between the radar sensor and the water surface increases, the detected frequency shift also increases, thus enabling the flow meter to precisely determine the surface velocity.

Water level is measured by measuring the distance from the sensor to the water surface, which is proportional to the frequency difference between the transmitted and the received signal. The radar periodically transmits a linear chirp ranging in frequency from 77 GHz to 81 GHz. As the distance between the radar and the water surface increases, so does the difference between the transmitted and received frequency, enabling the level meter to precisely determine the distance between the sensor and the water surface. The radio signal modulation and detection algorithms used in the sensor allow very precise measurements that are not dependent on air temperature, humidity, or other parameters of the environment.

The flow meter is able to detect water surface velocity ranging from 0.02 m/s to 15.0 m/s with precision of 0.001 m/s while the distance can be measured in range from 0.2 m to 15 m or 30 m with resolution of 0.5 mm and accuracy of  $\pm 2$  mm. An integrated tilt sensor measures the inclination angle of the sensors and the surface velocity measurement is automatically cosine-corrected according to the measured mounting tilt angle.

The flow meter is able to measure water flow at distances ranging from 0.2 m up to either 15 m or 30 m, depending on the device version: WL-15-1 is the 15 m version of the device, and WL-30-1 is the 30 m version.

Calculation of the flow (discharge) is done internally in the sensor combining surface velocity measurement and level measurement with configured cross section of the river or channel. Configuration of the measurement parameters like channel profile cross section, material of the edges and the location of the sensor above the water can be easily set using Geolux PC configuration application - Geolux Instrument Configurator. When parameters are set properly, the sensor will calculate flow with an accuracy of approximately  $\pm 1\%$  compared to ADCP measurement for the same location. Measurements of the surface velocity and water level will also be available in parallel to the flow readings on the sensor digital communication interfaces.

# 2

## Electrical Characteristics

The electrical characteristics of the Geolux RSS-2-300 WL flow meter are given in Table 1.

Table 1. Electrical Characteristics

Parameter	MIN	TYP	MAX	Unit
Communication interface: RS-232 interface speed RS-485 interface speed	1200 1200		115200 115200	bps bps
Radar Velocity Sensor Frequency Radiated power (EIRP) Sensitivity Beam-width (3dB) – Azimuth Beam-width (3dB) – Elevation Measurement range Resolution Accuracy Installation height above the water	24.075  -108  0.02 0.001	24.125  -110 12 24  1	24.175 20 -112  15.0  15	GHz dBm dBm ° ° m/s m/s % m
Radar Level Sensor Frequency Beam-width (3dB) – Azimuth Beam-width (3dB) – Elevation Resolution Accuracy Minimal distance Maximal distance	77.000   0.5 0.2	  5 (±2.5) 5 (±2.5) 2	81.000     15/30	GHz ° ° mm mm m m
Power supply voltage	9.0	12.0	27.0	V
Power Operational mode Sleep mode		1550 85		mW mW
Alarm Output Maximal Current			60	mA
Alarm Output Maximal Voltage			30	VDC
Analog Output Maximal Voltage			30	VDC
Operational Temperature Range	-40		+85	°C
Angle Compensation	0	30	75	deg.
Installation Height Above the Water	0.2		15/30	m
Sample rate Level and Discharge Velocity		1 10		sps sps
Ingress Protection Rating	IP68			
Mechanical		150x200x250		mm

# 3

## Cable Pin-Out

The flow meter is supplied with open end cable consisting of 12 wires coded with colours. Table 2 gives a detailed description for each wire.

It is possible to mount optional connectors on the cable end per user request. In this case, the connector specification and connection diagram must be specified when ordering the sensor.

Table 2. Cable Pin-Out

Pin No.	Wire Color		Pin Name	Pin Description
1	White		GND	This pin should be connected to the ground (negative) pole of the power supply.
2	Brown		+Vin	The power supply for the Radar Speed Sensor is provided on this pin. The Radar Speed Sensor power supply voltage must be in the range 9 VDC to 27 VDC, and the power supply must be able to provide at last 0.65W
3	Green		RS232 – TxD	RS-232 data transmit signal.
4	Yellow		RS232 – RxD	RS-232 data receive signal.
5	Grey		GND	Signal ground.
6	Pink		CAN – H	CAN2.0B high signal. (optional)
7	Blue		CAN – L	CAN2.0B low signal. (optional)
8	Red		SDI12 DATA	SDI12 data line
9	Orange		RS485 – D-	RS-485 data transmitter/receiver low signal.
10	Dark Red		RS485 – D+	RS-485 data transmitter/receiver high signal.
11	Black		Alarm SW or 4–20 mA Secondary (Optional)	Alarm 1 - open collector switch signal max. 60mA
12	Purple		4 – 20 mA	Sink for 4 – 20 mA analog interface. Connect sensing device as pull-up to sink the current

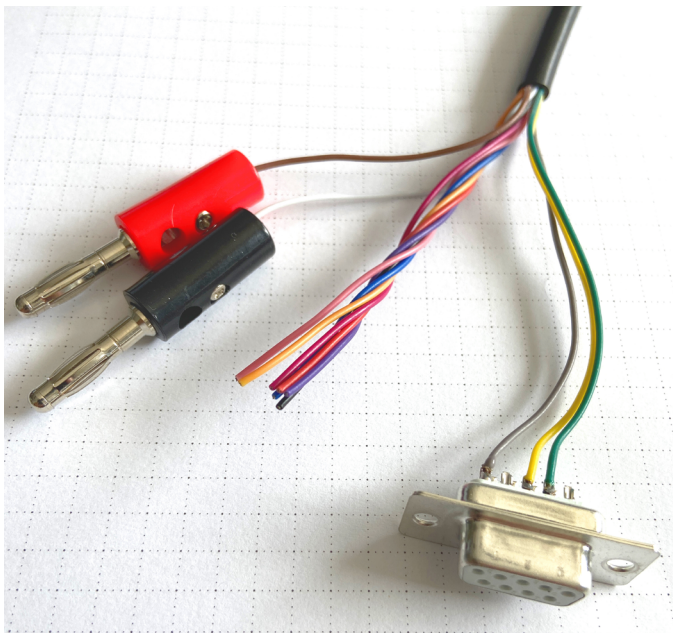
## 3.1. Serial RS-232 Interface

Serial RS-232 interface is implemented as standard PC full-duplex serial interface with voltage levels adequate for direct connection to PC computer or other embedded devices used for serial RS-232 communication.

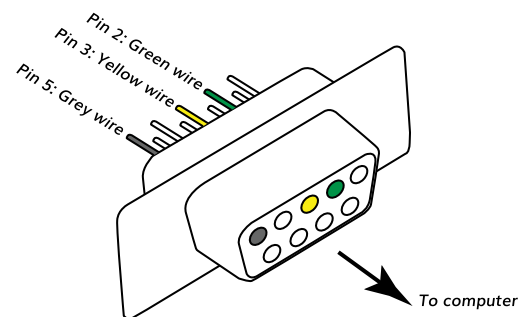
In case the RS-232 interface is connected to standard DB-9 PC connector, TxD line (green wire) is connected to pin 2 and RxD (yellow wire) is connected to pin 3. For proper operation of the serial interface, additional connection of signal GND (grey wire) is required on pin 5 of the DB-9 connector.

Optionally Geolux can supply a cable with a DB-9 connector connected to the cable, but this must be specified when ordering the sensors.

Several communication protocols are available, as well as custom ones on request. Details of communication protocols are described in chapter 7 of this user manual.



Picture 1. Serial RS232 DB-9 Cable



## 3.2. Serial RS-485 Interface

Serial RS-485 interface is implemented as standard industrial half-duplex communication interface. Communication interface is internally protected from short-circuiting and overvoltage. Depending on the receiving device, the interface can be used with only two wires (D+ dark red wire & D- orange wire) while in some cases ground connection (signal GND gray wire) is also required. For more details, please consult receiver specification.

The most common communication protocol used with RS-485 interface is Modbus-RTU but other protocols are also available. Details of communication protocols are described in chapter 7 of this user manual.

### 3.3. CAN Communication Interface (Optional)

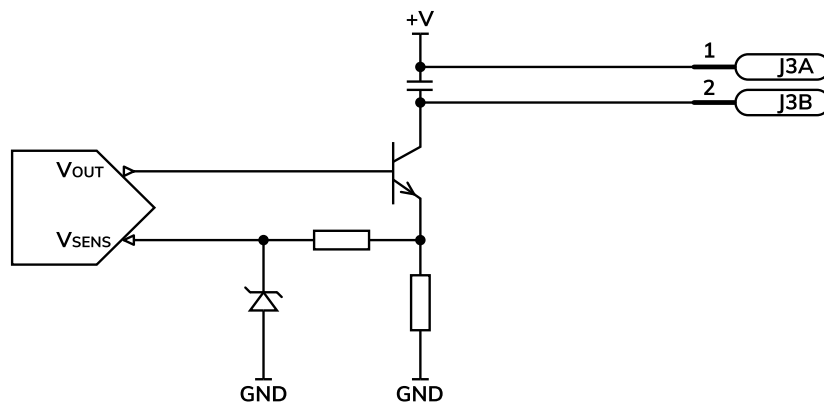
CAN communication interface is an optional communication interface that can be used for special applications. This interface is a higher speed interface (up to 1 Mbps) than other serial communication interfaces, thus enabling additional data transfer which would otherwise not be possible with RS-232 and RS-485 interfaces.

CAN interface is disabled in the default sensor version - for additional features using CAN interface please contact technical support.

### 3.4. Analog 4 – 20 mA Output

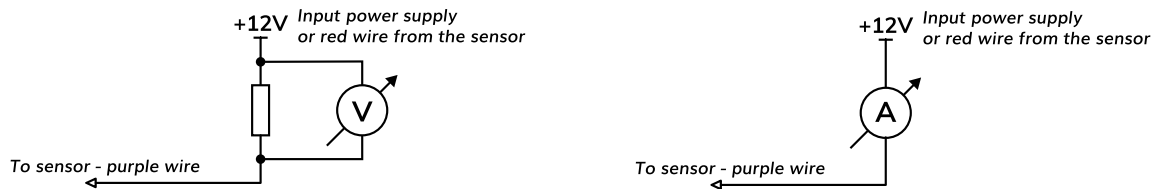
Analog current 4 – 20 mA output is provided for easier compatibility with older logging and control systems. Output is implemented as current sink architecture with common ground. Maximal voltage applied to the sink can go up to 30 VDC, providing greater flexibility in connections of the sensor to PLCs, loggers, or data concentrators.

Signal range and function for 4 – 20 mA analog output can be configured in the setup application so the sensor will be able to signal the best suitable value range with available current range. Current step in the sensor is 0.3  $\mu$ A, which limits the resolution, so care has to be taken while setting the minimal value to be represented by 4 mA and the maximal value to be represented by 20 mA so the resolution is sufficient for the system requirements.



Picture 2. Analog 4 – 20 mA Output Internal Architecture

Measurement of the current by the client device (logger, PLC, modem etc.) must be implemented as the high side current measurement as shown in Picture 3. If a sensing resistor is used, resistance should be selected from the range of 10  $\Omega$  up to 500  $\Omega$  with a recommended value of 100  $\Omega$  for the sensing resistor.



Picture 3. High Side Current Measurement for the 4 – 20 mA Analog Output

### 3.5. SDI-12 Interface

SDI-12 interface is widely used to connect hydrological equipment to dataloggers. SDI-12 uses a single communication line, and very slow speed communication to enable the use of very long communication cables.

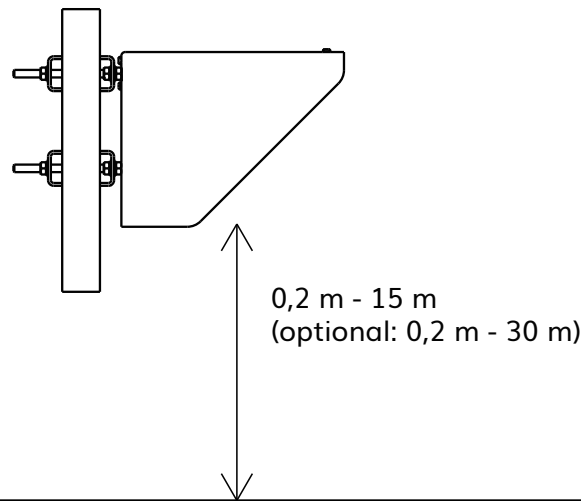
For hydrological applications, SDI-12 communication interface is a valid option and the instrument is natively able to communicate directly with SDI-12 master devices (dataloggers etc.).

# 4

## Installing the Flow Meter

The flow meter must be installed above the water surface, pointing toward the water surface at a vertical angle. The minimum height above the water surface is 0.2 metres and it is recommended to mount the sensor 0.5 metres above the water or higher, with a maximum height up to 15 or 30 metres, depending on the device version. The instrument should be mounted on the vertical pole with inclination tolerance of  $\pm 3^\circ$  to vertical plane reference.

Picture 4 shows how the radar should be positioned relative to the water surface.



Picture 4. Installing the Flow Meter

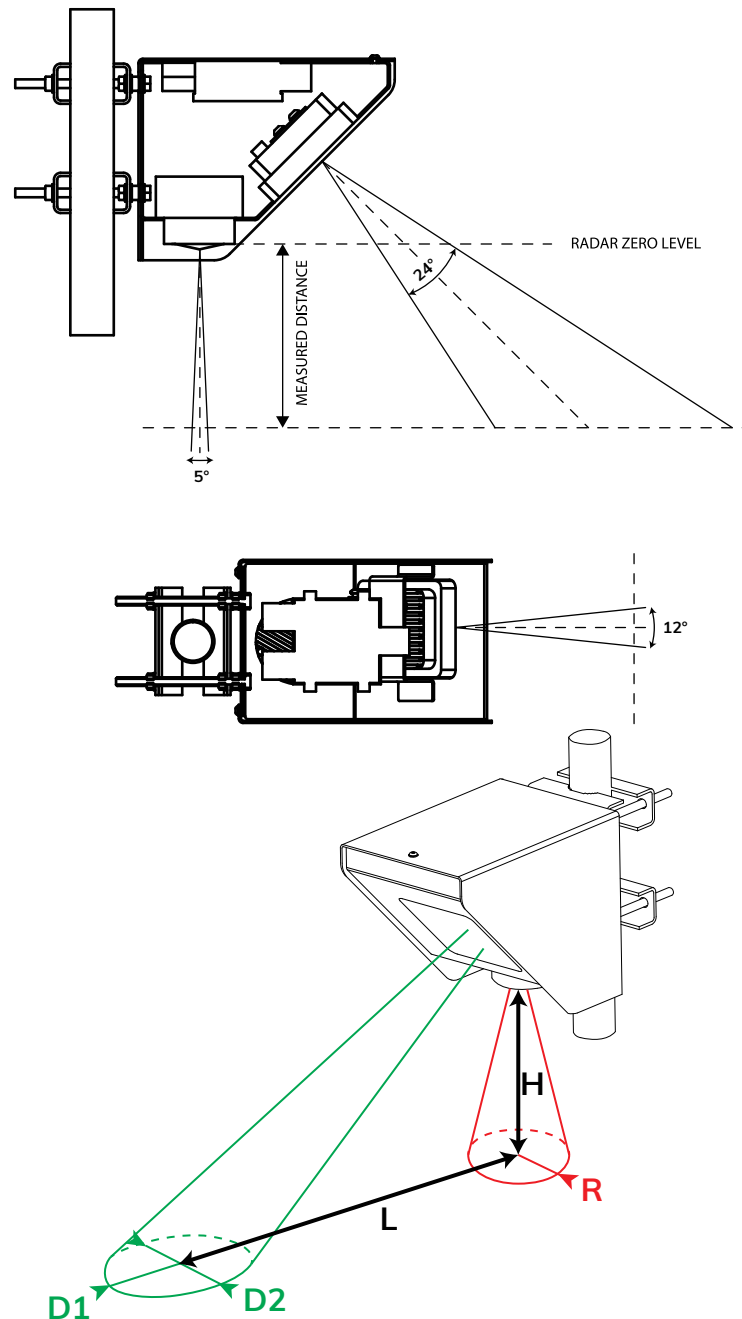
When mounting the instrument, special care must be taken to ensure that a direct line to the water surface is available and not obstructed for both the surface velocity and water level sensor. Any close objects in the vicinity of the sensor can reduce accuracy and introduce offsets in measurements. The best practice is to have a zone of 1 metre around both sensors clear of any other objects or structures.

### 4.1. Instrument Mounting and Location Selection

To achieve the specified accuracy, it is important to properly select the measurement site and to install the sensor with proper horizontal and vertical tilt angle. For optimal operation and best results, the instrument should be oriented in parallel with the water flow direction. Any deviation from parallel water flow direction will introduce offsets of the real measurement value, more precisely the value will be lower than the actual surface velocity of the water. It is recommended that the instrument is pointed upstream, so that the water flows towards the instrument.

The height of the instrument above the water surface and the inclination determine the area on the surface that is covered by the radar beam. This measurement area should be clear of any obstacles. The structure holding the instrument (pole, bridge fence, etc.) must be solid and without vibrations. There should be no vegetation between the radar and the measurement area because it could affect measurement accuracy. Water surface directly below the sensor should be void of vegetation, rocks, sand deposition or other obstacles that could affect measurement.

The surface velocity radar beam will cover an elliptical area on the water surface. The radar reports the average surface velocity of the covered area and uses complex Kalman filters with physical modelling of the water flow to give stable measurements even under turbulent conditions. However even the moderate waviness of the water surface will improve the measurement, if the water flow is strongly turbulent, fluctuations in measured data could be expected as well as somewhat reduced measurement accuracy. If strongly turbulent flow can be expected at monitoring site, then the filter length of the radar should be configured to 120 or more.



Picture 5. Radar Beam Widths and Coverage Areas

Height [H]	L [m]	D1 [m]	D2 [m]	R [m]
0.3 m	0.3	0.3	0.2	0.03
0.5 m	0.5	0.5	0.3	0.04
1 m	1.0	0.9	0.3	0.09
2 m	2.0	1.8	0.6	0.17
3 m	3.0	2.7	0.9	0.26
4 m	4.0	3.6	1.2	0.35
5 m	5.0	4.5	1.5	0.44
6 m	6.0	5.3	1.8	0.52
7 m	7.0	6.2	2.1	0.61
8 m	8.0	7.1	2.4	0.70
9 m	9.0	8.0	2.7	0.79
10 m	10.0	8.9	3.0	0.87
11 m	11.0	9.8	3.3	0.96
12 m	12.0	10.7	3.6	1.05
13 m	13.0	11.6	3.9	1.14
14 m	14.0	12.5	4.2	1.22
15 m	15.0	13.4	4.5	1.31

Lengths and diameters are calculated based on 3 dB signal drop (half signal power) due to the antenna pattern. For practical application the impact is that most of the return energy is reflected from the inside of the bounding shapes, ellipse for surface velocity sensor and circle for level sensor, but some energy could also be received from objects outside from the bounding shapes. Objects outside of the bounding shape should be fairly big to cause problems with the measurements and additionally, the sensors have internally implemented special signal processing algorithms to filter such reflections. However, it is recommended to keep the zone around the target shape of the radars as clear as possible to get best measurement accuracy.

## 4.2. Measurement Quality Indicator

Geolux RSS-2-300 WL instrument is constantly calculating various parameters of the signal in the signal processing algorithms and will continuously, along with measurement data, report the measurement quality. The quality indicator value ranges from 0 (best quality) to 3 (worst quality) and can be used to interpret the data in the analysis software with better understanding and confidence.

For example, when the radar is mounted on the railway bridge, one of common applications, the measurement quality will be very good most of the time, except when a train is passing due to the extensive vibrations. In this case the radar will still report measurements but the reported values could be quite wrong, and also the measurement quality indicator value will go up to a higher value. It is up to every user to interpret the quality indicator value for their application, but general recommendation is that measurements with quality indicator 3 cannot be trusted, value 2 could be questionable, and values 1 and 0 are very good and accurate.

## 4.3. Rain and Wind

Geolux RSS-2-300 WL instrument has integrated internal software filters to filter out effects of rain, fog, or wind both for surface velocity and for radar distance sensor. These filters however have some limitations. Majority of measurement inaccuracies caused by environmental factors can be solved by proper sensor installation.

For rain and snow suppression, the most effective solution is to mount the radar in a way that it points upstream and the water flows towards the radar. As rain falls down and the radar is tilted downwards, rain droplets will move away from the radar, while the water flows towards the radar. The radar can then easily distinguish the water movement from rain movement. To further improve rain filtering, the radar should be configured to report only incoming direction of the water flow. In this case, the radar will completely ignore all movement with direction going away from the sensor.

Influence of the wind on the accuracy of measured data is, in most cases small and can be neglected. The only exception is strong wind as it will create surface waves that are traveling in different direction from the water flow which can affect surface measurement accuracy.

## 4.4. Interference and Multiple Radars

The surface velocity radar operates in K band, in the frequency range around 24.125 GHz. Frequency stability and phase noise of the internal oscillator is very good and is always trimmed in the factory to a precise central frequency but even with the best possible trimming and most stable oscillators it is very unlikely that two devices will be working on the exact same frequency to cause interference. Doppler frequency shift caused by water in speed range up to 15 m/s is measured in kHz frequency shift. As this frequency shift is relatively small in comparison to the central frequency, in most cases below 0.00005%, it would be required to keep the difference between central frequencies of two radars in the same range for interference to occur.

The distance measurement radar operates in W-band ranging from 77 GHz to 81 GHz with linear frequency modulation, modulating the signal continuously in the aforementioned frequency range. For interference between two or more sensors to occur, it would be required to keep their central frequencies very precise and, just like with the surface velocity radar, timing synchronization of radars should be kept in range of 25 ns to each other. Such synchronization is very complex to achieve so the interference probability between several radars on the same location is very small.

Similarly, as with interference from two or more surface velocity radars on the same location, it is very unlikely that other radiation sources in K band will also affect radar measurements. It is possible that some wideband radiation sources can introduce small and impulse interference for a short period of time, but this should not, or is very unlikely to affect measurements reported by the radar sensor continuously.

## 4.5. Fogging and Evaporation

Generally, radar sensors are not affected by fog or evaporation of water unless very heavy evaporation is present and water density in the air is very high. Very high amount of evaporation can introduce reflections and can affect measurements of the surface velocity sensor. In the case of evaporation, the best solution for surface velocity sensor problem solving is to use outbound flow direction and to configure the sensor with only downstream directional filter. As evaporation is traveling upwards from the water surface, inbound or approaching to the radar, the directional filter will solve the problem in the majority of cases.

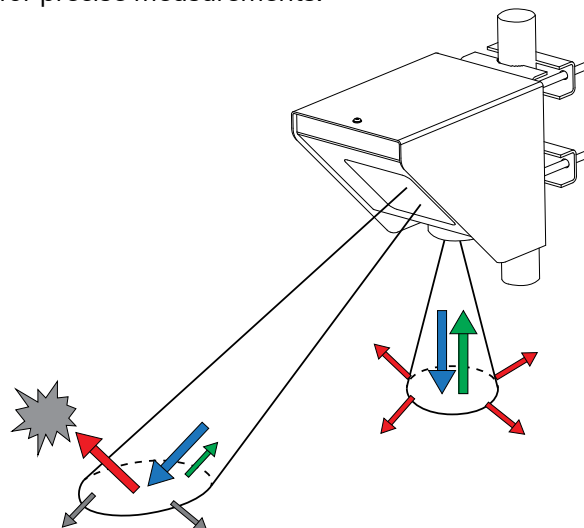
The best solution for distance measurement is, in most cases, to increase the average period of the averaging filter. As evaporation is naturally a turbulent event with significant difference in density over the surface area and in time, averaging of the distance measurement spectrum solves the accuracy problem in such conditions.

## 4.6. Reflections

Water reflects radar signals very well, which means most of the power of a wave transmitted from the radar transmitter will be reflected from the surface of the water.

Reflections of the radar beam transmitted power follow the same physical laws as in optics and every time the radar beam hits the water surface, part of the power is reflected away from the radar, part of the power is reflected towards the radar and only a small part of the power is absorbed by the water. Depending on the surface roughness and incident angle, the ratio between the power reflected in the direction away from the radar and the direction back towards the radar can significantly vary.

The ratio between the reflections is determined by water surface roughness. Generally, the rougher the water surface, the stronger the reflections towards the radar will be, thus easier detection and greater SNR (Signal to Noise Ratio) can be achieved which enables greater measurement accuracy. Geolux surface velocity radar is designed with special techniques to achieve accurate measurements even in environments with very small SNR, so the required surface roughness of 1 mm is usually enough for precise measurements.



Picture 6. Reflections of the Radar Beam

When selecting a location for installing the RSS-2-300 WL instrument, additional care must be taken to avoid that any part of the radar beam that is reflected away from the instrument (red arrow) hits any nearby moving objects (grey cloud). Such additional radar reflections can significantly affect measurement accuracy. Installations where pedestrians, cars or other objects are moving in front of the sensor closer than 75 meters should be avoided as it is proven in practice that it can cause problems.

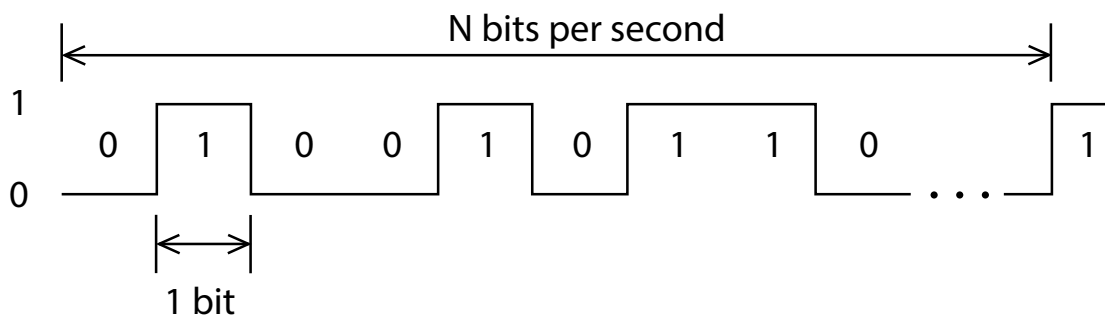
Indoor applications are generally not recommended as it could lead to wrong readings due to the reflection of the radar beam hitting any moving or rotating object which could cause false readings.

# 5

## Surface Velocity Radar Settings

### Communication Interfaces Parameters

#### Baud rate



**Baud rate** - Configures the baud rate (bits per second) for serial communication on both RS-232 and RS-485 data lines. This setting controls how many bits are sent on the communication line in one second. The available values are standardized. Using higher baud rates over longer lines may introduce errors in transferred data. The default instrument baud rate is 9600 bps.

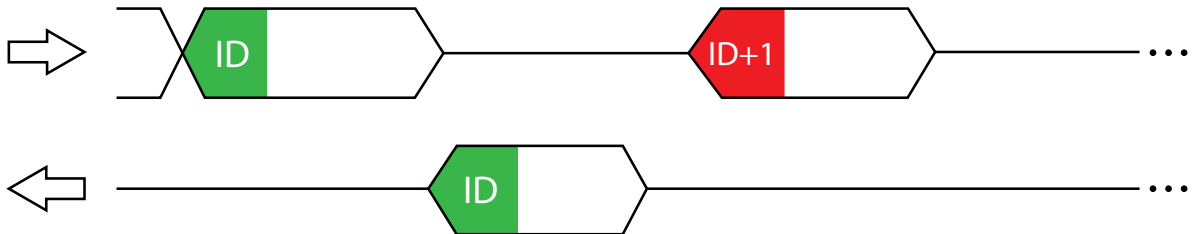
#### RS-232 and RS-485 protocol



**RS-232 protocol** - Selects the communication protocol to be used for data communication on RS-232 interface. The NMEA protocol is a GPS-like human readable messaging protocol where each data packet contains a checksum for data integrity verification.

**RS-485 protocol** - Selects the communication protocol to be used on RS-485 half-duplex interface. HS protocol is a simple request-response protocol for the simplest applications. Modbus RTU protocol is a standardized protocol which is commonly used in automation and instrumentation as it provides all measurements with detailed diagnostics of device operation and the possibility to change the instrument's operating parameters.

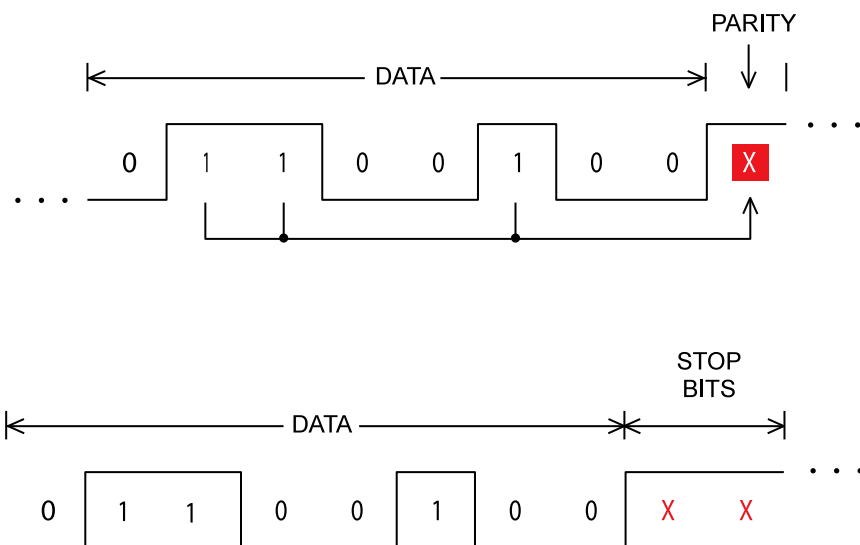
## Device ID



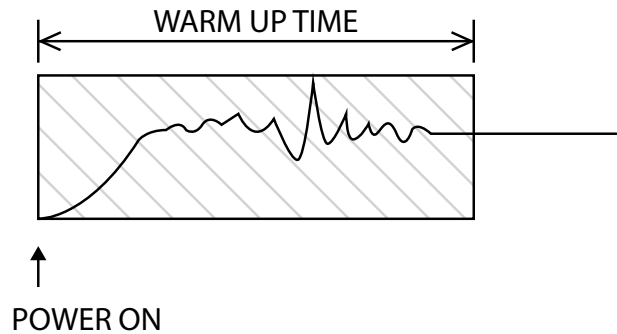
**Device ID** - Configures the device (slave) ID to be used on RS-485 interface protocols (Modbus RTU or HS). Both protocols use request/response format and allow multiple instruments to be connected on the same bus. When a remote master transmits the request message, it will use the device ID as a device address. All instruments will receive the request, but only the instrument with the matching device ID will answer to the received request.

## Modbus settings

**Modbus settings** - Configures the parity and number of stop bits used in communication. Parity is used in serial communication for basic error detection. When parity is set to *None*, no parity is used, and no error detection is possible on bit level. When parity is set to *Odd parity*, an additional bit is added to the communication that will be set to 1 when there is an odd number of bits with value 1 in the 8-bit payload byte. Similarly, when parity is set to *Even parity*, an additional bit is added to the communication that will be set to 1 when there is an even number of bits with value 1 in the 8-bit payload byte. Generally, all bytes on the receiver side where the parity bit is not matching the message will be discarded. The default setting on most devices that use Modbus is even parity. Stop bits are added to the end of each data byte transferred over serial communication, to allow pause between two bytes. One or two bits may be used. The default setting is even parity and one stop bit.



## Warm Up Time

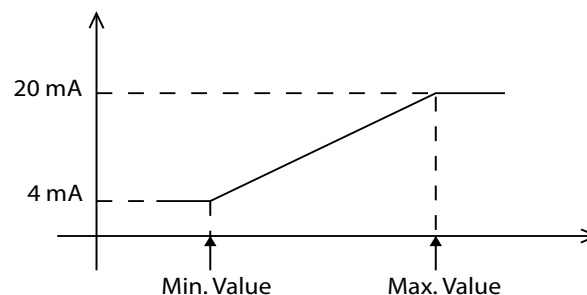


**Warm up time** - The time after sensor power-up, during which all measurements are ignored. This time is used to settle auto-gain parameters, Kalman filter values, averaging filter, and all other operational parameters. It is recommended to set this value to a minimum of 5 seconds. In extreme cases where a quick response after unit power-up is required, 3 seconds can be used, with a possibility of losing measurement accuracy.

## 4 – 20 mA output

**4 – 20 mA output** - This parameter is used to select the value that will correspond to the 4 – 20 mA output. When *Velocity* is selected, the output current will be proportional to the measured velocity. When *Level* is selected, the output current will be proportional to the measured level and when *Discharge* is selected, the output current will be proportional to the calculated discharge. When *None* is selected, the 4 – 20 mA output will be disabled.

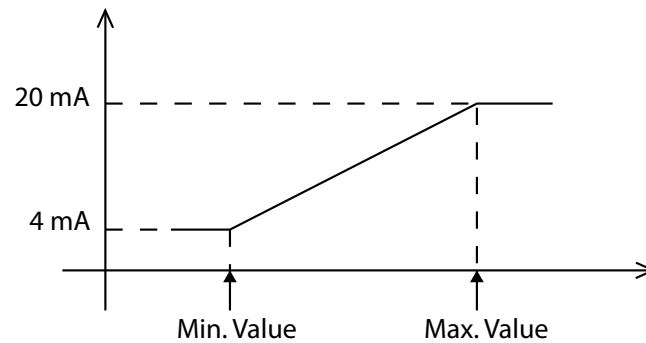
## 4 – 20 mA min. and 4 – 20 mA max.



**4 – 20 mA min.** – To configure the 4 – 20 mA output range, the minimum measured value which will correspond to 4 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm/s up to 1500 mm/s, it is recommended to configure the minimum value to slightly below 700 mm/s (for example 500 mm/s). Alternatively, if the resolution is not critical, then the minimum value for 4 – 20 mA output can be left to the instrument minimum of 0 mm/s.

**4 – 20 mA max.** – To configure the 4 – 20 mA output range, the maximum measured value which will correspond to 20 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm/s up to 1500 mm/s, it is recommended to configure the maximum value to slightly above 1500 mm/s (for example 2000 mm/s). Alternatively, if the resolution is not critical, then the maximum value for 4 – 20 mA output can be left to the instrument maximum of 15000 mm/s.

### Level 4 – 20 mA min. and 4 – 20 mA max.



**Level 4 – 20 mA min.** –To configure the 4 – 20 mA output range, the minimum measured value which will correspond to 4 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm up to 5000 mm, it is recommended to configure the minimum value to slightly below 700 mm (for example 500 mm). Alternatively, if the resolution is not critical, then the minimum value for 4 – 20 mA output can be left to the instrument minimum of 0 mm.

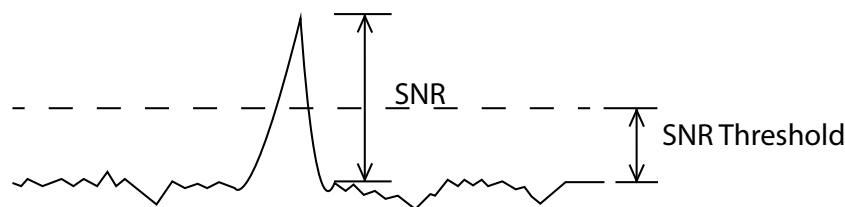
**Level 4 – 20 mA max.** – To configure the 4 – 20 mA output range, the maximum measured value which will correspond to 20 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm up to 5000 mm, it is recommended to configure the maximum value to slightly above 5000 mm/s (for example 6000 mm). Alternatively, if the resolution is not critical, then the maximum value for 4 – 20 mA output can be left to the instrument maximum.

## Processing Parameters

### Sensitivity Level

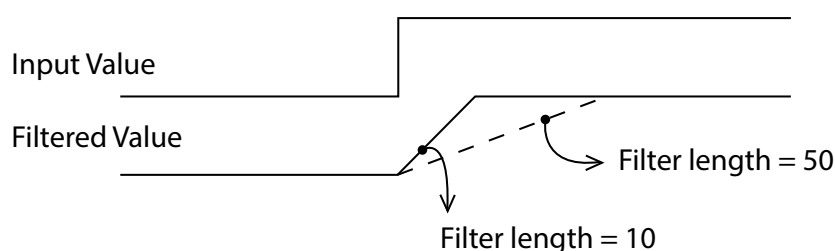
**Sensitivity level** – Configures the radar sensitivity level. The sensitivity level threshold is used by the radar to determine whether the reflected signal is too low to detect any flow. If the instrument is incorrectly reporting flow when there is no water in the channel, it's necessary to increase the value of this parameter.

### SNR threshold



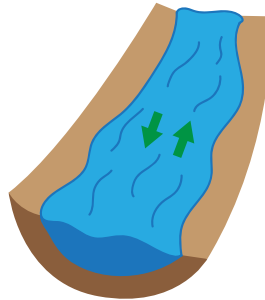
**SNR threshold** – The minimal Signal to Noise Ratio that is required to detect water flow. If the actual measured SNR is lower than the threshold, the instrument will not report any flow. Setting SNR threshold to a higher value will result with more robust measurements but may also result with no measurements when the water is very smooth. Generally, measurements with SNR below 10 dB may be inaccurate, and measurements with SNR below 6 dB should not be trusted. The SNR threshold should be set accordingly.

### Filter Length



**Filter length** – The length of the averaging filter, in number of readings, to smoothen the measured values. The instrument performs 10 readings per second, so a filter length value of 50 will result in 5 second integration time. When using longer filter lengths, more measured values are used for filtering, and the resulting data will be smoother. However, when the surface velocity changes, it will take more time for the new measurement to be reported. Typically, this parameter should be set to a value between 50 and 200. For highly turbulent water, longer filter length is recommended.

## Direction Filter



**Direction filter** – Direction filter is used to choose whether the instrument will detect flow in both directions, or if it should detect only incoming or only outgoing flow. If the direction filter is set to both directions, the instrument will measure the flow velocity in any direction and will also report the actual direction of the flow. If the direction filter is set to incoming direction, then the instrument will reject all radar returns that correspond to outgoing flow, and vice versa. On monitoring sites where it is expected that the flow will always be in only one direction, it is recommended to properly configure this parameter to either incoming or outgoing, as that will improve the consistency of measurements.

## Level Filter Type

Changing the type of filter which is used to smoothen the measured data.

**No filter** - No filtering is used and the raw measurements are reported.

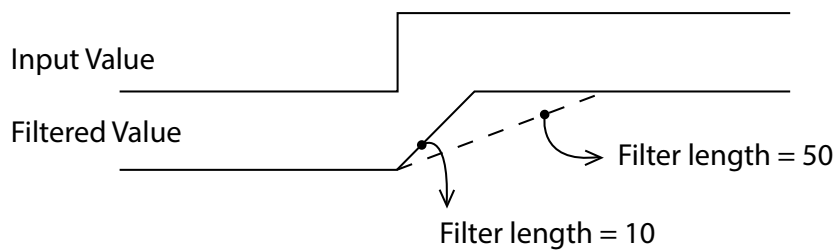
**IIR** - Infinite-Impulse Response filter is used to smooth the data. When compared to moving average filter, IIR filter reacts more quickly to initial change in the data, but it takes longer for the smoothed value to reach the new measurement. The use of IIR filter is discouraged for general applications. The IIR constant can be configured separately.

**Moving average** - The moving average filter calculates the average value of a number of raw measurements. The length for the moving average filter is configured separately through the *Filter Length* parameter.

**Median** - The median filter finds the median value from a number of raw measurements. The length for the median filter is configured separately through the *Filter Length* parameter

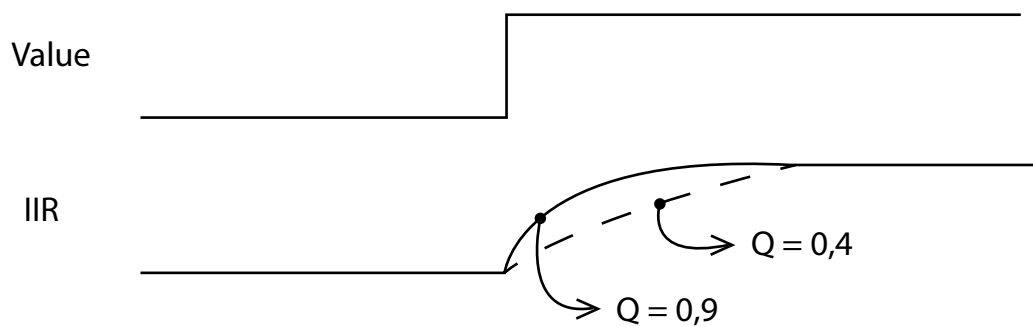
**Standard deviation** - This type of filter is similar to the moving average filter. It takes a number of raw measurements (as defined by the *Filter Length* parameter), then removes 20% of outliers, and calculates the average of the remaining 80% of values.

## Level Filter Length



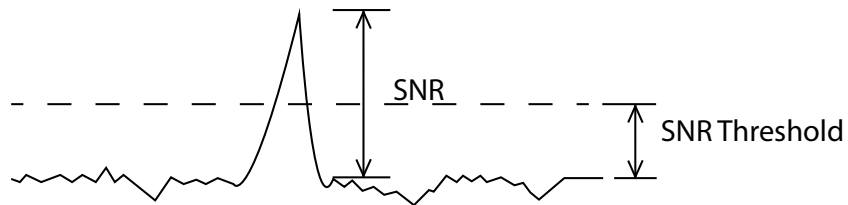
**Level filter length** – The length of the averaging filter, in number of readings, to smooth the measured values. The instrument performs 1 reading per second, so a filter length value of 10 will result in 10 seconds integration time. When using longer filter lengths, more measured values are used for filtering, and the resulting data will be smoother. However, when the water level changes, it will take more time for the new measurement to be reported. Typically, this parameter should be set to a value between 10 and 50. For highly turbulent water, longer filter length is recommended.

## IIR Constant



**IIR constant** - The constant used by Infinite-Impuls Response (IIR) filter if IIR filter type is selected. Accepted values are decimal numbers between 0 and 1. When the IIR constant value is closer to 0.0, the filter response will be slower. When the IIR constant value is closer to 1.0, then the filter response will be faster.

## Amplitude Threshold



**Amplitude threshold** - Setting the minimum amplitude of the spectral peak in signal analysis algorithm required to detect peaks and report distance. If no peak above this value is detected, the sensor will report distance equal to 0. The threshold is used to filter noise and false readings and it is recommended to keep this value between 0 and 1000.

## Peak Detector Type

**Peak detector type** - Configuring the type of algorithm which is used to detect the peaks in the radar echo curve. The default setting should be *Maximum peak*. In specific cases, such as when a water level needs to be measured, but there is a lot of vegetation protruding from the water surface, *Last peak* detector type should be used.

## Measurement Parameters

### Discharge unit

**Discharge unit** – The measurement unit used to report the measured discharge value.

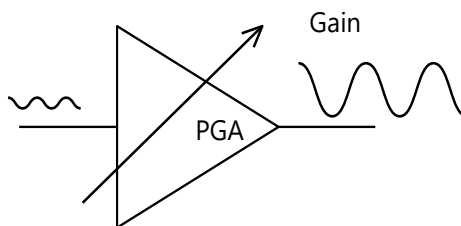
### Velocity unit

**Velocity unit** – The measurement unit used to report the measured velocity value. For NMEA protocol which is used over RS-232 connection, the velocity is reported as an integer value. To preserve higher precision with integer numbers, the measured velocity will be multiplied by 10 for m/s, km/h, mph, fps and fpm when being transferred over RS-232. When mm/s and cm/s units are used, the measured values will not be multiplied by 10. The Geolux Instrument Configurator PC application internally handles the multiplication factor which is used over RS-232 protocol, and it displays the correct values to the user.

### Level unit

**Level unit** – The measurement unit used to report the measured level value. The default measurement unit is millimetres. When changing the measurement unit, it's important to make sure that other parameters which depend on the measurement unit (such as active zone parameters) are also changed to the new unit.

### PGA sensitivity



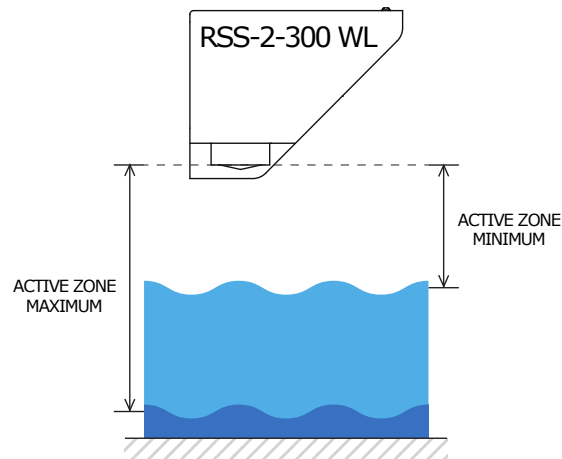
**PGA sensitivity** – This parameter limits the maximum gain (amplification level) of the internal programmable gain amplifier. It is strongly recommended to use the default value 8, which allows the internal signal amplifier to use the maximum gain when the reflected radar signal is very low. Setting this value to a lower value is used only when the instrument is mounted very close to the water surface, typically less than 1 metre, and in that case this parameter should be set to a value of 4 or 5.

### Velocity min. and Velocity max.

**Velocity min.** - This parameter is used for setting up the minimum velocity value of interest.

**Velocity max.** - This parameter is used for setting up the maximum velocity value of interest.

## Level active zone parameters

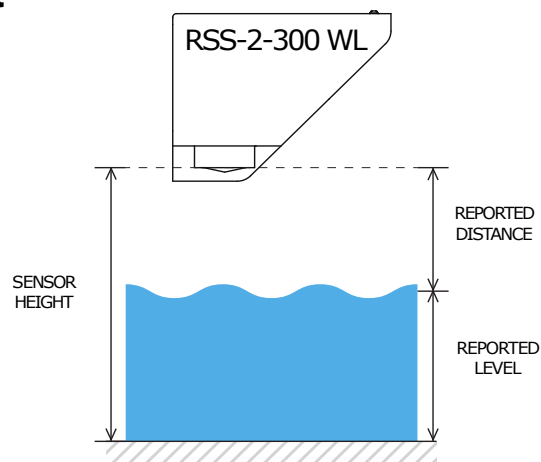


This parameter limits the operational range of the instrument. The instrument will detect water level only within the range set by the Active zone min. and Active zone max. parameters. This parameter is the best way to filter unwanted radar reflections from other structures and objects that are present on the monitoring site, which could cause false instrument readings.

**Active zone min.** - It is strongly recommended to set the Active zone min. value to the minimum possible distance between the water and the instrument at the specific monitoring site.

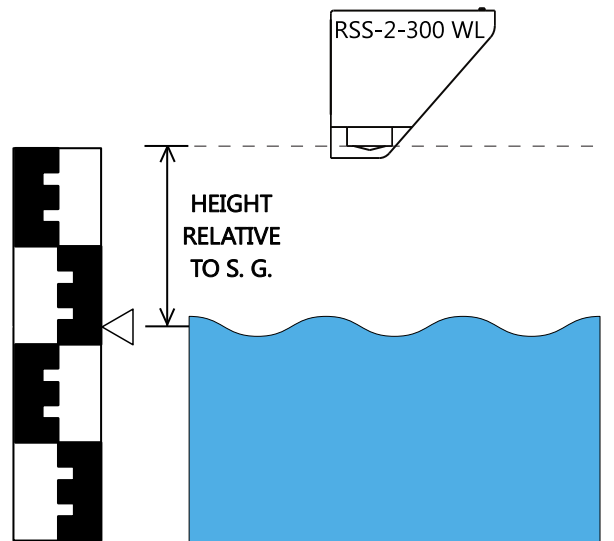
**Active zone max.** - It is strongly recommended to set the Active zone max. value to the maximum possible distance between the water and the instrument at the specific monitoring site. Typically, this is the distance between the instrument and the lowest point in the channel.

## Level sensor height



The height of the instrument needs to be set above the water zero-level “gauge zero”. The instrument will output relative measurement of the actual water level based on its height above the water zero-level. Example: if the instrument is mounted exactly 5 metres above the gauge zero level, then this parameter should be set to 5 metres. Then, if the instrument measures that the distance between the instrument and the water is 4 metres, it will report that the water level is 1 metre, because the water is 1 metre above the gauge-zero level. For user convenience, this parameter can also be indirectly set by inputting the current staff gauge reading.

## Staff Gauge



Setting the sensor height relative to the measurement is done using staff gauge. The sensor will output relative measurement of the actual water level based on its height above the riverbed.

## Power management

Switching the device between continuous scanning mode and SDI-12 sleep modes. In continuous mode the device constantly makes the measurements, which are transmitted over RS-232 interface and made available over Modbus and SDI-12 interfaces. The device is always available over RS-232 and Modbus interfaces. In any SDI12 sleep mode, the device remains in the sleep mode until SDI-12 Measure (aM!) command is received. While in deep sleep mode, the device will not be able to connect to Modbus or RS-232 interface. For reconfiguring the device which is set to operate in SDI-12 deep sleep mode, it's necessary to power-cycle the device, and then use this application to connect to the device within 20 seconds after power-up. If there is no attempt to connect to the device over RS-232 within 20 seconds, the device will automatically go back to sleep mode. The device consumes only 0.08W while in standby mode, and 0.04 W while in sleep mode.

# 6

## Data Interface

Geolux RSS-2-300 WL flow meter offers multiple data interfaces, in order to make the integration of the device with existing SCADA/telemetry systems easy.

### 6.1. Serial RS-232 Interface

Serial RS-232 interface is used for direct connection of a single surface velocity radar unit with the computer. The serial interface is used both for retrieving live flow measurements and for configuration of the surface velocity radar device. Geolux provides a PC application for unit configuration and flow monitoring free of charge.

Default communication parameters are:

Bitrate:	9600 bps
Data bits:	8
Stop bits:	1
Parity:	None

A NMEA-like communication protocol is used to deliver flow measurements over RS-232 interface. Detailed description of the protocol is given in chapter 7 of this user manual.

### 6.2. Serial RS-485 Interface

Serial RS-485 interface is used for connecting multiple flow meters to a single data logger. RS-485 interface uses a different protocol then the protocol used over RS-232 interface, in order to allow multiple surface velocity radars connected on a single RS-485 bus. The main difference from the protocol used over RS-232 interface is that the flow measurements are not reported automatically, but are instead reported only after being requested by the master device (data logger unit). Detailed description of the protocol is given in chapter 7 of this user manual.

Default communication parameters are:

Bitrate:	9600 bps
Data bits:	8
Stop bits:	1
Parity:	None

# 7

## Data Protocols

Geolux RSS-2-300 WL flow meter supports the following data protocols:

- NMEA-like protocol on RS-232 interface that constantly outputs the detected speed, distance (level), discharge and reflected signal power, and also the current measured tilt angles of both the surface velocity sensor and the level meter
- Servicing protocol on RS-232 interface for configuring the unit
- Request-response protocol on RS-485 interface that allows multiple units to be used on a single RS-485 bus
- Modbus-RTU protocol on RS-485 interface which is supported by variety of third-party data loggers

Support for additional protocols is available upon customer request.

### 7.1. NMEA Protocol (RS-232)

NMEA protocol is based on the standard protocol family widely used by navigation equipment. NMEA protocol is sentence oriented and is capable of sending multiple sentences with different information. The sentence content is designated by the starting keyword which is different for each sentence type. NMEA sentences are terminated with the checksum which makes this protocol extremely reliable. NMEA protocol is a single-direction protocol: data is only transmitted from the flow meter. At RS-232 interface the device periodically outputs following data sentences:

#### Direct flow measurement report

\$RDTGT,D1,S1,L1\*CSUM<CR><LF>

\$RDTGT:	The keyword sent in the beginning of each detection report. This sentence is sent whenever there is detected flow.
D1:	The detected flow direction (1 approaching, -1 receding).
S1:	The detected flow speed (speed is reported as speed*10 for m/s, km/h, mph, fps, fpm and as speed*1 for mm/s and cm/s).
L1:	The detected level of the signal reflection from the water surface.
CSUM:	The check sum of the characters in the report from \$ to * excluding these characters.

#### Average flow measurement report

\$RDAVG,S1\*CSUM<CR><LF>

\$RDAVG:	The keyword sent in the beginning of the report. This sentence reports smoothed flow measurement. This is the preferred reading, since it filters out minor fluctuations in flow speed reading due to waves.
S1:	The detected flow speed (speed is reported as speed*10 for m/s, km/h, mph, fps, fpm and as speed*1 for mm/s and cm/s).
CSUM:	The check sum of the characters in the report from \$ to * excluding these characters.

### Tilt angle report

\$RDANG,A\*CSUM<CR><LF>

\$RDANG: The keyword sent in the beginning of each tilt angle report.  
A: The measured tilt angle, in degrees, 0 being horizontal.  
CSUM: The check sum of the characters in the report from \$ to \* excluding these characters.

### Signal SNR report

\$RDSNR,S1,S2\*CSUM<CR><LF>

\$RDSNR: The keyword sent in the beginning of each SNR report.  
S1: The current SNR of measured velocity signal in dBm.  
S2: The average SNR of measured velocity signal in dBm.  
CSUM: The check sum of the characters in the report from \$ to \* excluding these characters.

### Quality of signal report

\$QOS,Q1,Q2\*CSUM<CR><LF>

\$QOS: The keyword sent in the beginning of each quality of signal report.  
Q1: Quality of signal estimate based on sensor vibration.  
Q2: Quality of signal estimate based on radar signal analysis.  
CSUM: The check sum of the characters in the report from \$ to \* excluding these characters.

Quality of signal factor:

0 – Excellent measurement quality  
1 – Good measurement quality  
2 – Low measurement quality  
3 – Unacceptable measurement quality

### Discharge report

\$DIS,D\*CSUM<CR><LF>

\$DIS: The keyword sent in the beginning of each discharge report.  
D: The measured discharge, in defined units.  
CSUM: The check sum of the characters in the report from \$ to \* excluding these characters.

### Water level report

\$LVL,L1,L2,T1,L3,L4,S1,S2\*CSUM<CR><LF>

\$LVL:	The keyword sent in the beginning of each level report.
L1:	Current distance from sensor to water, in defined units, 0 being sensor reference plane. If reporting -4 then there is no detected level.
L2:	Average distance from sensor to water, in defined units, 0 being sensor reference plane. If reporting -4 then there is no detected level.
T1:	Internal device temperature (in °C).
L3:	Current relative detected level, in defined units, 0 being sensor reference plane.
L4:	Average relative detected level, in defined units, 0 being sensor reference plane.
S1:	Measurement SNR (in dBm).
S2:	The standard deviation of water level measurements. The number of samples used to calculate the standard deviation is equal to the configured filter length.
CSUM:	The check sum of the characters in the report from \$ to * excluding these characters.

### Level sensor tilt angle report

\$LVLANG,A1,A2 \*CSUM<CR><LF>

\$LVLANG:	The keyword sent in the beginning of each level sensor tilt angle report.
A1:	The tilt angle of the instrument along X axis. For proper operation of the instrument, ensure that this angle is zero, or as close to zero as possible (between -1 and +1 degrees).
A2:	The tilt angle of the instrument along Y axis. For proper operation of the instrument ensure that this angle is zero, or as close to zero as possible (between -1 and +1 degrees).
CSUM:	The check sum of the characters in the report from \$ to * excluding these characters.

## 7.2. Servicing Protocol (RS-232)

The servicing protocol is used to retrieve and modify device operating parameters. Various device settings, such as unit system and filtering parameters are configured using this protocol. Since NMEA protocol is one way (it only outputs the data), the servicing protocol is always active.

To make radar configuration easy, Geolux provides the Geolux Instrument Configurator utility application. Regular users do not need to be concerned about the servicing protocol used between the Geolux Instrument Configurator and the surface velocity radar device. Geolux Instrument Configurator is described in chapter 8 of this manual.

The servicing protocol listens on RS-232 serial port for incoming requests, and on each received request, it will answer back.

The following requests are recognized by the servicing protocol and every command should be followed by <CR>, <LF> or <CR><LF> (enter):

### Change interfaces parameters:

**Baud rate** - Configures the baud rate (bits per second) for serial communication on both RS-232 and RS-485 data lines. This setting controls how many bits are sent on the communication line in one second. The available values are standardized. Using higher baud rates over longer lines may introduce errors in transferred data. The default instrument baud rate is 9600 bps.

```
#set_baud_rate=9600
#set_baud_rate=19200
#set_baud_rate=38400
#set_baud_rate=57600
#set_baud_rate=115200
```

**RS-232 protocol** - Selects the communication protocol to be used for data communication on RS-232 interface. The NMEA protocol is a GPS-like human readable messaging protocol where each data packet contains a checksum for data integrity verification.

```
#set_proto=nmea
```

**RS-485 protocol** - Selects the communication protocol to be used on RS-485 half-duplex interface. HS protocol is a simple request-response protocol for the simplest applications. Modbus RTU protocol is a standardized protocol which is commonly used in automation and instrumentation as it provides all measurements with detailed diagnostics of device operation and the possibility to change the instrument's operating parameters.

```
#set_485_proto=modbus_rtu
#set_485_proto=hs
```

**Device ID** - Configures the device (slave) ID to be used on RS-485 interface protocols (Modbus RTU or HS). Both protocols use request/response format and allow multiple instruments to be connected on the same bus. When a remote master transmits the request message, it will use the device ID as a device address. All instruments will receive the request, but only the instrument with the matching device ID will answer to the received request.

```
#set_can_id=<0-99>
```

**Modbus settings** - Configures the parity and number of stop bits used in communication. Parity is used in serial communication for basic error detection. When parity is set to *None*, no parity is used, and no error detection is possible on bit level. When parity is set to *Odd parity*, an additional bit is added to the communication that will be set to 1 when there is an odd number of bits with value 1 in the 8-bit payload byte. Similarly, when parity is set to *Even parity*, an additional bit is added to the communication that will be set to 1 when there is an even number of bits with value 1 in the 8-bit payload byte. Generally, all bytes on the receiver side where the parity bit is not matching the message will be discarded. The default setting on most devices that use Modbus is even parity. Stop bits are added to the end of each data byte transferred over serial communication, to allow pause between two bytes. One or two stop bits can be used. The default setting is even parity and one stop bit.

```
#set_485_modbus_type=0 (no parity, one stop bit)
#set_485_modbus_type=1 (no parity, two stop bits)
#set_485_modbus_type=2 (even parity, one stop bit (default))
#set_485_modbus_type=3 (odd parity, one stop bit)
```

**Warm up time** - The time after sensor power-up, during which all measurements are ignored. This time is used to settle auto-gain parameters, Kalman filter values, averaging filter, and all other operational parameters. It is recommended to set this value to a minimum of 5 seconds. In extreme cases where a quick response after unit power-up is required, 3 seconds can be used, with a possibility of losing measurement accuracy.

```
#set_dead_time=<3-100>
```

**4 – 20 mA output** - This parameter is used to select the value that will correspond to the 4 – 20 mA output. When *Velocity* is selected the output current will be proportional to the measured velocity. When *Level* is selected the output current will be proportional to the measured level and when *Discharge* is selected the output current will be proportional to the calculated discharge. When *None* is selected 4 – 20 mA output will be disabled.

```
#set_an420_type=velocity
#set_an420_type=level
#set_an420_type=discharge
#set_an420_type=none
```

**4 – 20 mA min.** - To configure the 4 – 20 mA output range, the minimum measured value which will correspond to 4 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm/s up to 1500 mm/s, it is recommended to configure the minimum value to slightly below 700 mm/s (for example 500 mm/s). Alternatively, if the resolution is not critical, then the minimum value for 4 – 20 mA output can be left to the instrument minimum of 0 mm/s.

```
#set_an420_min=<value>
```

**4 – 20 mA max.** – To configure the 4 – 20 mA output range, the maximum measured value which will correspond to 20 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm/s up to 1500 mm/s, it is recommended to configure the maximum value to slightly above 1500 mm/s (for example 2000 mm/s). Alternatively, if the resolution is not critical, then the maximum value for 4 – 20 mA output can be left to the instrument maximum of 15000 mm/s.

```
#set_an420_max=<value>
```

**Level 4 – 20 mA min.** – To configure the 4 – 20 mA output range, the minimum measured value which will correspond to 4 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm up to 5000 mm, it is recommended to configure the minimum value to slightly below 700 mm (for example 500 mm). Alternatively, if the resolution is not critical, then the minimum value for 4 – 20 mA output can be left to the instrument minimum of 0 mm.

```
#set_lvl_420_max=<value>
```

**Level 4 – 20 mA max.** – To configure the 4 – 20 mA output range, the maximum measured value which will correspond to 20 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 700 mm up to 5000 mm, it is recommended to configure the maximum value to slightly above 5000 mm/s (for example 6000 mm). Alternatively, if the resolution is not critical, then the maximum value for 4 – 20 mA output can be left to the instrument maximum.

```
#set_lvl_420_max=<value>
```

### Change processing parameters:

**Sensitivity level** - Configures the radar sensitivity level. The sensitivity level threshold is used by the radar to determine whether the reflected signal is too low to detect any flow. If the instrument is incorrectly reporting flow when there is no water in the channel, it's necessary to increase the value of this parameter.

```
#set_thld=<0-100>
```

**SNR threshold** - The minimal Signal to Noise Ratio that is required to detect water flow. If the actual measured SNR is lower than the threshold, the instrument will not report any flow. Setting SNR threshold to a higher value will result with more robust measurements but may also result with no measurements when the water is very smooth. Generally, the measurements with SNR below 10 dB may be inaccurate, and measurements with SNR below 6 dB should not be trusted. The SNR threshold should be set accordingly.

```
#set_thld_snr=<0-5120>
```

**Filter length** - The length of the averaging filter, in number of readings, to smoothen the measured values. The instrument performs 10 readings per second, so a filter length value of 50 will result in 5 second integration time. When using longer filter lengths, more measured values are used for filtering, and the resulting data will be smoother. However, when the surface velocity changes, it will take more time for the new measurement to be reported. Typically, this parameter should be set to a value between 50 and 200. For highly turbulent water, longer filter length is recommended.

```
#set_filter_len=<1-1000>
```

**Direction filter** - Direction filter is used to choose whether the instrument will detect flow in both directions, or if it should detect only incoming or only outgoing flow. If the direction filter is set to both directions, the instrument will measure the flow velocity in any direction and will also report the actual direction of the flow. If the direction filter is set to incoming direction, then the instrument will reject all radar returns that correspond to outgoing flow, and vice versa. On monitoring sites where it is expected that the flow will always be in only one direction, it is recommended to properly configure this parameter to either incoming or outgoing, as that will improve the consistency of measurements.

```
#set_direction=in
#set_direction=out
#set_direction=both
```

**Level filter type** - Changing the type of filter used for smoothing measured data.

*No filter* - No filtering is used and the raw measurements are reported.

*IIR* - Infinite-Impulse Response filter is used to smooth the data. When compared to moving average filter, IIR filter reacts more quickly to initial change in the data, but it takes longer for the smoothed value to reach the new measurement. The use of IIR filter is discouraged for general applications. The IIR constant can be configured separately.

*Moving average* - The moving average filter calculates the average value of a number of raw measurements. The length for the moving average filter is configured separately through *Filter length* parameter.

*Median* - The median filter finds the median value from a number of raw measurements. The length for the median filter is configured separately through *Filter length* parameter.

*Standard deviation* - This type of filter is similar to the moving average filter. It takes a number of raw measurements (as defined by *Filter length* parameter), then removes 20% of outliers, and calculates the average of the remaining 80% of values.

```
#set_lv_filter_type=0 (No filter)
#set_lv_filter_type=1 (IIR)
#set_lv_filter_type=2 (Moving average)
#set_lv_filter_type=3 (Median)
#set_lv_filter_type=4 (Standard deviation)
```

**Level filter length** - The length of the averaging filter, in number of readings, to smooth the measured values. The instrument performs 1 reading per second, so a filter length value of 10 will result in 10 seconds integration time. When using longer filter lengths, more measured values are used for filtering, and the resulting data will be smoother. However, when the water level changes, it will take more time for the new measurement to be reported. Typically, this parameter should be set to a value between 10 and 50. For highly turbulent water, longer filter length is recommended.

```
#set_lv_filter_len=<1-1000>
```

**IIR constant** - The constant used by Infinite-Impulse Response (IIR) filter if IIR filter type is selected. Accepted values are decimal numbers between 0 and 1. When the IIR constant value is closer to 0.0, the filter response will be slower. When the IIR constant value is closer to 1.0, then the filter response will be faster.

```
#set_IR_constant=<0-1>
```

**Level amplitude threshold** - Setting the minimum amplitude of the spectral peak in the signal analysis algorithm required to detect peaks and report distance. If no peak above this value is detected, the sensor will report distance equal to 0. The threshold is used to filter noise and false readings and it is recommended to keep this value between 0 and 1000.

```
#set_lvl_amplitude_threshold=<0,65535>
```

**Level peak detector** - Configuring the type of algorithm which is used to detect the peaks in the radar echo curve. The default setting should be *Maximum peak*. In specific cases, such as when the water level needs to be measured, but there is a lot of vegetation protruding from the water surface, *Last peak* detector type should be used.

```
#set_lvl_peak_detector=0 (Maximum peak)
#set_lvl_peak_detector=1 (Last peak)
```

#### Change processing parameters:

**Discharge unit** - The measurement unit used to report the measured discharge value.

```
#set_discharge_units=m3s
#set_discharge_units=liters
#set_discharge_units=ft3s
```

**Velocity unit** - The measurement unit used to report the measured velocity value. For NMEA protocol which is used over RS-232 connection, the velocity is reported as an integer value. To preserve higher precision with integer numbers, the measured velocity will be multiplied by 10 for m/s, km/h, mph, fps and fpm when being transferred over RS-232. When mm/s and cm/s units are used, the measured values will not be multiplied by 10. The Geolux Instrument Configurator PC application internally handles the multiplication factor which is used over RS-232 protocol, and it displays the correct values to the user.

```
#set_units=kmh
#set_units=mph
#set_units=fps
#set_units=fpm
#set_units=ms
#set_units=mms
#set_units=cms
```

**Level Unit** - The measurement unit used to report the measured level value. The default measurement unit is millimetres. When changing the measurement unit, it's important to make sure that other parameters which depend on the measurement unit (such as active zone parameters) are also changed to the new unit.

```
#set_lvl_units=mm
#set_lvl_units=cm
#set_lvl_units=m
#set_lvl_units=in
#set_lvl_units=ft
```

**PGA sensitivity** - This parameter limits the maximum gain (amplification level) of the internal programable gain amplifier. It is strongly recommended to use the default value 8, which allows the internal signal amplifier to use the maximum gain when the reflected radar signal is very low. Setting this value to a lower value is used only when the instrument is mounted very close to the water surface, typically less than 1 metre, and in that case this parameter should be set to a value of 4 or 5.

#set\_sensitivity=<0-8>

**Velocity min.** - This parameter is used for setting up the minimum velocity value of interest.

#set\_min\_velocity=<value>

**Velocity max.** - This parameter is used for setting up the maximum velocity value of interest.

#set\_max\_velocity=<value>

**Level active zone min.** - This parameter limits the operational range of the instrument. The instrument will detect water level only within the range set by the *Active zone min.* and *Active zone max.* parameters. This parameter is the best way to filter unwanted radar reflections from other structures and objects that are present on the monitoring site, that could cause false instrument readings. It is strongly recommended to set the *Active zone min.* value to the minimum possible distance between the water and the instrument at the specific monitoring site.

#set\_lv\_deadzone\_min=<value>

**Level active zone max.** - This parameter limits the operational range of the instrument. The instrument will detect water level only within the range set by the *Active zone min.* and *Active zone max.* parameters. This parameter is the best way to filter unwanted radar reflections from other structures and objects that are present on the monitoring site, that could cause false instrument readings. It is strongly recommended to set the *Active zone max.* value to the maximum possible distance between the water and the instrument at the specific monitoring site. Typically, this is the distance between the instrument and the lowest point in the channel.

#set\_lv\_deadzone\_max=<value>

**Level sensor height** - The height of the instrument needs to be set above the water zero-level "gauge zero". The instrument will output relative measurements of the actual water level based on its height above the water zero-level. Example: if the instrument is mounted exactly 5 metres above the gauge zero level, then this parameter should be set to 5 metres. Then, if the instrument measures that the distance between the instrument and the water is 4 metres, it will report that the water level is 1 metre, because the water is 1 metre above the gauge-zero level. For user convenience, this parameter can also be indirectly set by inputting the current staff gauge reading.

#set\_lv\_sensor\_height=<value>

**Level sensor staff gauge** - Setting the sensor height relative to the measurement is done using staff gauge. The sensor will output relative measurement of the actual water level based on its height above the riverbed.

```
#set_lv_staff_gauge=<value>
```

**Power management** - Switching between continuous scanning mode, standby mode and sleep mode. Standby and sleep modes are set when the SDI-12 interface is planned to be used. In continuous scanning mode, the device continuously performs measurements which are transmitted over the RS-232 interface and made available over Modbus and SDI-12 interfaces. In standby and sleep modes, the device remains in sleep mode until SDI-12 Measure (aM!) command is received. While in sleep mode, the device will not be able to connect to Modbus or RS-232 interfaces. In order to reconfigure a device which is set to operate in SDI-12 sleep mode, it's necessary to power-cycle the device and then use the Geolux Instrument Configurator PC application to connect to the device within 20 seconds after power-up. If there is no attempt to connect to the device over RS-232 interface within 20 seconds, the device will automatically go back to sleep mode. The device consumes only 0.08W while in standby mode, and 0.04 W while in sleep mode.

```
#set_sdi_sleep=0      (Continuous scanning )
#set_sdi_sleep=1      (Standby mode)
#set_sdi_sleep=2      (Sleep mode)
```

**Device in sleep mode** - This command puts device in sleep mode, in order to reconfigure a device which is in sleep mode, it's necessary to send any command.

```
#radar_sleep
```

**Reset device settings to default factory settings** - This command resets all settings on the device (Interface, Processing, Measurement and Profile Settings) to default factory settings.

```
#radar_reset_default
```

### Retrieve current device status

```
#get_info
```

Requests the current device status. Here is an example status output:

```
# firmware:6.4.1
# serial:123456
# sensor_type:WL
# direction:both
# baud_rate:9600
# dead_time:10
# can_id:1
# angle:45
# filter_type:2
# filter_len:50
# pga_gain:200
# proto:nmea
# 485_proto:modbus_rtu
# 485_modbus_type:2
# units:mms
```

```
# sensitivity:8 (Auto)
# thld:124
# thld_snr:1024
# an420_type:9
# an420_min:0.000
# an420_max:10000.000
# min_velocity:0.000
# max_velocity:15000.000
# level_sensor:2
# sdi12_sleep:0
# discharge_units:liters
# lvl_firmware:237
# lvl_units:mm
# lvl_filter_type:4
# lvl_filter_len:15
# lvl_deadzone_min:200.000
# lvl_deadzone_max:15000.000
# lvl_420_min:0.000
# lvl_420_max:15000.000
# lvl_sensor_height:0.000
# lvl_peak_detector:0
# lvl_amplitude_threshold:0
```

## 7.3. Request-Response Protocol (RS-485)

A different data protocol is used on RS-485 interface which allows connection of multiple units on the single RS-485 line. Before the units are connected on the single RS-485 bus, each unit must be configured with a different device identifier. The device identifier is configured using the PC application. Please check chapter 8 for instructions.

The request-response protocol, unlike NMEA protocol, does not automatically report periodic flow measurement readings. Instead, when the unit is polled from the data logger, it responds with the measurement.

## 7.4. HS Protocol

The request is sent from the data logger to the flow meter:

<0x25> ID CSUM

**0x25:** The first byte sent in the request is '%' character. Its ASCII value in HEX is 0x25.

**ID:** Exactly two bytes long. This is the unit ID written as two ASCII characters. For example, if the polled unit ID is 2, then ID will be sent as "02". In HEX representation it is the following two bytes: <0x30><0x32>.

**CSUM:** Checksum, calculated by adding in modulo 256 the two byte values of the ID. If the device ID is 2, then ID was sent as <0x30><0x32>. Checksum is then  $0x30 + 0x32 = 0x62$ .

After receiving the request, if the device ID matches, the flow meter will respond with the current averaged flow velocity reading:

<0xA5> ID SPEED;LEVEL CSUM

**0xA5:** The first byte sent in the response is byte with HEX value of 0xA5.

**ID:** Exactly two bytes long. This is the unit ID written as two ASCII characters. For example, if the unit ID is 2, then ID will be sent as "02". In HEX representation it is the following two bytes: <0x30><0x32>.

**SPEED:** The speed readout in currently selected units, formatted as real (float) number with exactly three digits after the decimal dot separator. For example, if the current averaged speed is 5.7143, it will be reported as 5.714, or in HEX values: <0x35><0x2E><0x37><0x31><0x34><0x33>.

**LEVEL:** The level readout in meters, formatted as a real (float) number with exactly three digits after the decimal dot separator. For example, if the current averaged level is 5.7143, it will be reported as 5.714, or in HEX values: <0x35><0x2E><0x37><0x31><0x34><0x33>.

**CSUM:** Checksum, calculated by adding in modulo 256 the two byte values of the ID and all byte values from the SPEED.

The command that puts the instrument to Power save mode is as follows:

<0x2b> ID CSUM:

0x2b: The first byte sent in the request is '+' character. Its ASCII value in HEX is 0x2b.

ID: Exactly two bytes long. This is the unit ID written as two ASCII characters. For example, if the polled unit ID is 2, then ID will be sent as "02". In HEX representation it is the following two bytes: <0x30><0x32>.

CSUM: Checksum, calculated by adding in modulo 256 the two byte values of the ID. If the device ID is 2, then ID was sent as <0x30><0x32>. Checksum is then  $0x30 + 0x32 = <0x62>$ .

After receiving the request, the device goes to power save mode.

The command that restores the instrument from Power save mode to normal Operational mode is as follows:

<0x2d> ID CSUM

0x2d: The first byte sent in the request is '-' character. Its ASCII value in HEX is 0x2d.

ID: Exactly two bytes long. This is the unit ID written as two ASCII characters. For example, if the polled unit ID is 2, then ID will be sent as "02". In HEX representation it is the following two bytes: <0x30><0x32>.

CSUM: Checksum, calculated by adding in modulo 256 the two byte values of the ID. If the device ID is 2, then ID was sent as <0x30><0x32>. Checksum is then  $0x30 + 0x32 = <0x62>$

After receiving the request, the device goes from Power save mode to normal Operational mode.

## 7.5. Modbus Protocol (RS-485)

When configured in Modbus operation mode, the unit responds to Modbus requests over RS-485 data line. The baud rate and device ID configured through the PC application, and 1 stop bit, even parity, 8 data bits configuration is used.

Modbus registers that are accessed by Modbus protocol are 16-bit (2-byte) registers. Any number of registers can be read or written to over Modbus.

Modbus is a request-response protocol where a master (such as datalogger) sends out requests, and slave devices (such as RSS-2-300 WL sensor) respond. The request and response format, with examples is given in tables 3-6.

In each request, the master can either ask the slave to retrieve the value of one or more registers, or the master can set the value of one or more registers. Each register holds one 16-bit value.

Table 3. Master Request Format

Name	Address	Fun	Data Start Address		Register Count		CRC16	
Length	1 byte	1 byte	2 bytes (H,L)		2 bytes (H,L)		2 bytes (L,H)	
Example	0X01	0X03	0X00	0X00	0X00	0X01	0X84	0X0A

Table 4. Request Example

Name	Content	Detail
Address	0X01	Slave address (Sensor id)
Function	0X03	Read slave info
Data Start Address	0X00	The address of the first register to read (HIGH)
	0X00	The address of the first register to read (LOW) – Sensor ID registers
Number of Regs	0X00	High
	0X01	Low (read only 1 register)
CRC16	0X84	CRC Low
	0X0A	CRC High

Table 5. Slave (Sensor) Response Format

Name	Address	Fun	Byte Count	Data		CRC16	
Length	1 byte	1 byte	1 byte	2 bytes(H,L)		2 bytes(L,H)	
Example	0X01	0X03	0X02	0X00	0X01	0X79	0X84

Table 6. Response Example

Name	Content	Detail
Address	0X01	Slave address (Sensor id)
Function	0X03	Read slave info
Data Length	0X02	Data length is 2 bytes
Data	0X00	Data high byte
	0X01	Data low byte, means ID is 1
CRC16	0X79	CRC Low
	0X84	CRC High

Table 7 defines the data returned by the unit when the master requests that the register is read. Table 8 defines how to write device configuration. Rows highlighted in blue denote the important values measured by the sensor. Rows highlighted in green denote operating parameters that can be changed in the field.

Table 7. Retrieving Data from the Sensor

Fun	Register Address	Data Length	Data Range	Details
0X03	0X0000	2 byte	1~255	Read device ID
	0X0001	2 byte	0 – device range [mm]	Read baud rate
	0X0002	2 byte	0 → 9600 1 → 38400 2 → 57600 3 → 115200 4 → 19200	Read velocity unit type
	0X0003	2 byte	0-15000 (mm/s)	Read instantaneous speed
	0X0004	2 byte	0-15000 (mm/s)	Read averaged speed
	0X0005	2 byte	0-360	Read tilt angle
	0X0006	2 byte	0 → incoming 1 → outgoing	Read flow direction
	0X0007	2 byte	1-512	Read filter length
	0X0008	2 byte	0-8	Read defined PGA gain sensitivity
	0X0009	2 byte	0 → both 1 → incoming 2 → outgoing	Read flow direction filter setting
	0000A	2 byte	0-100	Read sensitivity value
	0X000B	2 byte	1	Read device type, always 1
	0X000C	2 byte	0-3840	Read SNR threshold (dBm * 256)
	0X000D	2 byte	621	Read firmware code 6.2.1
	0x000E	2 byte	1,2,5,10,20,50,100,200	Read current PGA gain level
	0x000F	2 byte	0-2047	Read relative signal level
	0x0010	2 byte	0 – 65535	Read instantaneous speed in selected unit (integer part)
	0x0011	2 byte	0 – 65535	Read instantaneous speed in selected unit (decimal part * 1000)
	0x0012	2 byte	0 – 65535	Read averaged speed in selected unit (integer part)
	0x0013	2 byte	0 – 65535	Read averaged speed in selected unit (decimal part * 1000)
	0x0014	2 byte	0 – 10000	Read instantaneous SNR level (dBm * 256)

Fun	Register Address	Data Length	Data Range	Details
0X03	0x0015	2 byte	0 – 10000	Read averaged SNR level (dBm * 256)
	0x0016 – 0x001B	2 byte	0	Reserved, always 0
	0x001C	2 byte	0-15000	Velocity min. (mm/s)
	0x001D	2 byte	0-15000	Velocity max. (mm/s)
	0x001E – 0x001F	2 byte	0	Reserved, always 0
	0x0020	2 byte	0-65535	Read calculated water discharge, integer part in defined units
	0x0021	2 byte	0-65535	Read calculated water discharge, decimal part in defined units
	0x0022	2 byte	0-65535	Read distance to water surface, integer part in defined units
	0x0023	2 byte	0-65535	Read distance to water surface, decimal part in defined units
	0x0024	2 byte	0-65535	Read measured water level, integer part in defined units, relative to defined staff gauge zero
	0x0025	2 byte	0-65535	Read measured water level, decimal part in defined units, relative to defined staff gauge zero
	0x0026	2 byte	0 – 10000	Read level sensor SNR level (dBm * 256)
	0x0027	2 byte	0 – 150	Read temperature from level sensor (Celsius)
	0x0028	2 byte	0 – 200	Read number of frames for level sensor window filtering
	0x0029	2 byte	0 → no filter 1 → IIR filter 2 → moving average 3 → median filter 4 → standard deviation	Read filter type for level sensor
	0x002A	2 byte	0-1000	Read level sensor IR filter constant
	0x002B	2 byte	0 – level range	Read level sensor active zone minimum in defined units

Fun	Register Address	Data Length	Data Range	Details
0X03	0x002C	2 byte	0 – level range	Read level sensor active zone maximum in defined units
	0x002D	2 byte	0 → mm 1 → cm 2 → m 3 → in 4 → ft	Read level sensor unit type
	0x002E	2 byte	0 → m <sup>3</sup> /s 1 → liters 2 → ft <sup>3</sup> /s	Read discharge unit type
	0x002F	2 bytes	0 → maximum peak 1 → last peak	Peak detector type for level sensor
	0x0030	2 bytes	0-65335	Level spectrum amplitude threshold
	0x0031	2 bytes	Standard deviation	Standard deviation of measurement
	0x0032	2 bytes	0 – 360	Level sensor x-axis tilt angle
	0x0033	2 bytes	0 – 360	Level sensor y-axis tilt angle
	0x0034	2 bytes	239	Read level sensor firmware code

Table 8. Writing Data to the Sensor

Fun	Register Address	Data Length	Data Range	Details
0X06	0X0000	2 byte	1~255	Change device ID
	0X0001	2 byte	0 → 9600 1 → 38400 2 → 57600 3 → 115200 4 → 19200	Change baud rate
	0X0002	2 byte	0 → mm/s 1 → m/s 2 → mph 3 → km/h 4 → fps 5 → fpm 6 → cm/s	Change velocity unit type
	0X0007	2 byte	1-512	Change filter length
	0X0008	2 byte	0-8	Change PGA gain sensitivity
	0X0009	2 byte	0 → both 1 → incoming 2 → outgoing	Change flow direction filter type
	0X000A	2 byte	0-100	Change sensitivity level
	0X000C	2 byte	0-3840	Change SNR threshold (dBm * 256)
	0x001C	2 byte	0-15000	Velocity min. (mm/s)
	0x001D	2 byte	0-15000	Velocity max. (mm/s)
	0x0028	2 byte	0-200	Change number of frames for level sensor window filtering
	0x0029	2 byte	0 → no filter 1 → IIR filter 2 → moving average 3 → median filter 4 → standard deviation	Change level sensor filter type
	0x002A	2 byte	0-1000	Change level sensor IR filter constant $IR_{const} = \frac{value_{int}}{1000}$
	0x002B	2 byte	0 – level range	Change level sensor active zone minimum in defined units
	0x002C	2 byte	0 – level range	Change level sensor active zone minimum in defined units
	0x002D	2 byte	0 → mm 1 → cm 2 → m 3 → in 4 → ft	Change level sensor unit type

Fun	Register Address	Data Length	Data Range	Details
0X06	0x002E	2 byte	0 → m3/s 1 → liters 2 → ft3/s	Change discharge unit type
	0x002F	2 bytes	0 → maximum peak 1 → last peak	Peak detector type for level sensor
	0x0030	2 bytes	0-65335	Level spectrum amplitude threshold
	0x0051	2 byte	0 → turned off 1 → turned on	Low power mode (1 sleep mode)

## 7.6. SDI-12

Supported SDI-12 commands are:

In all commands, 'a' represents the device address. Blue rows indicate that parameters can be set using this command.

Table 9. SDI-12 Commands

Name	Command	Response	Details
Address Query	?!	a<CR><LF>	Device will identify using its SDI-12 address, default address is 0
Ping Sensor	a!	a<CR><LF>	Device will respond if its address is 'a'
Address Change	aAb!	b<CR><LF>	Device will respond if its address is 'a' with its new address 'b'
Send Identification	a!!	a13GEOLUX 2300WLfff<CR><LF>	a – address SDI-12 version – 1.3 vendor identification – GEOLUX sensor model – 2300W sensor version – fff, where fff is firmware version
Start Verification	aV!	a00001<CR><LF>	One value is ready imminently
Send Data	aD0!	a+d<CR><LF>	d – verification: 0->not ready , 1->ready
Additional Data	aD1! .. aD9!	a0<CR><LF>	No values are returned for additional data.
Start Measurement	aM!/aMC!	ammm9<CR><LF>	9 values are ready within mmm seconds for M command and 12 values are ready within mmm seconds for C command

Name	Command	Response	Details
Send Data	aD0!	a<val0><CR><LF> a<val0><CRC><CR><LF>	val0 → a±f±f+d+d+d <cl><rf> ±f - discharge in defined units ±f - average velocity in defined units +d - average SNR in dBm +d - angle in dBm +d - signal quality (3->unacceptable, 2 ->low, 1->good, 0->excellent )
Additional Data	aD1! .. aD9!	aD1! a<val1><CR><LF> a<val1><CRC><CR><LF>	val1 → a±f±f±d±f <cl><rf> ±f - relative level depending on sensor height in defined units ±f - distance from sensor to water in defined units ±d - level SNR in dBm ±f - standard deviation of water level in mm
Concurrent Measurement	aC!/aCC!	ammm12<CR><LF>	val2 → a±d+d+d <cl><rf> ±d – internal device temperature in °C +d – measured tilt angle of device in x direction +d – measured tilt angle of device in y direction
Send Data	aD0!	a<val0><CR><LF> a<val0><CRC><CR><LF>	
	aD1!	a<val1><CR><LF> a<val1><CRC><CR><LF>	
	aD2!	a<val2><CR><LF> a<val2><CRC><CR><LF>	
Additional Data	aD3! ... aD9!	a<CR><LF> a<CRC><CR><LF>	No values are returned for additional data.
Continuous Measurement	aR0! ... aR9!	a<CR><LF> a<CRC><CR><LF>	The continuous mode is not supported
Get Velocity/ Discharge Unit	aXGWUN!	a+d<CR><LF>	+d – measurement unit for velocity 0 – mm/s, 1 – m/s, 2 – mph, 3 – km/h, 4 – fps, 5 – fpm
Set Velocity/ Discharge Unit	aXGWUN+d!	a+d<CR><LF>	+d – measurement unit for velocity 0 – mm/s, 1 – m/s, 2 – mph, 3 – km/h, 4 – fps, 5 – fpm
Get Velocity Average Factor	aXGWAV!	a+d<CR><LF>	+d – averaging velocity length 1-512
Set Velocity Average Factor	aXGWAV+d!	a+d<CR><LF>	+d – averaging velocity length 1-512
Get Direction Filter Factor	aXGDFT!	a+d<CR><LF>	+d – direction filter for velocity 0 – both, 1 – incoming, 2 – outgoing
Set Direction Filter Factor	aXGDFT+d!	a+d<CR><LF>	+d – direction filter for velocity 0 – both, 1 – incoming, 2 – outgoing

Name	Command	Response	Details
Get Velocity Sensitivity Factor	aXGSENS!	a+d<CR><LF>	+d – sensitivity level for velocity 1-100
Set Velocity Sensitivity Factor	aXGSENS+d!	a+d<CR><LF>	+d – sensitivity level for velocity 1-100
Get Measurement Unit for Level	aXGLUN!	a+d<CR><LF>	+d – measurement unit for level 0 – m, 1 – cm, 2 – mm, 3 – in, 4 – ft
Set Measurement Unit for Level	aXGLUN+d!	a+d<CR><LF>	+d – measurement unit for level 0 – m, 1 – cm, 2 – mm, 3 – in, 4 – ft
Get Minimum Active Zone Value	aXGDZ0!	a+f<CR><LF>	+f – active zone minimum value, sensor will not report measurements lower than this
Set Minimum Active Zone Value	aXGDZ0+f!	a+f<CR><LF>	+f – active zone minimum value, sensor will not report measurements lower than this
Get Maximum Active Zone Value	aXGDZ1!	a+f<CR><LF>	+f – active zone maximum value, sensor will not report measurements higher than this
Set Maximum Active Zone Value	aXGDZ1+f!	a+f<CR><LF>	+f – active zone maximum value, sensor will not report measurements higher than this
Get Sensor Height Value	aXGSHR!	a+f<CR><LF>	+f – sensor height above riverbed
Set Sensor Height Value	aXGSHR+f!	a+f<CR><LF>	+f – sensor height above riverbed
Set Current Staff Gauge Reading	aXGSGR+f!	a+f<CR><LF>	+f – current staff gauge reading, device will calculate sensor height above riverbed as: staff gauge reading + distance from sensor to water
Get Average Time in Seconds for Level	aXGLAV!	a+f<CR><LF>	+f – averaging time in seconds
Set Average Time in Seconds for Level	aXGLAV+f!	a+f<CR><LF>	+f – averaging time in seconds
Get Measurement Unit for Discharge	aXGDUN!	a+d<CR><LF>	+d – measurement unit for level 0 – m <sup>3</sup> /s, 1 – liters, 2 – ft <sup>3</sup> /s
Set Measurement Unit for Discharge	aXGDUN+d!	a+d<CR><LF>	+d – measurement unit for level 0 – m <sup>3</sup> /s, 1 – liters, 2 – ft <sup>3</sup> /s

Name	Command	Response	Details
Get Level Filter Type	aXGLFT!	a+d<CR><LF>	+d – filter type for level 0 – no filter, 1 – IIR filter, 2 – Moving average, 3 – Median, 4 – Standard deviation
Set Level Filter Type	aXGLFT+d!	a+d<CR><LF>	+d – filter type for level 0 – no filter, 1 – IIR filter, 2 – Moving average, 3 – Median, 4 – Standard deviation
Get Peak Detector Type For Level	aXGPDT!	a+d<CR><LF>	+d – identifies the peak detector type, can be any of the following: 0 – report the distance to the maximum peak which corresponds to the maximum radar signal reflection 1 - report the last peak which corresponds to the furthest reflection from the radar; this may include multipath reflections in typical cases and should be avoided
Set Peak Detector Type For Level	aXGPDT+d!	a+d<CR><LF>	+d – identifies the peak detector type, can be any of the following: 0 – report the distance to the maximum peak which corresponds to the maximum radar signal reflection 1 - report the last peak which corresponds to the furthest reflection from the radar; this may include multipath reflections in typical cases and should be avoided

Device supports all other commands required by SDI-12 v1.3 and will respond to them but all relevant data can be acquired using the commands from the table above.

# 8 Radar Configurator Utility

Geolux provides a user-friendly PC application, Geolux Instrument Configurator, for configuring the surface velocity radar operating parameters. Additionally, the Geolux Instrument Configurator displays measurements.

When started, the Geolux Instrument Configurator displays its main window. Initially, no data is displayed, as the connection to the surface velocity radar is not established.



Picture 7. Geolux Instrument Configurator Main Window

To connect the Geolux Instrument Configurator with the flow meter, connect your PC to the radar using a serial cable connection. Then, click the *Connect* button in the upper left corner and select *Flow Meter* from the window which appears. In the next window, select the appropriate COM port and interface. If RS-485 interface is selected, additionally select the baud rate and the Modbus ID. In case of multiple devices connected on a single RS-485 bus, make sure that each device has a unique Modbus ID. When the *Connect* button is clicked, Geolux Instrument Configurator will try to establish a data link between your PC and the flow sensor. If the connection is successful, the device will appear under *Connected devices* and the measurements will be displayed in the *Data* tab, Picture 8. A detailed description of the displayed parameters is available when hovering the mouse over the icon of a specific parameter. Initially, only the most important parameters are displayed while the rest are hidden. By clicking the button with arrows next to the displayed parameters, the user can view all the data received from the device.



Picture 8. Geolux Instrument Configurator – Data View

Clicking the Settings button enables the user to configure the flow meter or upgrade the device to a newer firmware version. The device settings are divided into 3 groups: *Interfaces*, *Processing* and *Measurement*. By clicking the name of a specific group, all the settings which belong to that group can be viewed and changed. The following settings are displayed:

#### Interfaces

Baud rate  
RS-232 protocol  
RS-485 protocol  
Device ID  
Modbus settings  
Warm up time  
4-20 mA output  
4-20 mA min.  
4-20 mA max.  
Level 4-20 mA min.  
Level 4-20 mA max.

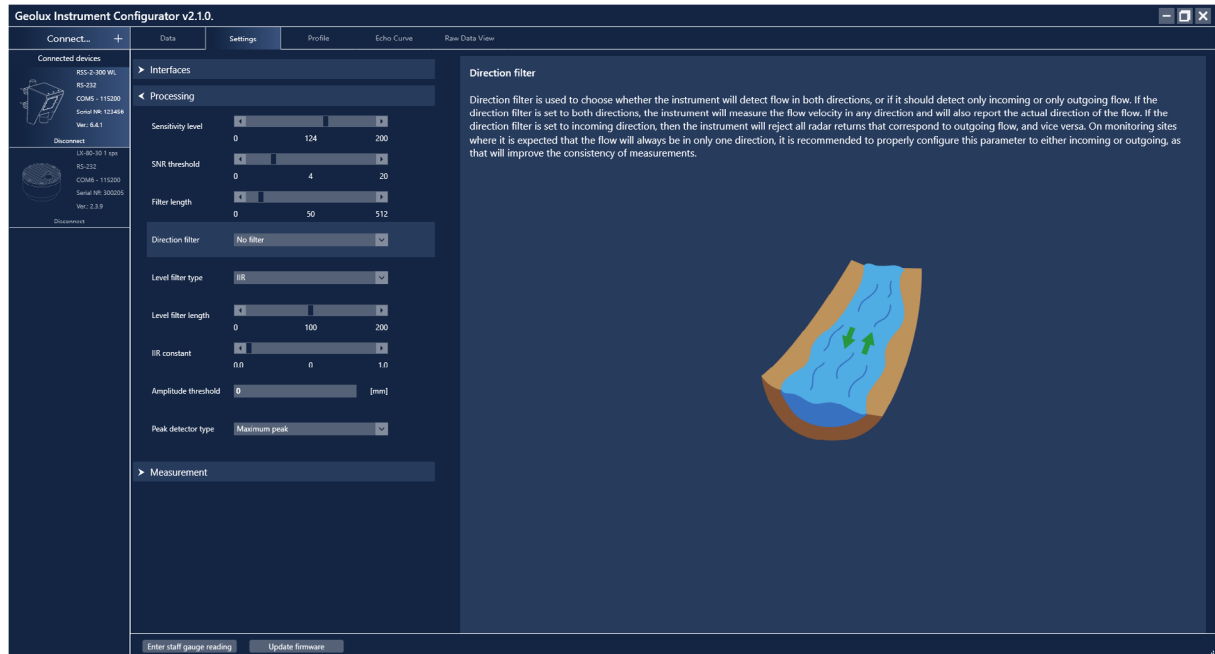
#### Processing

Sensitivity level  
SNR threshold  
Filter length  
Direction filter  
Level filter type  
Level filter length  
IIR constant  
Amplitude threshold  
Peak detector type

#### Measurement

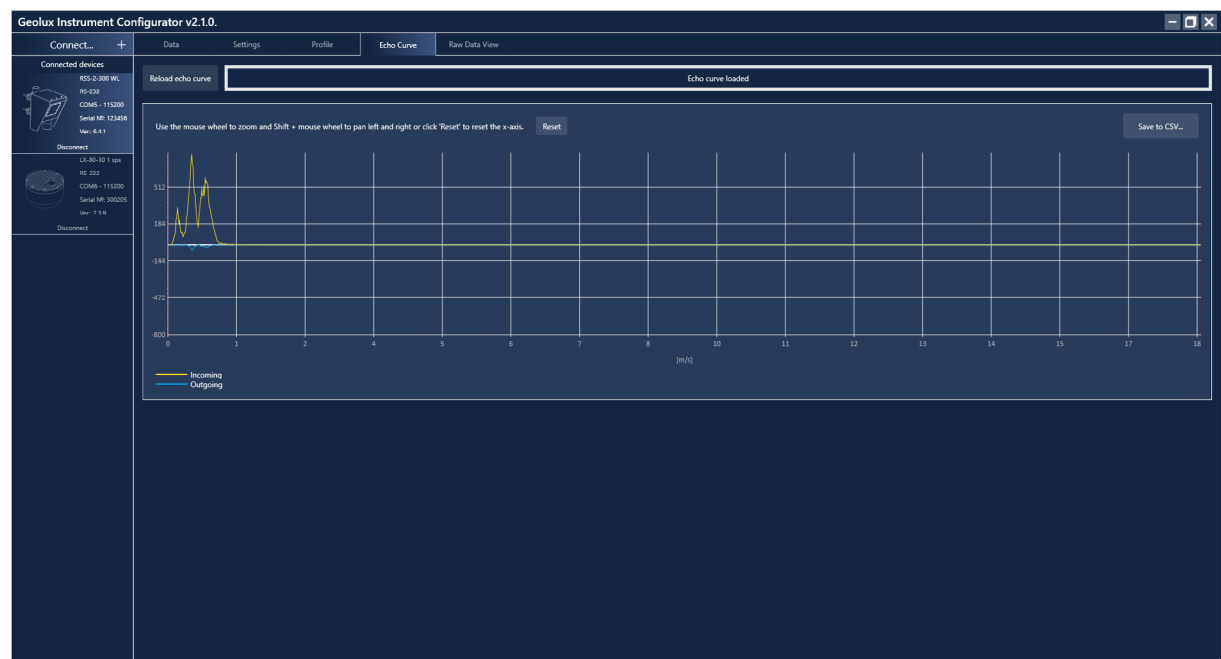
Discharge unit  
Velocity unit  
Level unit  
PGA sensitivity  
Velocity min.  
Velocity max.  
Level active zone min.  
Level active zone max.  
Level sensor height  
Power management

A detailed description (as described in chapter 5 of this user manual) of the selected setting appears on the right side of the window when the user clicks on, or begins to change, a specific setting. When a setting is changed, the Set button will appear next to the setting. By clicking the Set button, the user confirms the change, and the new settings are saved.



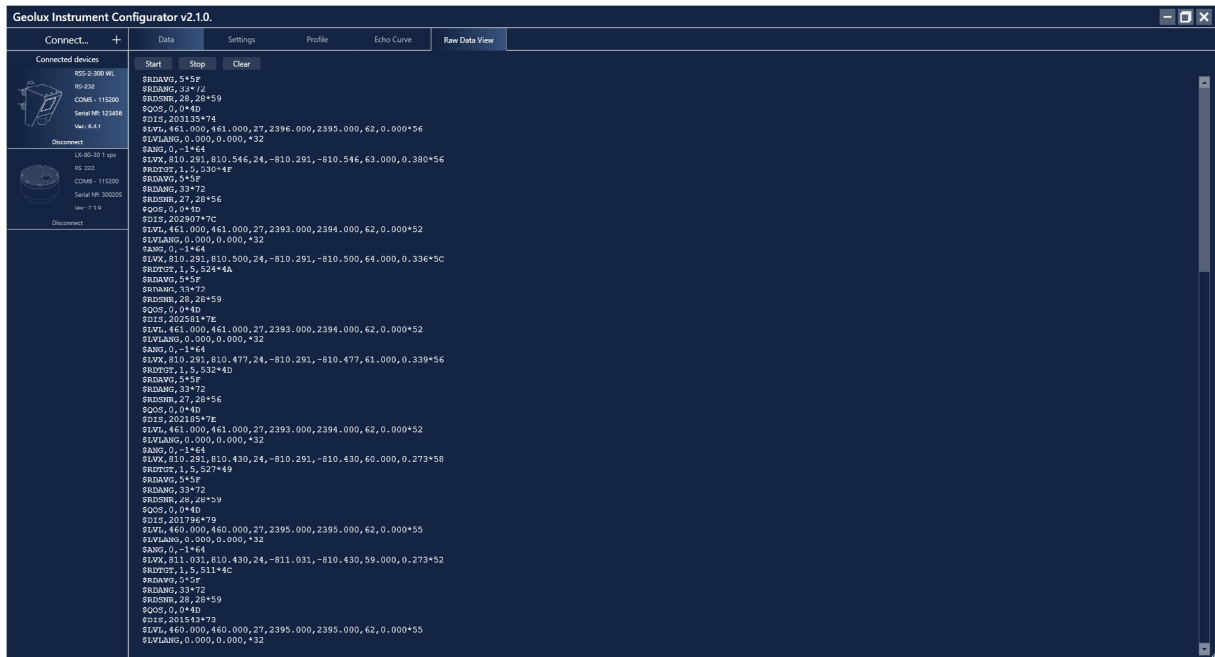
Picture 9. Geolux Instrument Configurator – Settings View

Geolux Instrument Configurator also enables echo curve acquisition. Navigating to the *Echo Curve* tab and clicking the *Load echo curve* button loads the current echo curve. The echo curve plot shows both the incoming and outgoing directions with yellow and blue lines respectively. Depending on the *Direction filter* selected in *Settings*, the echo curve which is not of interest will be shown in grey. If desired, echo curves can be saved to a .csv file.



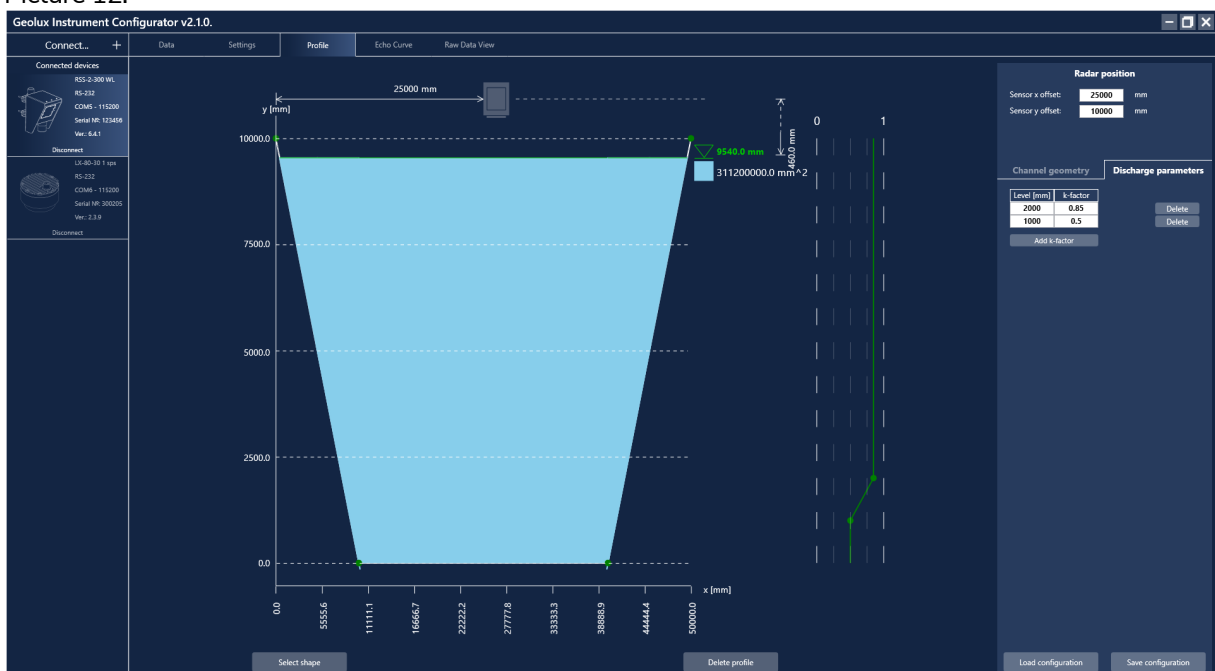
Picture 10. Geolux Instrument Configurator – Echo Curve View

Navigating to the Raw Data View tab and clicking the Start button enables the user to view the raw data which is being transmitted by the device. Clicking the Stop button stops the acquisition of the raw data, while clicking the Clear button clears the previously acquired data.



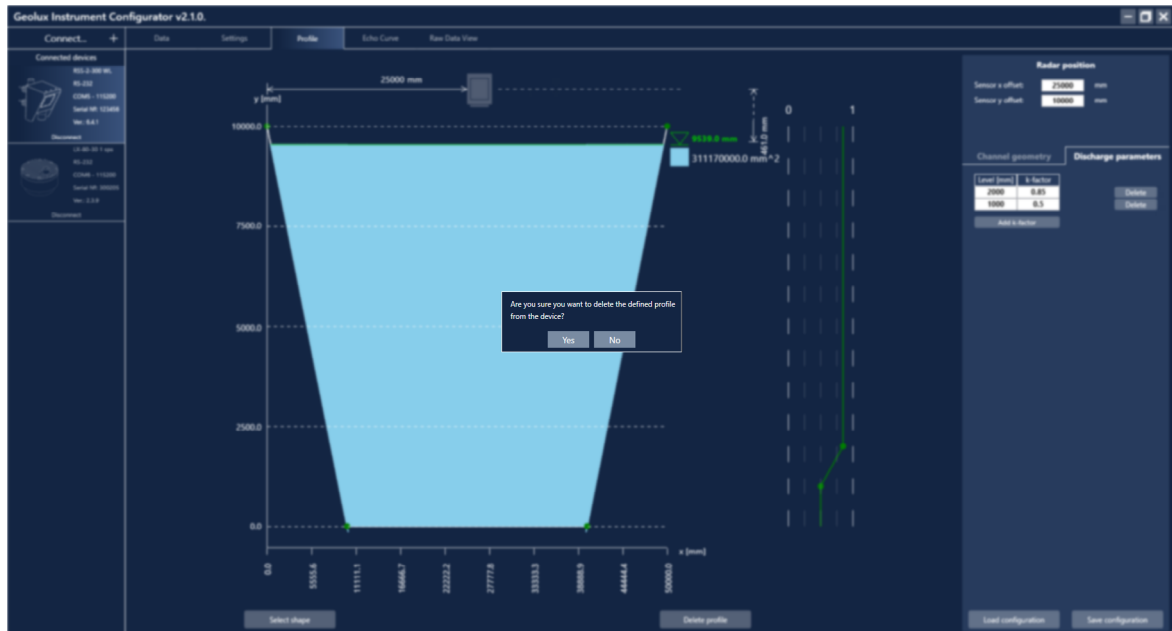
Picture 11. Geolux Instrument Configurator - Raw Data View

Navigating to the Profile tab enables the user to define the channel profile geometry and discharge parameters which are used for discharge calculation. If the channel profile geometry is already defined and saved to the device, the existing configuration will be loaded and the profile shape will appear, Picture 12.



Picture 12. Channel Profile Geometry Saved on the Device

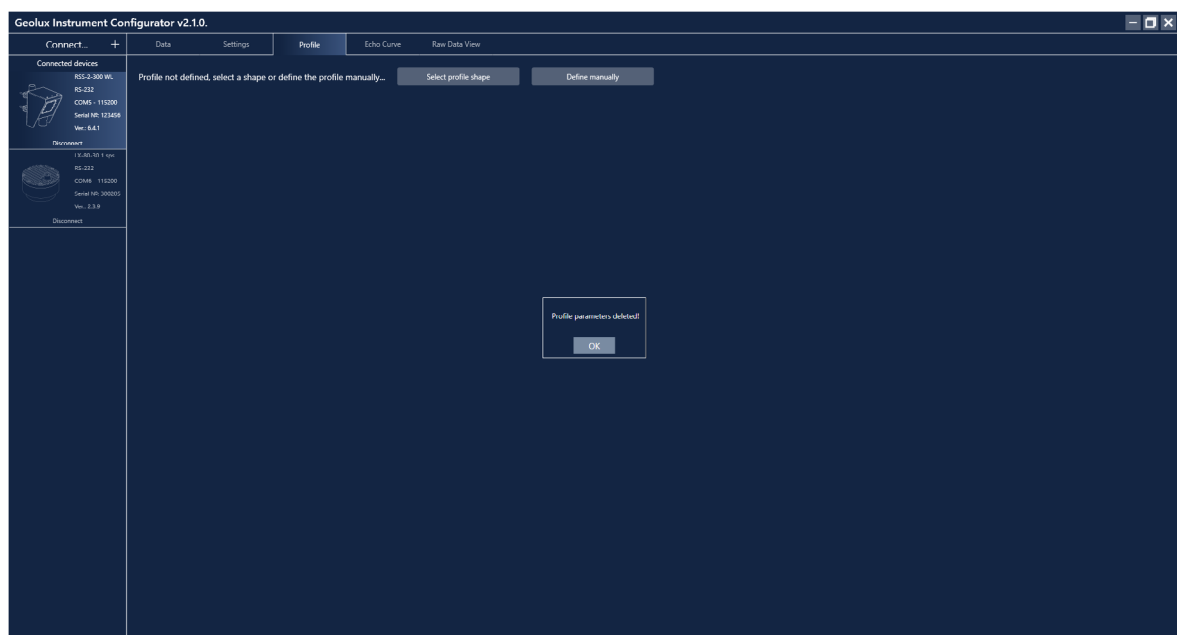
By clicking the *Delete profile* button the user can delete the channel profile geometry which was saved on the device.



Picture 13. Deleting the Existing Channel Profile Geometry

## 8.1. Configuring the Unit for Discharge Calculation

If there is no channel profile geometry saved on the device, or if the user has deleted the defined geometry and wants to define a new one, the geometry can be manually defined, or a predefined shape can be selected to define the channel profile geometry, as described in chapters 8.1.1. and 8.1.2.



Picture 14. Select a Shape or Define the Channel Profile Geometry Manually

## 8.1.1. Defining the Channel Profile Geometry Manually

After clicking the *Define manually* button, a blank channel profile geometry definition page is shown, as seen in Picture 15.



Picture 15. Channel Profile Geometry Definition Page

On the right side of the channel profile geometry definition page, in the *Radar position* section, the user has to input the *Sensor x offset* and *Sensor y offset* of the radar. X offset of the radar is the distance from the leftmost point of the channel to the radar while the y offset represents the distance from the radar to the lowest point of the channel.

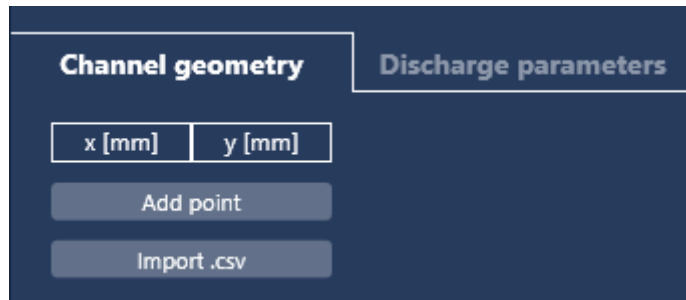
After inputting or changing the value, the *Set* button will appear. The user has to click the *Set* button to confirm the change.



Picture 16. Radar Position

After defining the radar position, the channel geometry must be defined. The user can choose to add points by clicking the *Add point* button, or import the geometry from a .csv file by clicking the *Import .csv* button.

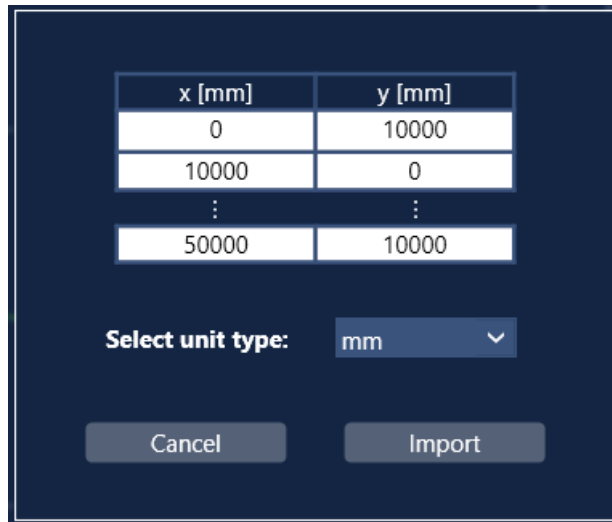
If the user chooses to define the channel geometry by adding points, the *Set* or *Delete* button must be selected after inputting the x and y coordinates of a certain point, otherwise the next point cannot be added.



The dialog box has two tabs: "Channel geometry" (active) and "Discharge parameters". Under "Channel geometry", there are two input fields: "x [mm]" and "y [mm]". Below these fields are two buttons: "Add point" and "Import .csv".

Picture 17. Channel Geometry

If the user has the geometry saved in a .csv file, a preview window with the values from the .csv file will appear as shown in Picture 18. In the preview window the user must select the unit type corresponding to the values. After clicking the *Import* button in the preview window, the channel geometry table will be filled with the values from the .csv file.



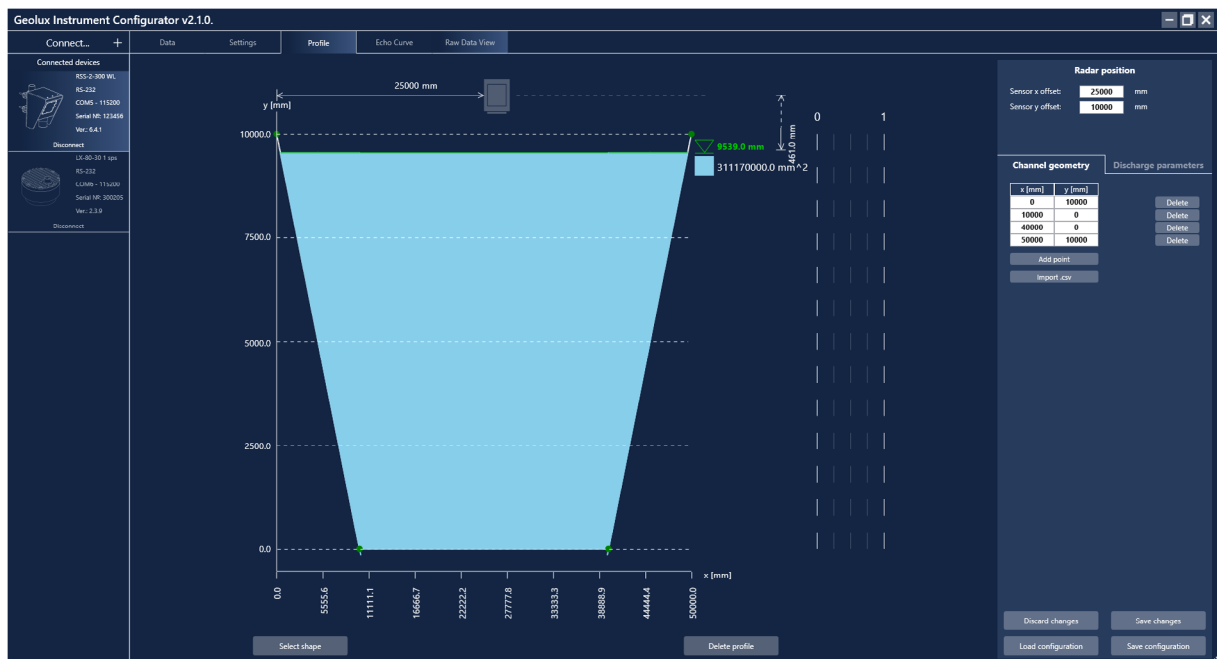
The preview window shows a table with two columns: "x [mm]" and "y [mm]". The table contains the following data:

x [mm]	y [mm]
0	10000
10000	0
⋮	⋮
50000	10000

Below the table, there is a label "Select unit type:" followed by a dropdown menu currently showing "mm". At the bottom are two buttons: "Cancel" and "Import".

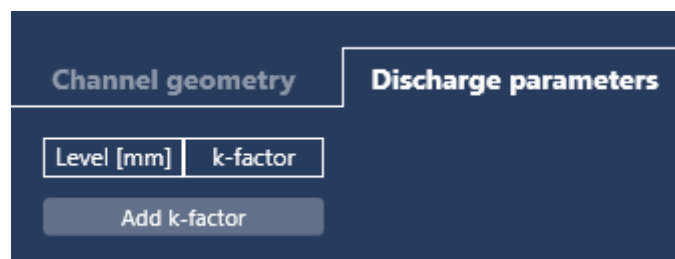
Picture 18. Import .csv File Preview Window

After defining the channel geometry, either by adding points or importing the geometry from a .csv file, the channel profile shape will be drawn on the left side of the channel profile geometry definition page, indicating the sensor position as well as the measured water level and the area of the cross-section that is filled with water.



Picture 19. Defined Channel Profile Geometry

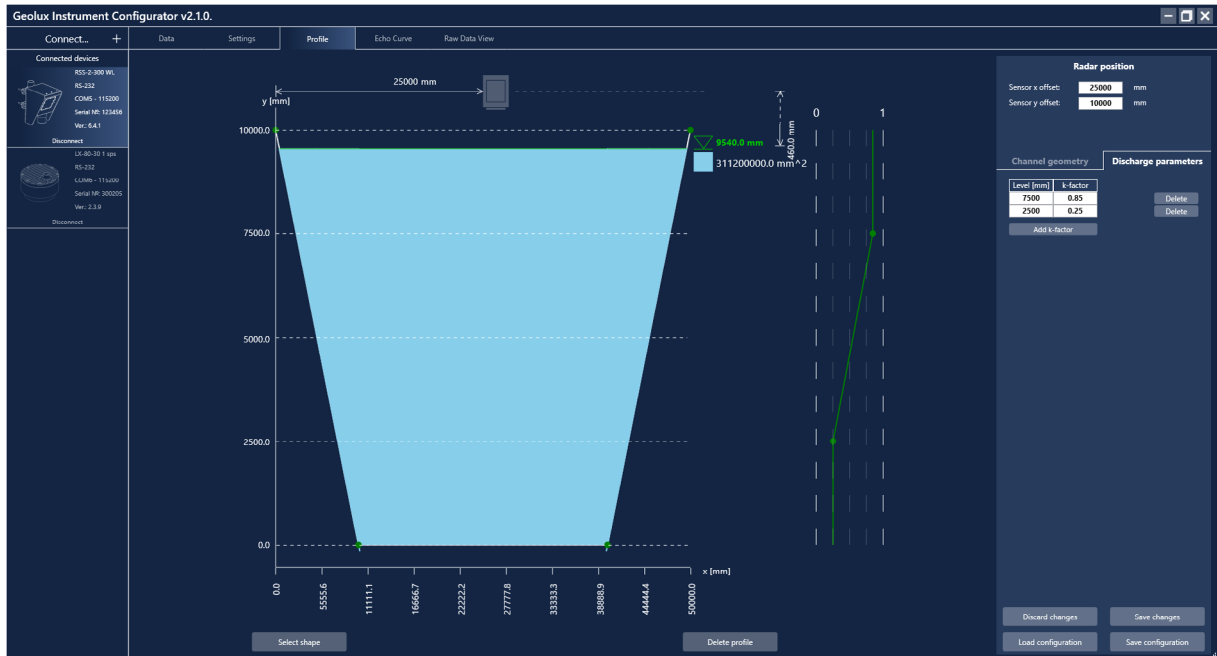
The next step needed for discharge calculation is to define the k-factor values. Clicking the *Discharge parameters* button next to the *Channel geometry* button enables the user to input k-factor values corresponding to different water level values by clicking the *Add k-factor* button.



Picture 20. Discharge Parameters

After the discharge parameters have been defined, the values will be drawn on a graph next to the defined channel profile geometry picture.

After defining the channel geometry and discharge parameters, the changes need to be saved to the device. This is done by clicking the *Save changes* button. If the user does not wish to save the changes, clicking the *Discard changes* button will discard all the changes made and load the configuration currently saved on the device. The defined configuration can be saved to the user's computer in the form of an .xml file by clicking the *Save configuration* button. The saved configuration can later be loaded from the created .xml file by clicking the *Load configuration* button and saved to the device by clicking the *Save changes* button.



Picture 21. Defining the Discharge Parameters

## 8.1.2. Selecting a Predefined Channel Profile Shape

After clicking the *Select profile shape* button, Picture 14, or *Select shape* button, Picture 21, a new window appears with 9 predefined shapes from which the user can choose.

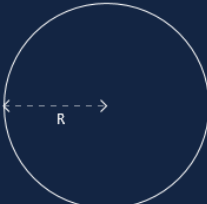


Picture 22. Predefined Shapes

When the user selects a certain shape, a table and a picture of the selected shape appear. The user has to fill the table and select the desired unit. The required values from the table are shown on the picture below the table. The following pictures (20. – 25.) show the definition of 2 different channel shapes.

Fill the table to define the profile geometry.

R	unit
	mm

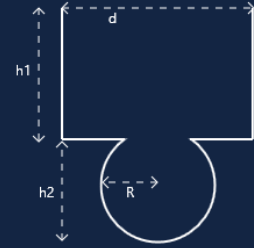


Cancel

Next

Fill the table to define the profile geometry.

R	h1	h2	d	unit
				mm



Cancel

Next

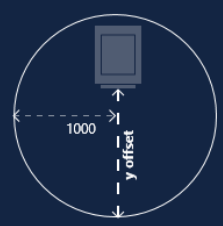
Picture 23. Defining the Channel Geometry of a Predefined Shape

Clicking the Next button leads to the next step, i.e. defining the y offset of the radar, Picture 24. The required y offset distance is clearly show in the picture, as well as the values defined in the previous step. If changes need to be made to the values from the previous step, it can be done by clicking the Back button.

Set the radar y offset, i.e. the distance from the radar to the lowest point of the channel.

y offset [mm]

1000



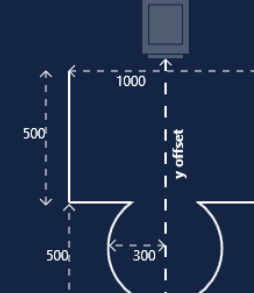
Back

Next

Set the radar y offset, i.e. the distance from the radar to the lowest point of the channel.

y offset [mm]

1000

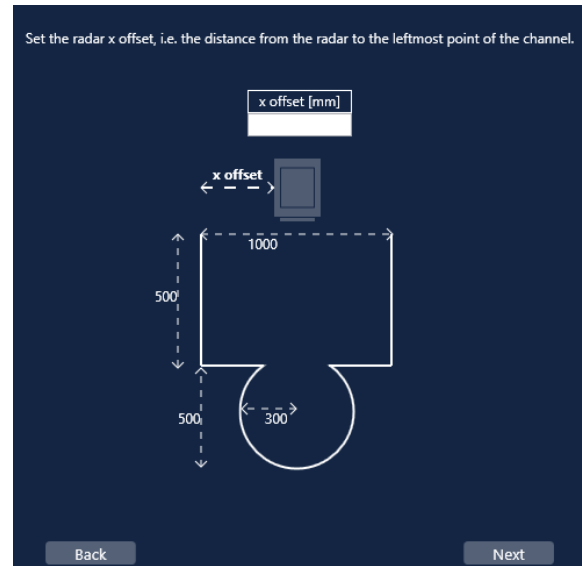


Back

Next

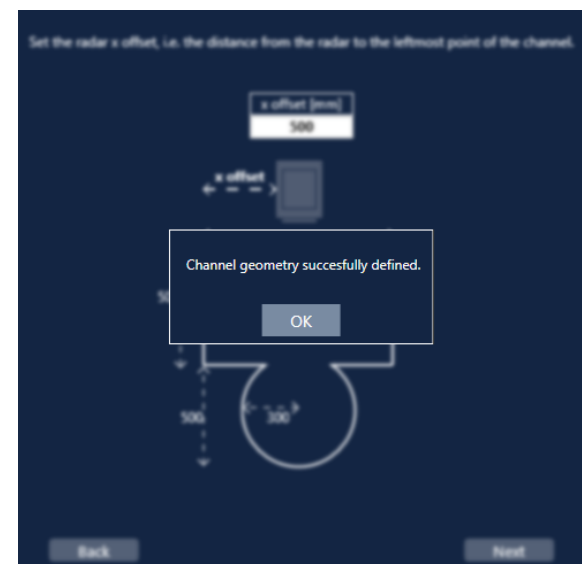
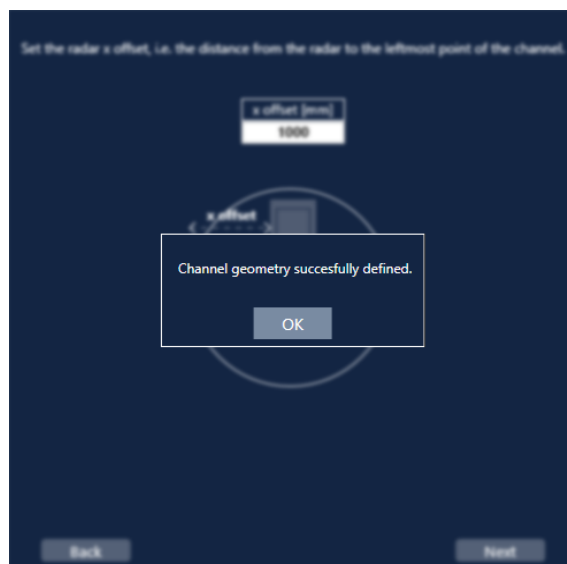
Picture 24. Defining the y Offset of the Radar

The next step is to define the x offset of the radar.



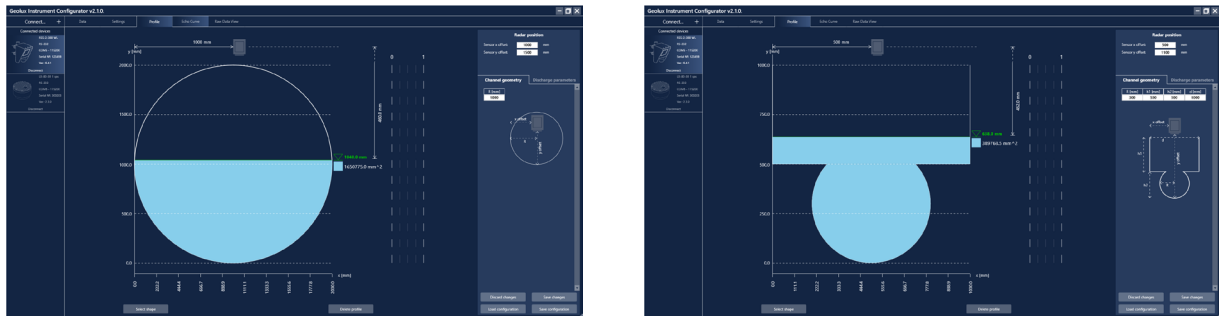
Picture 24. Defining the x Offset of the Radar

Defining the x offset of the radar concludes the channel profile geometry definition.



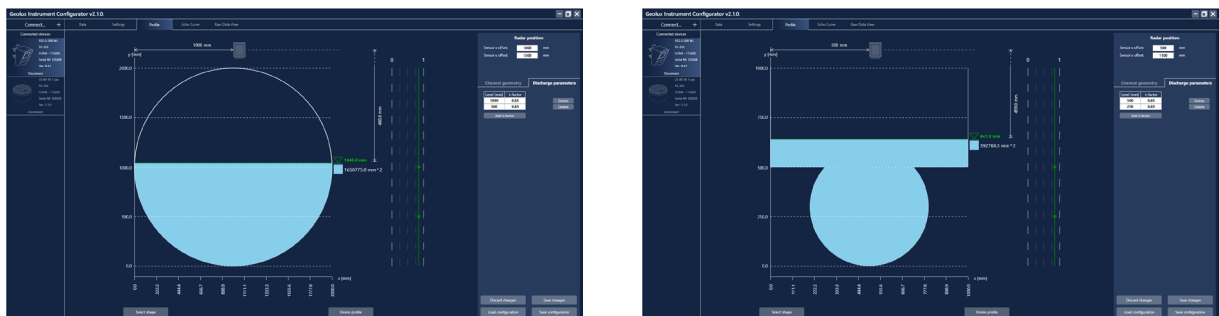
Picture 26. Channel Geometry Defined

After completing all the steps of defining the channel geometry, the selected shape will appear in the Main window, and the Radar position and Channel geometry sections will be defined by the inputted values.



Picture 27. The Defined Shape Shown in the Main Window

The last step is to define the discharge parameters as described in chapter 8.1.1., Picture 20. After setting the discharge parameters, the values will appear in green on the graph next to the channel geometry picture as seen in Picture 28.



Picture 28. Defining the Discharge Parameters

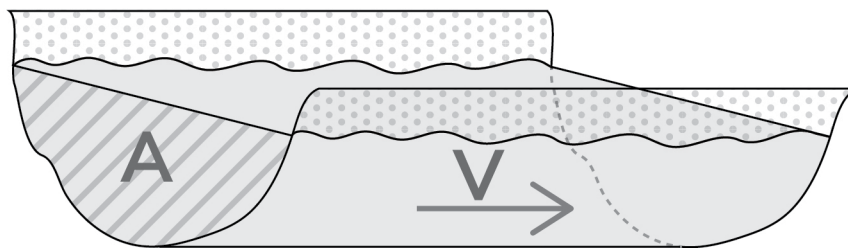
# 9

## Calculating Discharge from Surface Velocity and Liquid Level

Geolux RSS-2-300 WL flow meter measures surface velocity at the water surface and water level. This measurement can be used to calculate actual discharge – the total volume of water that passes through a channel cross-section in a specific period of time. Discharge measurement is important for a wide variety of purposes including flood and pollution control, irrigation, watercourse regulations and broadly as an input data for dimensioning of almost any new structure on the open channel flows.

Discharge is calculated by multiplying mean flow velocity and channel cross-section area. The cross-section area is the area of the slice in the water column made perpendicular to the flow direction.

Let us assume a rectangular channel profile, with constant flow velocity at all points, as seen in Picture 29.



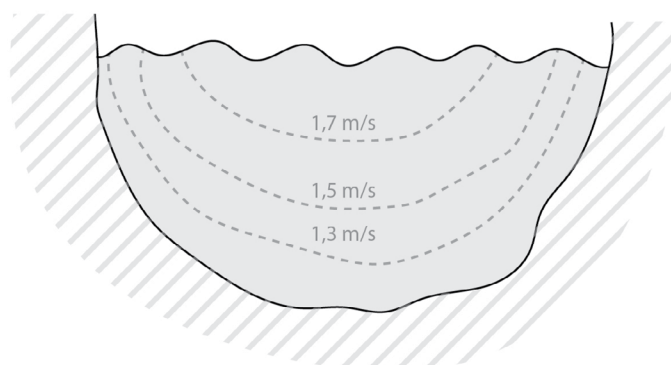
Picture 29. Simple Channel Diagram

The discharge can be calculated according to the formula:

$$Q=V \cdot A$$

where Q is discharge (for example in m<sup>3</sup>/s), V is flow velocity (for example in m/s), and A is cross-section area (for example in m<sup>2</sup>).

For real-world measurements it is important to understand that the velocity of the moving water varies both across the stream channel and from the surface to the bottom of the stream due to friction, as in Picture 30.



Picture 30. Flow Velocity in a Typical Cross-Section

In order to determine the discharge in a realistic channel, the area must be precisely measured by measuring water depths at a series of points across the stream and multiplying by the width of the stream within each segment represented by the depth measurement. The mean cross-section flow velocity needs to be determined from measured surface flow velocity. Studies performed by USGS reveal that, typically, the mean velocity is 80-95% of the surface velocity, the average being 85%.

Knowing non-rectangular area of the stream cross-section, and knowing the surface flow velocity, the following formula can be used:

**$$Q=0.85 \cdot V \cdot A$$**

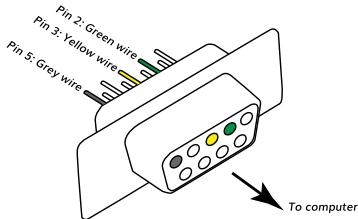
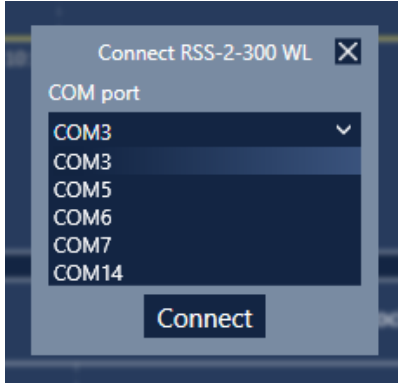
More details about water flow measurements can be found in the following technical note:

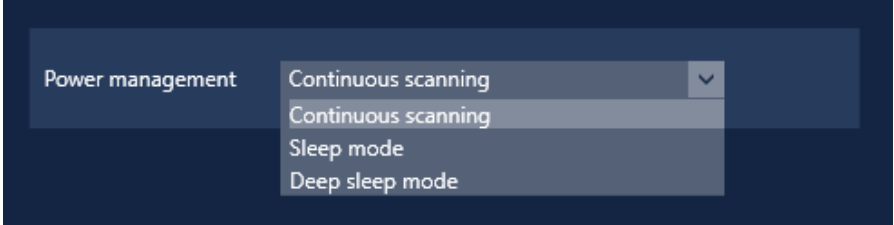
[https://geolux.ams3.digitaloceanspaces.com/documents/technote3\\_surface\\_flow.pdf](https://geolux.ams3.digitaloceanspaces.com/documents/technote3_surface_flow.pdf)

# 10

## Troubleshooting

Geolux RSS-2-300 WL non-contact open channel flow meter offers multiple data interfaces, in order to make the integration of the device with existing SCADA/telemetry systems easy.

Problem	Possible solutions
The instrument does not connect to the PC application over RS-232 connection.	<p><b>1. Make sure that the cable is properly connected to the instrument</b> Check that the cable M12 circular connector is firmly connected and screwed to the instrument. It is not sufficient to simply attach the cable connector to the instrument connector, the cable connector must be screwed into the instrument connector.</p> <p><b>2. Check power supply</b> Make sure that the power is being supplied to the instrument. A direct-current voltage, between 9 and 27 Volts must be connected to brown (+) and white (-) wires of the instrument cable. The power supply must be able to deliver at least 500 mA of current.</p> <p><b>3. Check RS-232 connector</b> The yellow, green and grey wires from the instrument cable must be properly connected to the serial port on the computer. Make sure that the grey wire (signal ground) is connected – the RS-232 connection will not work if the signal ground is not connected. Also, make sure that the yellow (device Rx) and green (device Tx) are properly connected. If you are using a standard DB9 type connector on the PC computer, the wires should be connected like in the following diagram:</p>  <p><b>4. Make sure that you are using the correct COM port</b> If there are multiple COM ports available on your computer, make sure that you are selecting the correct COM port in the PC application. If you are not certain which COM port number is assigned to the COM port that is being used to establish a connection with the instrument, try setting up the connection with each COM port available in the system, until the connection is established.</p> 

	<p><b>5. Check that the device is not operating in low power</b></p> <p>The instrument can be configured to operate in low power mode. While in low power mode, the instrument will not make any measurements but it's communication interfaces will be active. To check whether the instrument is operating in low power mode, check Power management parameter which is available under... and make sure that Continuous scanning is selected.</p>  <p><b>6. Make sure that the COM port is not already open</b></p> <p>Only one application may use a single COM port in the system. Make sure that no other open application uses the same COM port that you are trying to open.</p> <p><b>7. Try restarting the application and/or the computer</b></p> <p>Close and reopen the configurator application and try to establish the connection again.</p> <p>Restart your computer and try to establish the connection to the instrument again.</p>
<p>The instrument does not respond over Modbus (RS-485) interface.</p>	<p><b>1. Make sure that the cable is properly connected to the instrument</b></p> <p>Check that the cable M12 circular connector is firmly connected and screwed to the instrument. It is not sufficient to simply attach the cable connector to the instrument connector, the cable connector must be screwed into the instrument connector.</p> <p><b>2. Check power supply</b></p> <p>Make sure that the power is being supplied to the instrument. A direct-current voltage, between 9 and 27 Volts must be connected to brown (+) and white (-) wires of the instrument cable. The power supply must be able to deliver at least 500 mA of current.</p> <p><b>3. Check RS-485 connector</b></p> <p>Make sure that the RS-485 lines on the instrument cable are properly connected to the RS-485 connector. The dark red wire should be connected to D+ line, and the orange line should be connected to D- line.</p> <p>Make sure that the D+ and D- lines are not swapped.</p> <p>Make sure that you have correctly identified and connected the dark red (magenta) wire, as there is also another bright red wire that is used to provide output power for 4-20 mA output. It is possible to misidentify the wire and to connect the bright red wire to D+ instead of dark red wire.</p>

#### 4. Check that you are using the correct slave device ID

The default Modbus device ID is 1. The Modbus device ID can be changed by connecting the instrument to the PC application (over RS-232 connection).

Connect the instrument to the PC using RS-232 connection. Open the Geolux Instrument Configurator application and establish a connection between the instrument and the PC. Then check the Modbus ID parameter and make sure that it is the same as the slave device ID used in issued Modbus requests.



#### 5. Make sure that there are no two devices on the bus with the same Device ID.

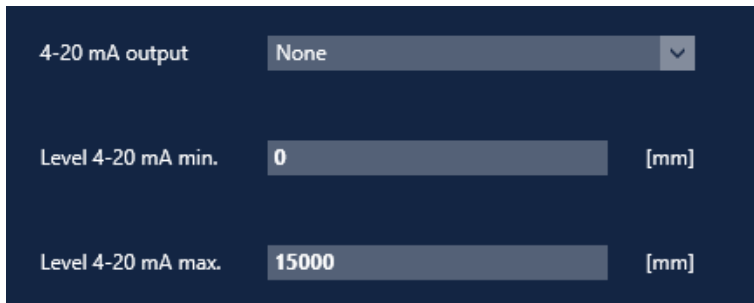
Modbus allows to have multiple devices connected on the same bus simultaneously. Each device must have a unique slave device ID assigned, so that the bus master can distinguish between the devices. If two or more devices are assigned the same slave device ID, a bus conflict will happen and prohibit the master to correctly communicate with the slave devices. To resolve this problem, change the instrument's slave device ID to a unique number through the Geolux Instrument Configurator PC application.

#### 6. Check that you are using the correct Modbus connection parameters (baud rate, parity, stop bits)

The default Modbus connection parameters are 9600 bps, even parity, 1 stop bit. These parameters can be changed by connecting the instrument to the PC application (over RS-232 connection).

Connect the instrument to the PC using RS-232 connection. Open the Geolux Instrument Configurator application and establish a connection between the instrument and the PC. Then check and verify that all Modbus connection parameters are correct.



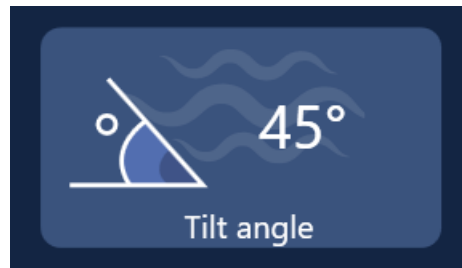
<p>The instrument does not respond over SDI-12 interface.</p>	<ol style="list-style-type: none"> <li><b>1. Make sure that the cable is connected properly to the instrument</b> Check that the cable M12 circular connector is firmly connected and screwed to the instrument. It is not sufficient to simply attach the cable connector to the instrument connector, the cable connector must be screwed into the instrument connector.</li> <li><b>2. Check power supply</b> Make sure that the power is being supplied to the instrument. A direct-current voltage, between 9 and 27 Volts must be connected to brown (+) and white (-) wires of the instrument cable. The power supply must be able to deliver at least 500 mA of current.</li> <li><b>3. Check SDI-12 connection</b> Check and verify that the black wire from the instrument cable is connected to the SDI-12 data line, and that the grey wire from the instrument cable is connected to the Ground (GND) line on the SDI-12 data logger. It is important that both the data line and the signal ground lines are connected.</li> </ol>
<p>The 4-20 mA output is not correct.</p>	<ol style="list-style-type: none"> <li><b>1. Make sure that the cable is properly connected to the instrument</b> Check that the cable M12 circular connector is firmly connected and screwed to the instrument. It is not sufficient to simply attach the cable connector to the instrument connector, the cable connector must be screwed into the instrument connector.</li> <li><b>2. Check power supply</b> Make sure that the power is being supplied to the instrument. A direct-current voltage, between 9 and 27 Volts must be connected to brown (+) and white (-) wires of the instrument cable. The power supply must be able to deliver at least 500 mA of current.</li> <li><b>3. Make sure that the wires from the cable are properly connected</b> For 4-20 mA readout the purple wire (4-20 mA sink output) must be connected to the negative (-) input of the 4-20 mA interface.</li> <li><b>4. Check the instrument configuration parameters related to 4-20 mA output</b> Connect the instrument over RS-232 connection to the Geolux Instrument Configurator application. Check the parameters related to 4-20 mA: 4-20 mA min. and 4-20 mA max. Properly configure these parameters.</li> </ol> 

The instrument is operating, but:

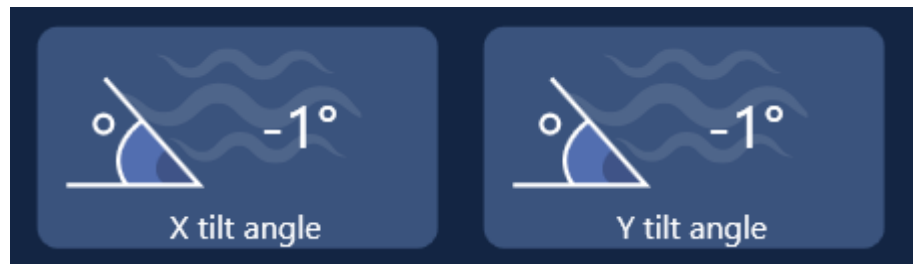
- it does not report surface velocity measurement,
- it reports incorrect measurement
- it does not report distance/level measurement,
- it reports 0 (zero) distance,
- it reports incorrect measurement

### 1. Check that the instrument is positioned properly

Make sure that the instrument is installed above the water surface, pointing toward the water surface at a vertical angle. Recommended vertical angle is 45 degrees.



Make sure that the instrument is leveled and pointing towards the water surface at the right angle (the radar beam should be perpendicular to the water surface). Both tilt angles should be zero degrees, or not bigger than 2° in any direction.



### 2. Check that there are no obstructions between the instrument and the water surface

There should be no obstructions between the instrument and the water surface, so that the radar waves can freely travel from the instrument's antenna to the water surface and back. Objects such as rocks, construction elements (metal, concrete, etc.), vegetation (tree branches, water vegetation, etc.) can all affect the instrument's reading.

If there are some minimal obstructions far away from the water surface, and the radar is reporting the distance to these objects instead of the distance to the water surface, you can adjust the active zone of the instrument. The active zone limits the minimum and maximum range within which the instrument searches for the water surface. For example, if there is an obstruction 1 meter away from the instrument, and the instrument reports a distance of 1 meter, but the water surface is expected to be between 3 and 5 meters, you can adjust the active zone to be within 3 and 5 meters, and then the instrument will discard all measurements outside of that range.

Level active zone min.	10	[mm]
Level active zone max.	15000	[mm]

**3. Check that the distance between the instrument and the water surface is within the instrument's operating range.**

Use a tape measure or a similar tool to measure the distance between the instrument's antenna and the water surface. If the distance to the water surface is greater than the instrument's operational range, the instrument will not be able to measure the distance and the water level.

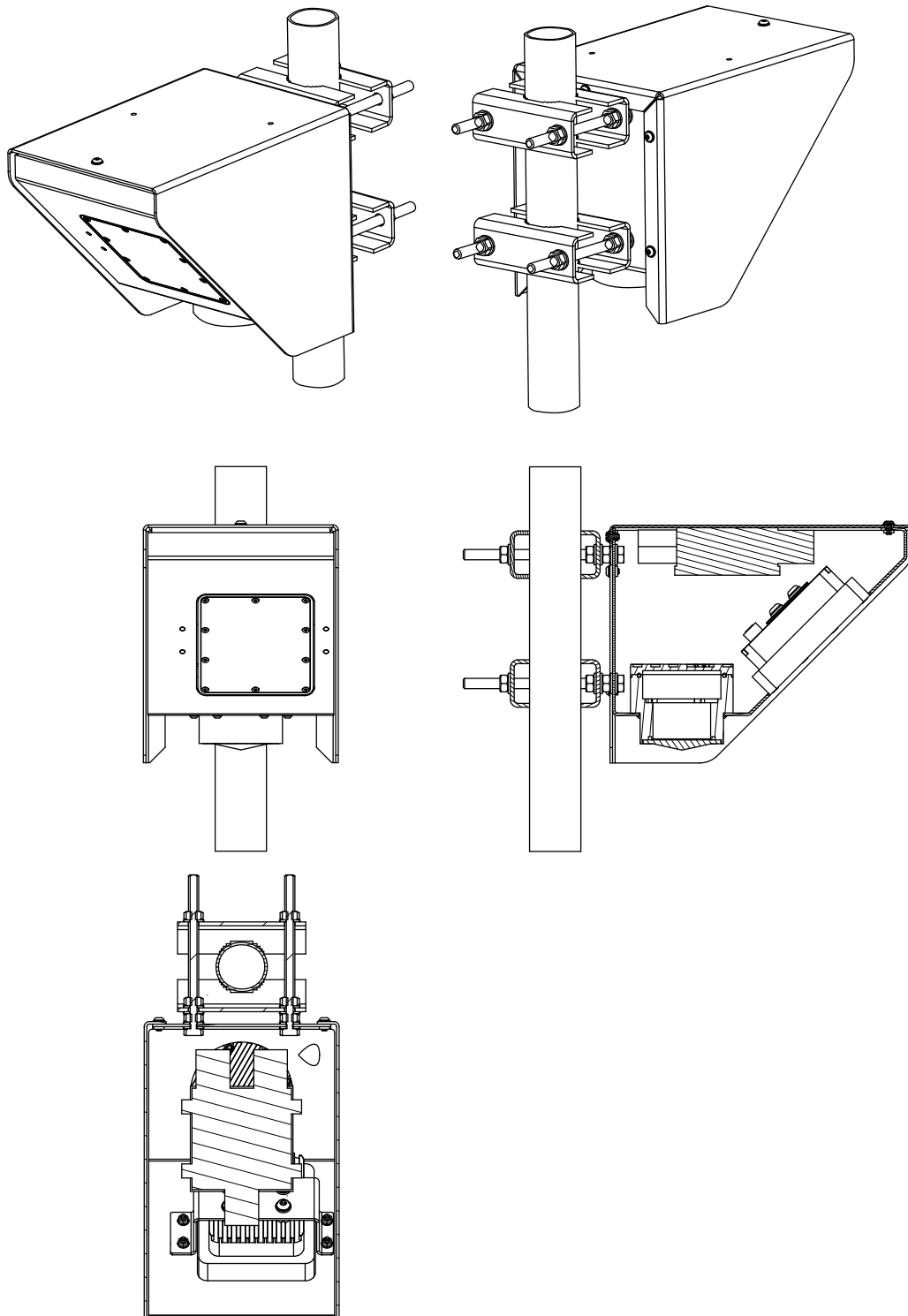
**4. Check that the distance between the instrument and the water surface is within configured active zone.**

Connect the instrument to the Geolux Instrument Configurator PC application over RS-232 connection. Check the active zone parameters – if the distance to the actual water surface is outside of the predefined active distance, the instrument will not be able to report the correct distance. Modify the active zone parameters so that the actual distance to the water surface is within the active zone.

Level active zone min.	10	[mm]
Level active zone max.	15000	[mm]

# 11

## Appendix A – Mechanical Assembly





2022.