RSS-2-300WL

Non-Contact Flow Meter

User Manual

v6.7.9

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Starting Point

Thank you for purchasing Geolux RSS-2-300WL 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-2-300WL 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 ±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 ±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-2-300WL 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

FCC and ISED Canada Regulatory Compliance

FCC ID: 2AN9X-RSS2300WL; IC: 26475-RSS2300WL

FCC

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

ISED Canada

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:
(1) This device may not cause interference.
(2) This device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil contient des émetteurs/récepteurs exempts de licence qui sont conformes aux RSS exemptes de licence d'Innovation, Sciences et Développement économique Canada. Son fonctionnement est soumis aux deux conditions suivantes:
(1) Cet appareil ne doit pas provoquer d'interférences.
(2) Cet appareil doit accepter toutes les interférences, y compris les interférences susceptibles d'entraîner un fonctionnement indésir-able de l'appareil.

RSS-Gen compliance requires:

(i) The installation of the LPR/TLPR device shall be done by trained installers, in strict compliance with the manufacturer's instructions.
(ii) The use of this device is on a "no-interference, no-protection" basis. That is, the user shall accept operations of high-powered radar in the same frequency band which may interfere with or damage this device. However, devices found to interfere with primary licensing operations will be required to be removed at the user's expense.
(iii) The installer/user of this device shall ensure that it is at least 10 km from the Dominion Astrophysical Radio Observatory (DRAO) near Penticton, British Columbia. The coordinates of the DRAO are latitude 49°19'15'' N and longitude 119°37'12'' W. For devices not meeting this 10 km separation (e.g., those in the Okanagan Valley, British Columbia,) the installer/user must coordinate with, and obtain the written concurrence of, the Director of the DRAO before the equipment can be installed or operated. The Director of the DRAO may be contacted at 250-497-2300 (tel.) or 250-497-2355 (fax). (Alternatively, the Manager, Regulatory Standards, Industry Canada, may be contacted.)

RF Exposure Notice

In order to comply with FCC and ISED Canada RF Exposure requirements, a minimum separation distance of 20 cm must be maintained between the device and all persons during normal operation.

Afin de se conformer aux exigences de la FCC et de l'ISED en matière d'exposition aux RF, une distance de séparation minimale de 20 cm doit être maintenue entre l'appareil et toutes les personnes pendant le fonctionnement normal.

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.

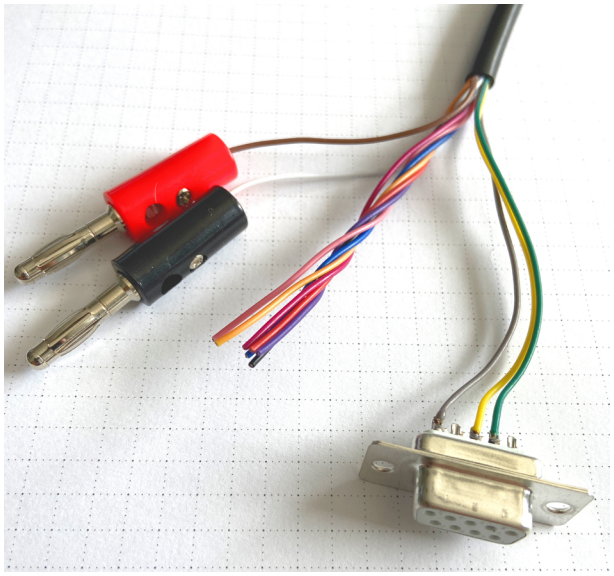
Table 2. Cable Pin-Out

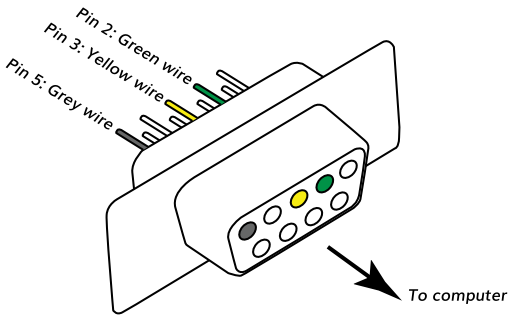
Pin No.	Wire Color	Pin Name	Pin Description
1	White	GND	This pin should be connected to the ground (negative) pole of the power supply.
2	Brown	+Vin	The power supply for the Radar Speed Sensor is provided on this pin. The Radar Speed Sensor power supply voltage must be in the range of 9 VDC to 27 VDC, 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.





Picture 1. Serial RS232 DB-9 Cable

Geolux recommends using Waveshare USB TO RS232/485/TTL converter for connecting Geolux instruments to computers without a native RS-232 port.

https://www.waveshare.com/catalog/product/view/id/3629/s/usb-to-rs232-485-ttl/category/37/

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

Several communication protocols are available, and custom on request. Details of communication protocols are described later in this user manual.

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)

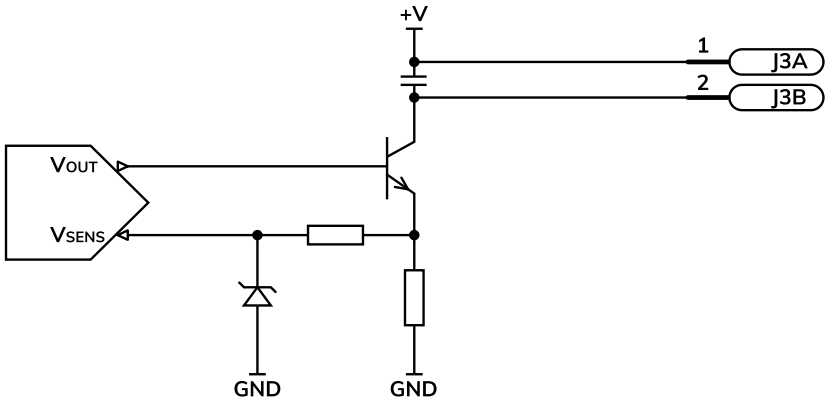
CAN communication interface is an optional communication interface that can be used for special applications. This interface is a higher speed interface (up to 1 Mbps) than other serial communication interfaces, thus enabling additional data transfer which would otherwise not be possible with RS-232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

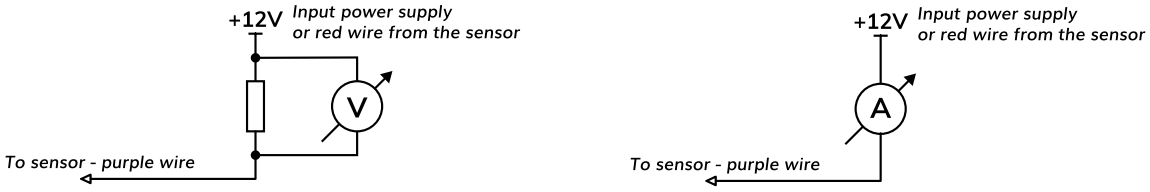
Analog current 4 – 20 mA output is provided for easier compatibility with older logging and control systems. Output is implemented as current sink architecture with common ground. Maximal voltage applied to the sink can go up to 30 VDC, providing greater flexibility in connections of the sensor to PLCs,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

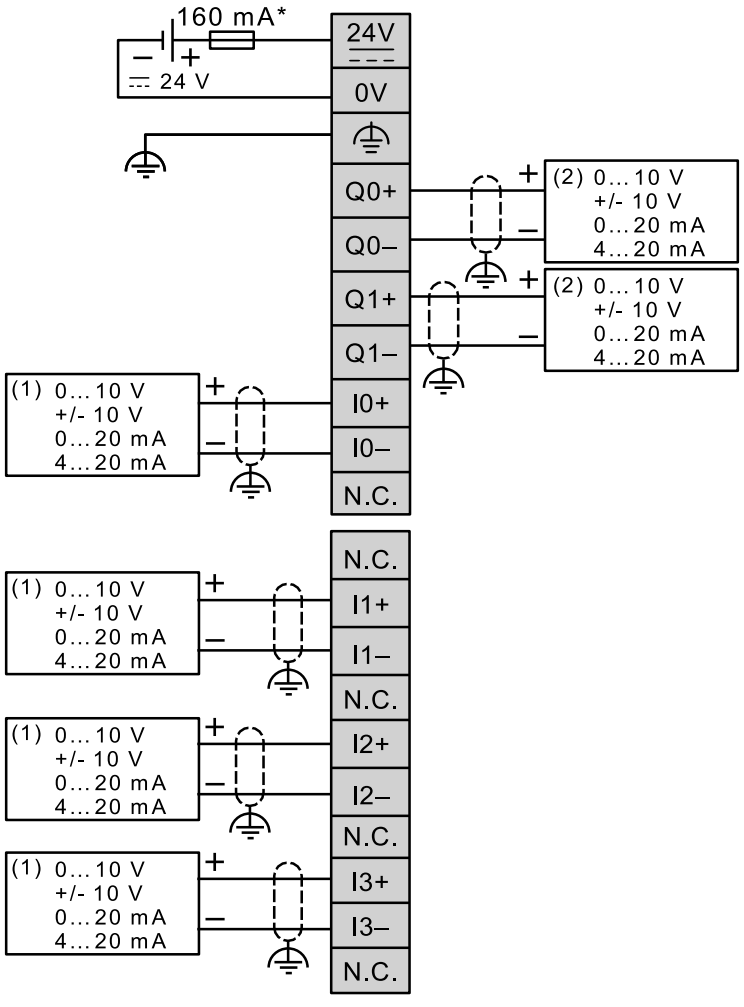
Measurement of the current by the client device (logger, PLC, modem etc.) must be implemented as the high side current measurement as shown in Picture 3. If a sensing resistor is used, resistance should be selected from the range of 10 Ω up to 500 Ω with a recommended value of 100 Ω for the sensing resistor.



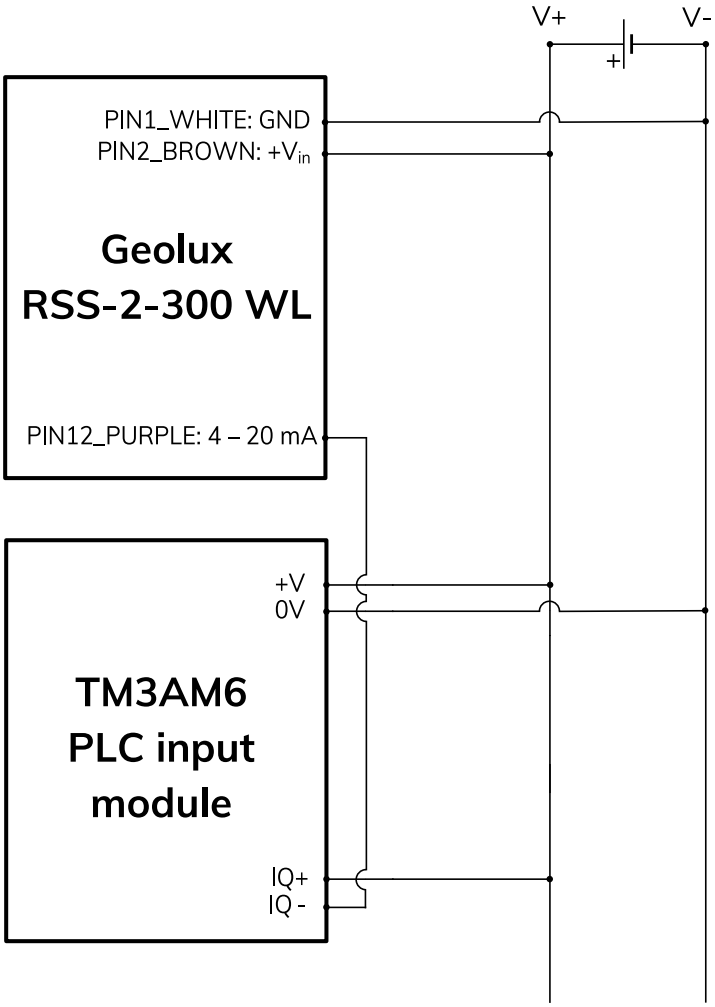
Picture 3. High Side Current Measurement for the 4 – 20 mA Analog Output

3.4.1. Connection to Schneider TM3AM6 analog input module

The TM3AM6 analog module contains 4 analog inputs, marked I0 to I3. Each analog input consists of two connectors, marked as I+ and I-. Each analog input can be configured to work either as analog voltage input (0 – 10 V or -10 to +10 V), or as analog current input (0 – 20 mA or 4 – 20 mA). This is the wiring diagram from the TM3AM6 user manual:



In order to connect the Geolux instrument to the TM3AM6 module, the first step is to configure the selected input port as analog current input operating on 4 – 20 mA range. This is done by using Schneider software. After the analog input module is configured, the second step is to connect the Geolux instrument to the TM3AM6 module, according to the following schematic diagram:



It is important to note that the 4 – 20 mA wire from the Geolux instrument should be connected to negative (-), not positive (+) terminal of the analog input port.

3.5. SDI-12 Interface

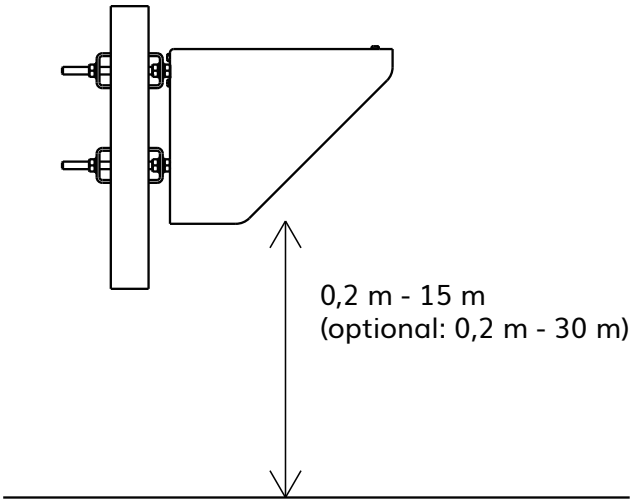
SDI-12 interface is widely used to connect hydrological equipment to dataloggers. SDI-12 uses a single communication line, and very slow speed communication to enable the use of very long communication cables.

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 ±3° to vertical plane reference.

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



Picture 4. Installing the Flow Meter

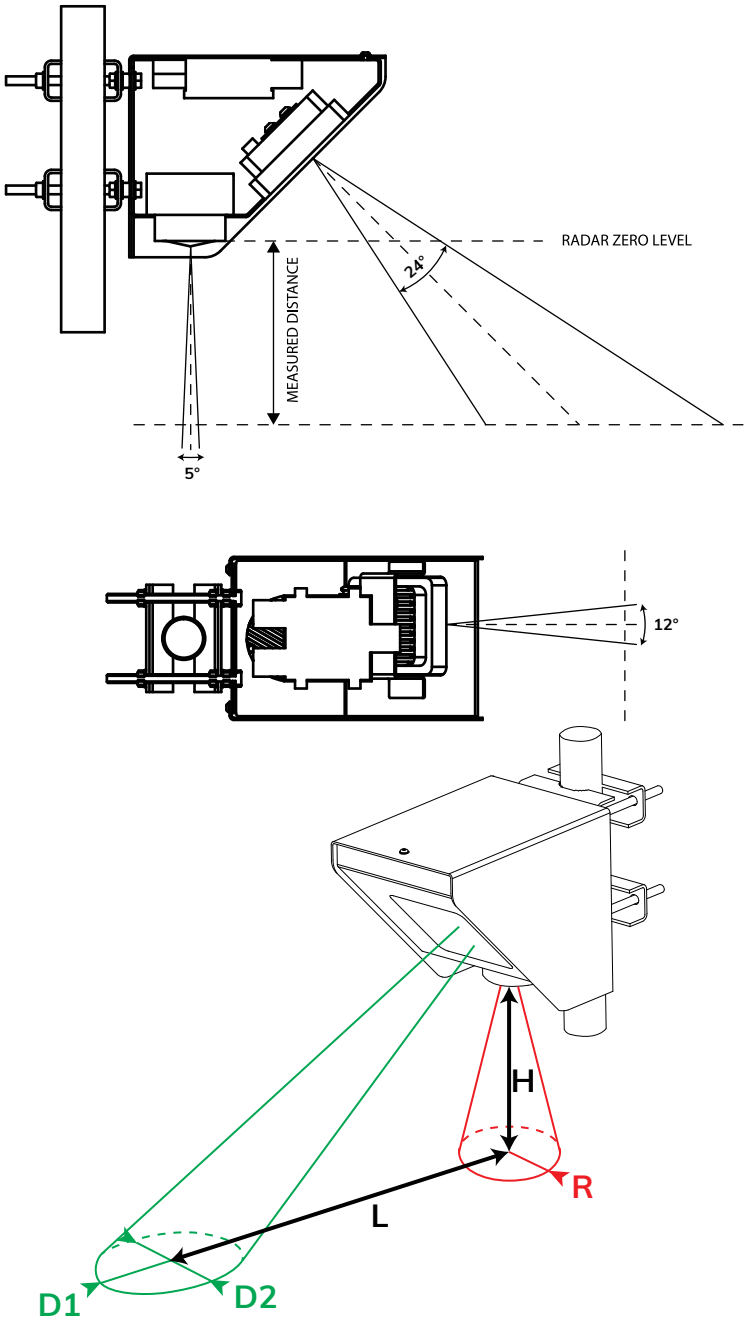
When mounting the instrument, special care must be taken to ensure that a direct line to the water surface is available and not obstructed for both the surface velocity and water level sensor. Any close objects in the vicinity of the sensor can reduce accuracy and introduce offsets in measurements. The 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 modeling 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	0.013
0.5 m	0.5	0.5	0.3	0.022
1 m	1.0	0.9	0.3	0.044
2 m	2.0	1.8	0.6	0.087
3 m	3.0	2.7	0.9	0.131
4 m	4.0	3.6	1.2	0.174
5 m	5.0	4.5	1.5	0.218
6 m	6.0	5.3	1.8	0.262
7 m	7.0	6.2	2.1	0.305
8 m	8.0	7.1	2.4	0.349
9 m	9.0	8.0	2.7	0.393
10 m	10.0	8.9	3.0	0.436
11 m	11.0	9.8	3.3	0.480
12 m	12.0	10.7	3.6	0.523
13 m	13.0	11.6	3.9	0.567
14 m	14.0	12.5	4.2	0.611
15 m	15.0	13.4	4.5	0.654

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-2-300WL 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-2-300WL 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.

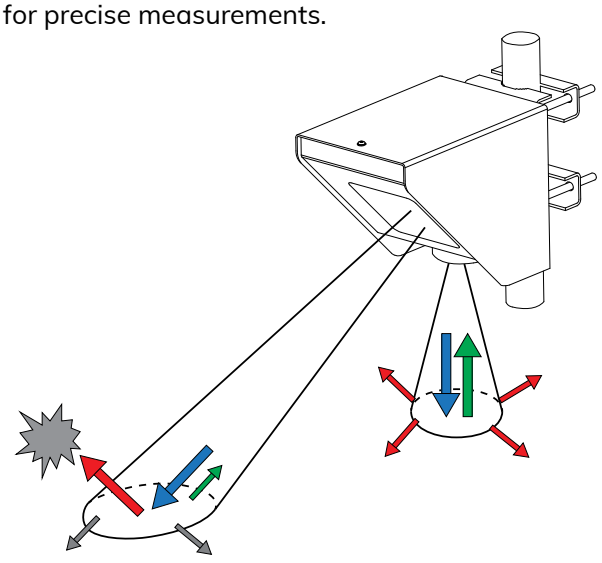
The best solution for distance measurement is, in most cases, to increase the average period of the averaging filter. As evaporation is naturally a turbulent event with significant difference in density over the surface area and in time, averaging of the distance measurement spectrum solves the accuracy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

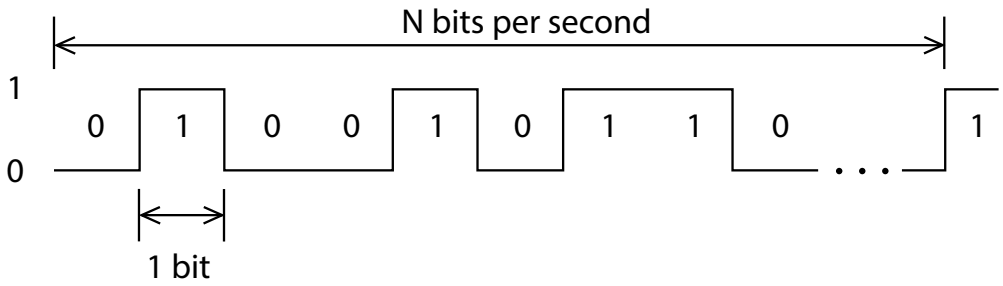
When selecting a location for installing the RSS-2-300WL instrument, additional care must be taken to avoid that any part of the radar beam that is reflected away from the instrument (red arrow) hits any nearby moving objects (grey cloud). Such additional radar reflections can significantly affect measurement 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 Flow Meter Settings

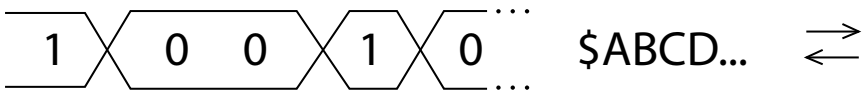
Communication Interfaces Parameters

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.

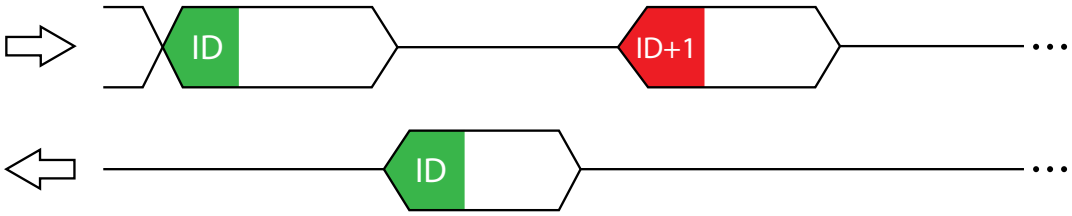
RS-232 and RS-485 protocol



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.

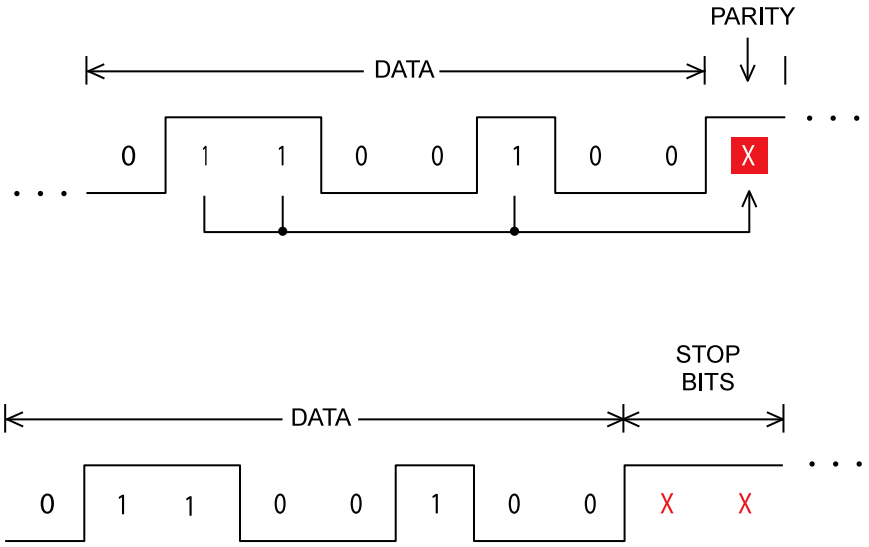
RS-485 protocol - Selects the communication protocol to be used on RS-485 half-duplex interface. HS protocol is a simple request-response protocol for the simplest applications. Modbus RTU protocol is a standardized protocol which is commonly used in automation and instrumentation as it provides all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

Device ID



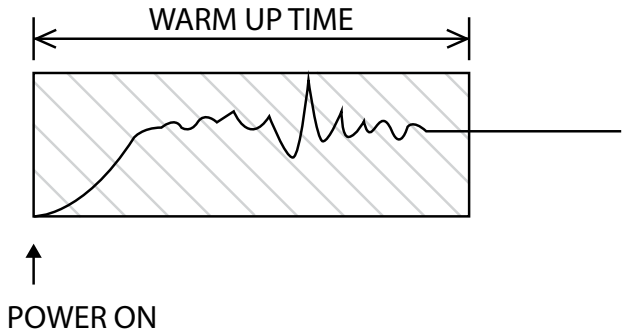
Device ID - Configures the device (slave) ID to be used on RS-485 interface protocols (Modbus RTU or HS). Both protocols use request/response format and allow multiple instruments to be connected on the same bus. When a remote master transmits the request message, it will use the device ID as a device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

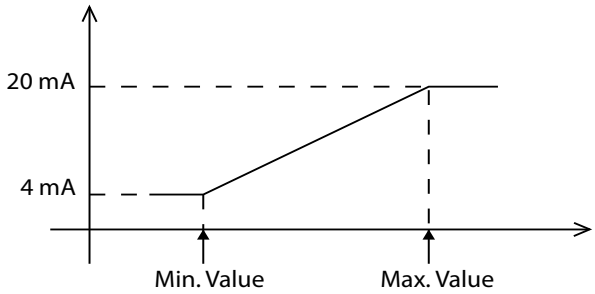


Warm up time - The time after sensor power-up, during which all measurements are ignored. This time is used to settle auto-gain parameters, Kalman filter values, averaging filter, and all other operational parameters. It is recommended to set this value to a minimum of 5 seconds. In extreme cases where 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.

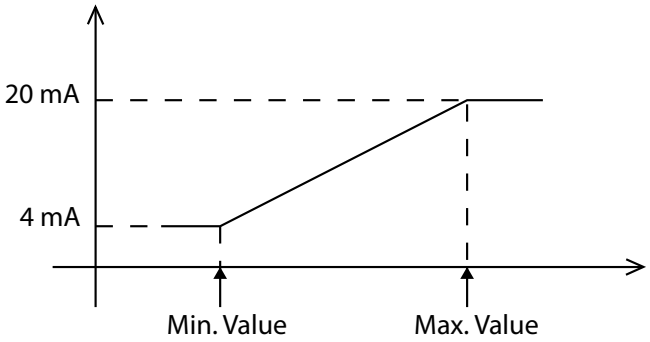
4 – 20 mA min. and 4 – 20 mA max.



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.

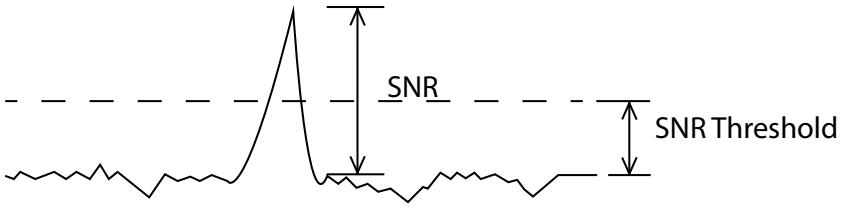
Level 4 – 20 mA max. – To configure the 4 – 20 mA output range, the maximum measured value which will correspond to 20 mA analog output needs to be set. The value is set in the currently configured measurement unit. Example: if values measured by the instrument are expected to be within the range of 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.

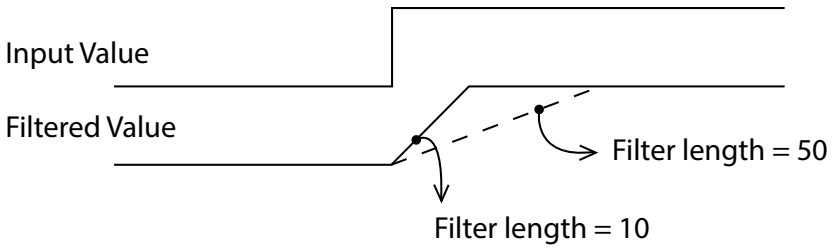
SNR threshold



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. The SNR is calculated according to the following formula, where A_peak is the absolute signal level amplitude at the detected peak, and A_avg is the average signal level amplitude of the complete signal, except for the detected peak:

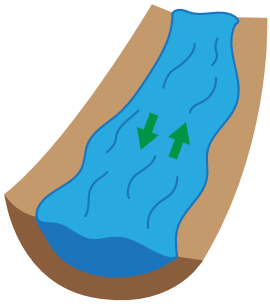
$$SNR = 10 * \log(A_peak / A_avg)$$

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.

Extra fast

Extra fast – Enables or disables the extra fast setting. When the radar is powered-up in normal operation mode, it will need a few seconds to self-configure in an optimal way for the current flow conditions. This is not necessary with stable flow conditions when the strength of the reflected radar signal is high (which can be checked by monitoring the reported SNR value). In that case, enabling the extra fast setting will force the radar to skip self-configuration and save a few seconds at power-up before the first measurement is reported.

Peak width

Peak width – When a velocity peak is detected, this parameter tells the radar how wide to consider the side velocities for the final velocity report. If the flow is uniform across the surface, then normal peak width can be selected.

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.

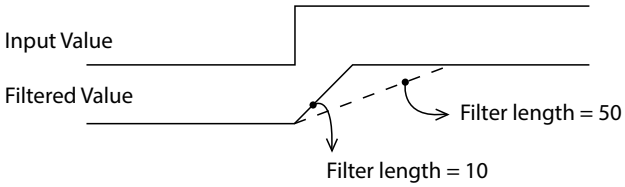
IIR - Infinite-Impulse Response filter is used to smooth the data. When compared to moving average filter, IIR filter reacts more quickly to initial change in the data, but it takes longer for the smoothed value to reach the new measurement. The use of IIR filter is discouraged for general applications.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

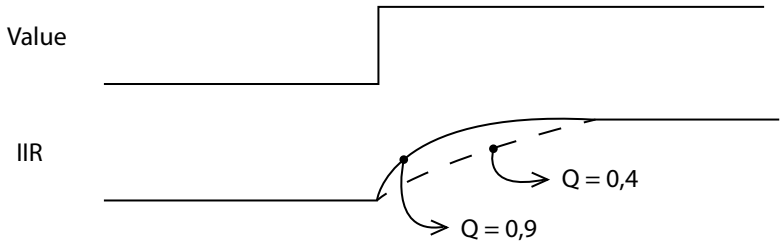
Standard deviation - This type of filter is similar to the moving average filter. It takes a number of raw measurements (as defined by the *Filter Length* parameter), then removes 20% of outliers, and calculates the average of the remaining 80% of values.

Level filter length



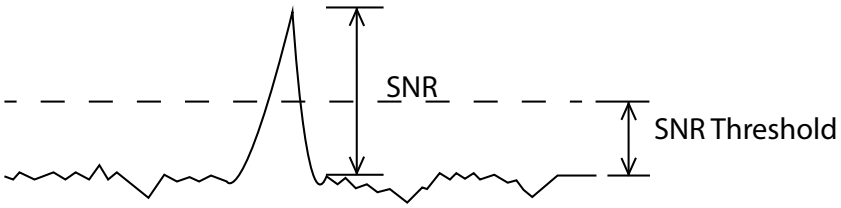
Level filter length – The length of the averaging filter, in number of readings, to smooth the measured values. The instrument performs 1 reading per second, so a filter length value of 10 will result in 10 seconds integration time. When using longer filter lengths, more measured values are used for 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-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.

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.

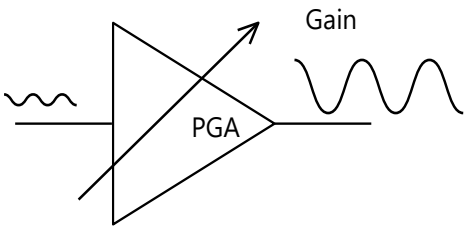
Totalizer unit

Totalizer unit – The measurement unit used to report the total flow volume.

Area unit

Area unit – The measurement unit used to report the cross-section area of the submerged channel profile.

PGA sensitivity

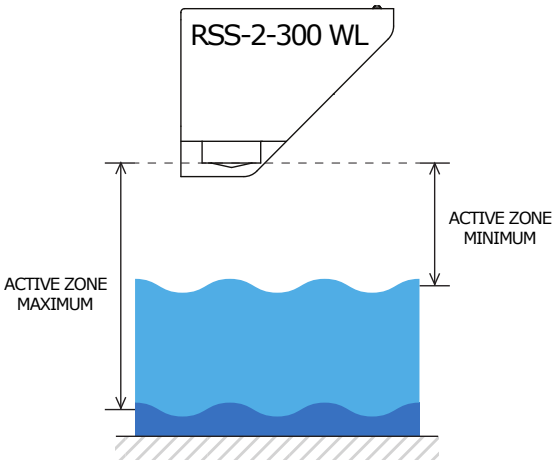


PGA sensitivity – This parameter limits the maximum gain (amplification level) of the internal programmable gain amplifier. It is strongly recommended to use the default value 8, which allows the internal signal amplifier to use the maximum gain when the reflected radar signal is very low. Setting this 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.

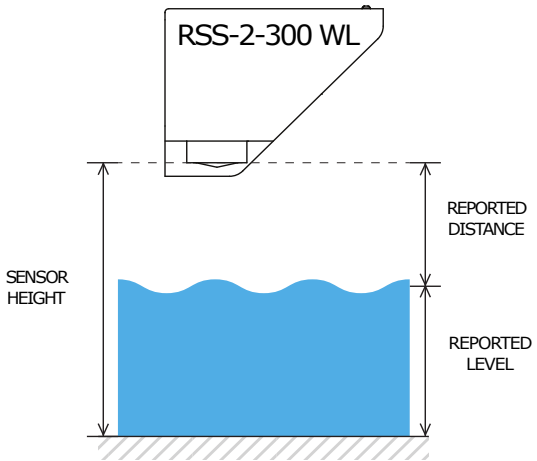
Level active zone parameters



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.

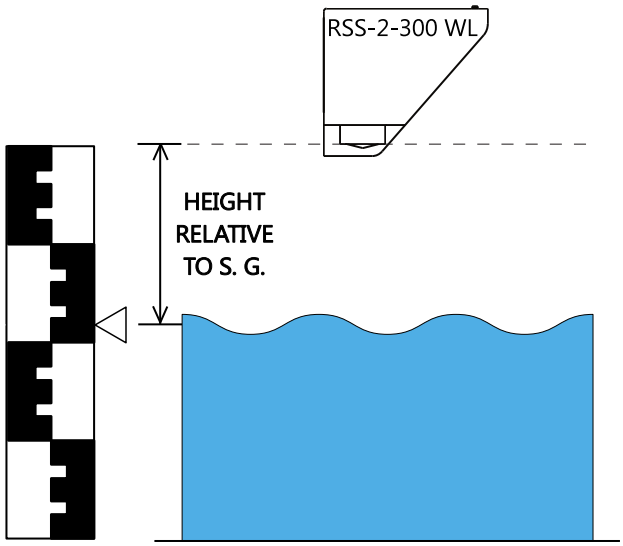
Level sensor height



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



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

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 SDI-12 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.

Totalizer calculation

Enables or disables the calculation of the total flow volume.

Totalizer hard save

Enables or disables the totalizer hard save. When the setting is enabled, the current total flow volume value will be saved to flash in case of device reset, and upon power-up, new values will be added to the saved value. If the setting is disabled the total flow volume calculation will be reset and start from 0.

Dynamic flow profiler

Enables or disables the dynamic flow profiler funcionality. The default value is 0 (Disabled).

Main output value

Configures whether the average velocity value or the dynamic flow profiler velocity value will be used as the main output for velocity measurement. The default value is 0 (Average velocity value).

6 Data Interface

Geolux RSS-2-300WL 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:	Even
Device ID:	1

7 Data Protocols

Geolux RSS-2-300WL 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:	This is an indicator of the Quality of the Service (measurements) related to the instrument vibrations. If the instrument is vibrating, the measurements may be incorrect, and the amount of vibrations is measured and reported. Geolux Instrument Configurator color-codes
Q2:	This is an indicator of the Quality of the Service (measurements) related to the radar signals. Geolux Instrument Configurator color-codes these values. Measurements can be trusted when QoS is green. Measurements may be inaccurate when the indicator is yellow or red.
CSUM:	The check sum of the characters in the report from $ to * excluding these characters.

Quality of signal factors and corresponding color codes:

0 – Excellent measurement quality (Green)
1 – Good measurement quality (Green)
2 – Low measurement quality (Yellow)
3 – Unacceptable measurement quality (Red)

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.

Cross-section area report

$AREA,A*CSUM<CR><LF>

$AREA:	The keyword sent in the beginning of each area report.
A:	The calculated cross-section area of the submerged channel profile, in selected units.
CSUM:	The check sum of the characters in the report from $ to * excluding these characters.

Total volume report

$TOT,T1,T2*CSUM<CR><LF>

$TOT:	The keyword sent in the beginning of each totalizer report.
T1:	The total flow volume value, in defined units.
T2:	Time, in seconds, during which the calculation has been active (drops to 0 on device reset).
CSUM:	The check sum of the characters in the report from $ to * excluding these characters.

The total volume report is only visible if the *Totalizer calculation* parameter is set to 1.

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). A value of -99 indicates a serious problem with the device - contact Geolux support.
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. GLZIMA protocol is a measurement push protocol that sends data on a defined time interval. Between measurement cycles, the device enters sleep mode and wakes up on its own after the defined time interval has elapsed.

#set_485_proto=modbus_rtu
#set_485_proto=hs
#set_485_proto=glzima

GLZIMA sleep period - The interval between two GLZIMA protocol measurement cycles. Between measurement cycles, the device enters sleep mode and wakes up on its own after this time interval has elapsed.

#set_glzima_sleep_sec=<0,1800>

Device ID - Configures the device (slave) ID to be used on RS-485 interface protocols (Modbus RTU or HS) and SDI-12 interface. All 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. Note that the ID used for RS-485 protocols is in the range of 1 to 247 (0 is not allowed), while the SDI-12 ID can be 0-9, A-Z and a-z (numerically corresponding to 0-61), so values greater than 61 are not valid).

#set_can_id=<0-247>

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 (event 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 the 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. The SNR is calculated according to the following formula, where A_peak is the absolute signal level amplitude at the detected peak, and A_avg is the average signal level amplitude of the complete signal, except for the detected peak:

$$SNR = 10 * \log(A_peak / A_avg)$$

#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

Extra fast - Enables or disables the extra fast setting. When the radar is powered-up in normal operation mode, it will need a few seconds to self-configure in an optimal way for the current flow conditions. This is not necessary with stable flow conditions when the strength of the reflected radar signal is high (which can be checked by monitoring the reported SNR value). In that case, enabling the extra fast setting will force the radar to skip self-configuration and save a few seconds at power-up before the first measurement is reported.

#set_extra_fast=0 (Disabled)
#set_extra_fast=1 (Enabled)

Peak width - When a velocity peak is detected, this parameter tells the radar how wide to consider the side velocities for the final velocity report. If the flow is uniform across the surface, then normal peak width can be selected.

#set_peak_width=0 (Very narrow)
#set_peak_width=1 (Narrow)
#set_peak_width=2 (Normal)
#set_peak_width=3 (Wide)

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_lvl_filter_type=0 (No filter)
#set_lvl_filter_type=1 (IRR)
#set_lvl_filter_type=2 (Moving average)
#set_lvl_filter_type=3 (Median)
#set_lvl_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_lvl_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>

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>

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 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)
#set_lvl_peak_detector=2 (First 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

Totalizer unit - The measurement unit used to report the total flow volume.

#set_totalizer_units=0 (m^3)
#set_totalizer_units=1 (L)
#set_totalizer_units=2 (ft^3)

Area unit - The measurement unit used to report the cross-section area of the submerged channel profile.

#set_area_units=0 (mm^2)
#set_area_units=1 (cm^2)
#set_area_units=2 (m^2)
#set_area_units=4 (in^2)
#set_area_units=5 (ft^2)

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.

#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_lvl_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_lvl_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_lvl_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_lvl_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 0.08 W while in standby mode, and 0.04 W while in sleep mode.

#set_sdi12_sleep=0 (Continuous scanning)
#set_sdi12_sleep=1 (Standby mode)
#set_sdi12_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

Totalizer calculation - This command enables or disables the totalizer calculation.

#set_totalizer_calc=0 (Disabled)
#set_totalizer_calc=1 (Enabled)

Totalizer hard save - This command enables or disables the totalizer hard save. When the setting is enabled, the current total flow volume value will be saved to flash in case of device reset, and upon power-up, new values will be added to the saved value. If the setting is disabled the total flow volume calculation will be reset and start from 0.

#set_totalizer_hardsave=0 (Disabled)
#set_totalizer_hardsave=1 (Enabled)

Totalizer reset - This command resets the totalizer measurement.

#totalizer_reset

Dynamic flow profiler - This command enables or disables the dynamic flow profiler funcionality. The default value is 0 (Disabled).

#set_dfp_en=0 (Disabled)
#set_dfp_en=1 (Enabled)

Main output value - When the DFP functionality is enabled, this command configures whether the average velocity value or the dynamic flow profiler velocity value will be used as the main output for velocity measurement. The default value is 0 (Average velocity value).

#set_dfp_use_as_main=0 (Average velocity value)
#set_dfp_use_as_main=1 (Dynamic flow profiler velocity value)

Change DFP parameters:

When the DFP funcionality is enabled, the following commands can be used to configure the DFP parameters:

Minimum DFP level - The minimum level (in millimetres) at which the DFP velocity value is calculated. The default value is 0.

#set_dfp_lvl_min_mm=<value>

Maximum DFP level - The maximum level (in millimetres) at which the DFP velocity value is calculated. The default value is 30000.

#set_dfp_lvl_max_mm=<value>

Ratio filter - The ratio filter utilizes a percentage (by default, set at 20%) to incorporate the dynamic flow profiler into the current measrement. With this filter, a stable DFP value for a specific level allows the output velocity value to consist of 20% DFP velocity and 80% current measured velocity. This filter serves the purpose of smoothing out abrupt transitions from periods with no measurements to periods with available measurements. Each level has the flexibility to configure its own ratio accordingly.

#set_dfp_ratio_fil_en=0 (Disabled)
#set_dfp_ratio_fil_en=1 (Enabled)

Ratio - The ratio used for the ratio filter. The default value is 80.

#set_dfp_ratio=<0-100>

DFP level SNR threshold - When the level SNR value surpasses this threshold, the velocity measurement will be stored for the dynamic flow profiler funcionality. The default value is 20.

#set_dfp_lvl_snr_thr=<value>

DFP velocity SNR threshold - When the velocity SNR value surpasses this threshold, the velocity measurement will be stored for the dynamic flow profiler funcionality. The default value is 11.

#set_dfp_vel_snr_thr=<value>

Below minimum threshold velocity - This setting enables or disables the usage of DFP velocity as the main velocity below the defined Minimum DFP level. The velocity is obatined by interpolation between zero and the first DFP level point velocity.

#set_dfp_low_vel_as_main=0 (Disabled)
#set_dfp_low_vel_as_main=1 (Enabled)

Obtaining the DFP Settings:

To get the status of all of the DFP settings the following command can be used:

#dfp_get_info

The response to this command can be either just:

dfp_en:0

if the DFP funcionality is disabled, or:

dfp_en:1
dfp_lvl_min_mm:<value_mm>
dfp_lvl_max_mm:<value_mm>
dfp_use_as_main:<0,1>
dfp_vel_snr_thr:<value>
dfp_lvl_snr_thr:<value>
dfp_ratio_fil_en:<0,1>
dfp_ratio:<value>
dfp_low_vel_as_main:<0,1>

if the DFP funcionality is enabled.

Obtaining the DFP Measurements Status:

The DFP measurements status for a specific level can be obtained via RS-232 or RS-485 interface. To get the measurements status for a specific level over the RS-232 interface, the following command should be issued:

#dfp_get_status_lvl_mm=<value_mm>

where *<value_mm>* is the distance from the sensor to the desired level. The sensor will give the following response:

#dfp_status_lvl:<def_value_mm>,<threshold_min_write>,
<threshold_max_write>,<threshold_min>,<threshold_max>,
<measurement_cnt>,<history_id_used_curent>,<history_id_cnt>,
<age_of_current_history_block>

#dfp_msr_incoming_status_lvl:<msr_cnt>,<min_val>,
<max_val>,<mean>,<std_dev>

#dfp_msr_outgoing_status_lvl:<msr_cnt>,<min_val>,
<max_val>,<mean>,<std_dev>

where the following notation applies:

<def_value_mm> - The defined value used for the DFP functionality

<threshold_min_write> - Minimum value, corresponding to the defined value, that will be used for the DFP funcionality. Values below this threshold will not be stored for the DFP functionality.

<threshold_max_write> - Maximum value, corresponding to the defined value, that will be used for the DFP funcionality. Values above this threshold will not be stored for the DFP functionality.

<threshold_min> - Minimum value corresponding to the defined value.

<*threshold_max*> - Maximum value corresponding to the defined value.

<*measurement_cnt*> - Measurement count.

<*history_id_used_curent*> - ID of the current block.

<*history_id_cnt*> - Number of predefined blocks used for the defined value.

<*age_of_current_history_block*> - Relative age of DFP points.

<*msr_cnt*> - Number of velocity measurements.

<*min_val*> - Minimum velocity measurement value.

<*max_val*> - Maximum velocity measurement value.

<*mean*> - Mean velocity measurement value.

<*std_dev*> - Standard deviation of velocity measurements.

It is also possible to get the measurements status for all configured levels at once by issuing the following command:

#dfp_get_status_all

The format for each configured level status response is the same as the status response for a single level. The response to the above command can vary from 1 to 10 seconds, depending on the number of DFP points configured.

Obtaining the Saved DFP Measurements:

Obtaining measurements is only available via the RS-232 interface by sending the following command:

#dfp_print_msrs=<value_mm>,<request_count_msrs>

where <*value_mm*> is the value for which the measurements are requested, while <*request_count_msrs*> is the number of measurements to fetch. If a large number of measurements is requested, the sensor will send the measurements in chunks of the following format:

#dfp_print_msrs:<dfp_point_value_mm>,<request_count_msrs>,
<msrs_offset>,<current_msrs_cnt>;
<msr_1>,<msr_2>,<msr_3>, ... ,<msr_current_data_cnt>,

where the following notation applies:

<*dfp_point_level_mm*> - The DFP point value in millimetres closest to requested <*value_mm*>

<*request_count_msrs*> - The requested number of measurements

<*msrs_offset*> - The offset of data sent in the current chunk. This offset is the number of measurements, not the number of chunks.

<*current_msrs_cnt*> - The count of measurements that will be sent in the current chunk.

<*msr_1*>,<*msr_2*>,<*msr_3*>, ... ,<*msr_current_data_cnt*> - The measurements that are sent separated with a colon. Positive values represent the incoming velocity values and negative values represent the outgoing velocity values.

All measurements have been sent when the sensor responds with:

#dfp_print_msrs:OK

Storing (Importing) Measurements for a Specific Level:

Storing measurement for a specific level is done via the RS-232 interface by sending two (or more) separate commands. First, the level point (distance from the sensor to the desired water level) must be set, and then the measurements can be imported:

command: #set_dfp_custom_lvl_point=<value_mm>
response: #set_dfp_custom_lvl_point:OK

command: #dfp_save_msr=<vel_1>,<vel_2>,...,<vel_20>
response: #dfp_save_msr:OK

Using these two commands, the user can store custom velocity measurements to the sensor. *<value_mm>* represents the distance (in millimetres) from the sensor to the desired level for which the measurements will be stored, while *<vel_1>,<vel_2>*, etc. represent the measurements, which can be positive or negative. Positive values represent the incoming velocity values, while the negative values represent the outgoing velocity values. The maximum number of velocity values per command is 20, so if there are more than 20 velocity values that need to be stored, multiple *#dfp_save_msr* commands must be sent.

Resetting the DFP Measurements for a Specific Level:

If, for some reason, the user wants to reset the measurements saved for a specific level, the following command can be used:

#dfp_reset_lvl_mm=<level_mm>,<flag_leave_last_block_of_measurements>

where *<value_mm>* represents the distance (in millimetres) from the sensor to the desired level. The *<flag_leave_last_block_of_measurements>* can be set to either 0 or 1. If it is set to 0 all of the measurements will be erased. If it is set to 1, the last block of measurements will remain, while all the previous measurements will be erased.

Resetting All of the DFP Measurements:

If the discharge parameters (k-factors and corresponding levels), the level sensor height, or the DFP range (minimum or maximum DFP value) have been changed, the saved DFP measurements will no longer be valid and need to be reset. The following command is used to reset all of the saved DFP measurements:

#dfp_reset

Retrieve current device status

#get_info

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

firmware:6.5.7

serial:123456
sensor_type:WL
direction:both
baud_rate:9600
dead_time:10
can_id:1
angle:160
filter_type:2
filter_len:50
fft_integ_time:0
pga_gain:20
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
border_velocity:500.000
extra_fast:0
power_save:0
level_sensor:2
sdi12_sleep:0
totalizer_hardsave:0
totalizer_calc:1
discharge_units:liters
totalizer_units:m3
area_units :m2
lvl_units:mm
lvl_firmware:240
lvl_filter_type:4
lvl_filter_len:20
lvl_deadzone_min:200.000
lvl_deadzone_max:15000.000
lvl_420_min:0.000
lvl_420_max:15000.000
lvl_sensor_height:5470.000
lvl_peak_detector:0
lvl_aplitude_threshold:0

7.3. HS Protocol

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 by using the PC application. Please check Chapter 7 for instructions.

The HS protocol is a request-response protocol which, unlike NMEA protocol, does not automatically report periodic flow measurement readings. Instead, when the unit is polled form the data logger, it

responds the measurement.

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*.

7.4. 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-2-300WL 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. In Tables 7 and 8, field *Fun* corresponds to Modbus function codes, i.e. 0x03 – *Read holding register* and 0x06 – *Write holding register*.

Table 7. Retrieving Data from the Sensor

Fun	Register Address	Data Length	Data Range	Details
0x03	0x0000	2 bytes	1 – 247	Read device ID
	0x0001	2 bytes	0 → 9600 1 → 38400 2 → 57600 3 → 115200 4 → 19200	Read baud rate
	0x0002	2 bytes	0 → mm/s 1 → m/s 2 → mph 3 → km/h 4 → fps 5 → fpm 6 → cm/s	Read velocity unit type
	0x0003	2 bytes	0 – 15000 (mm/s)	Read instantaneous speed
	0x0004	2 bytes	0 – 15000 (mm/s)	Read averaged speed
	0x0005	2 bytes	0 – 360	Read tilt angle
	0x0006	2 bytes	0 → incoming 1 → outgoing	Read flow direction
	0x0007	2 bytes	1 – 512	Read filter length
	0x0008	2 bytes	0 – 8	Read defined PGA gain sensitivity
	0x0009	2 bytes	0 → both 1 → incoming 2 → outgoing	Read flow direction filter setting
	0x000A	2 bytes	0 – 100	Read sensitivity value
	0x000B	2 bytes	1	Read device type, always 1
	0x000C	2 bytes	0 – 3840	Read SNR threshold (dBm * 256)
	0x000D	2 bytes	621	Read firmware code 6.2.1
	0x000E	2 bytes	1,2,5,10,20,50,100,200	Read current PGA gain level
	0x000F	2 bytes	0 – 2047	Read relative signal level
	0x0010	2 bytes	0 – 65535	Read instantaneous speed in selected units (integer part)
	0x0011	2 bytes	0 – 65535	Read instantaneous speed in selected units (decimal part * 1000)
	0x0012	2 bytes	0 – 65535	Read averaged speed in selected units (integer part)
	0x0013	2 bytes	0 – 65535	Read averaged speed in selected units (decimal part * 1000)
	0x0014	2 bytes	0 – 10000	Read instantaneous SNR level (dBM * 256)

Fun	Register Address	Data Length	Data Range	Details
0x03	0x0015	2 bytes	0 – 10000	Read averaged SNR level (dBM * 256)
	0x0016	2 bytes	3 printable characters	Read serial number [0-2]
	0x0017	2 bytes	3 printable characters	Read serial number [3-5]
	0x0018	2 bytes	0 → excellent 1 → good 2 → low 3 → unacceptable	Read QoS - angle, vibrations - first 2 bits of first byte Read QoS - signal - second 2 bits of first byte. (example 0x0B is QOS angle 3 and QOS signal 2)
	0x0019 – 0x001A	2 bytes	0	Reserved, always 0
	0x001B	2 bytes	0 → very narrow 1 → narrow 2 → normal 3 → wide	Read peak width
	0x001C	2 bytes	0 – 15000	Read velocity min. (mm/s)
	0x001D	2 bytes	0 – 15000	Read velocity max. (mm/s)
	0x001E	2 bytes	0 → turned off 1 → turned on	Extra fast setting
	0x001F	2 bytes	0	Reserved, always 0
	0x0020	2 bytes	0 – 65535	Read calculated water discharge, integer part in selected units
	0x0021	2 bytes	0 – 65535	Read calculated water discharge, decimal part in selected units
	0x0022	2 bytes	0 – 65535	Read distance to water surface, integer part in selected units
	0x0023	2 bytes	0 – 65535	Read distance to water surface, decimal part in selected units
	0x0024	2 bytes	0 – 65535	Read measured water level, integer part in selected units, relative to defined staff gauge zero
	0x0025	2 bytes	0 – 65535	Read measured water level, decimal part in selected units, relative to defined staff gauge zero
	0x0026	2 bytes	0 – 10000	Read level sensor SNR level (dBM * 256)
	0x0027	2 bytes	0 – 150	Read temperature from level sensor (Celsius)

Fun	Register Address	Data Length	Data Range	Details
0x03	0x0028	2 bytes	0 – 200	Read number of frames for level sensor window filtering
	0x0029	2 bytes	0 → no filter 1 → IIR filter 2 → moving average 3 → median filter 4 → standard deviation	Read filter type for level sensor
	0x002A	2 bytes	0 – 1000	Read level sensor IR filter constant
	0x002B	2 bytes	0 – level range	Read level sensor active zone minimum in selected units
	0x002C	2 bytes	0 – level range	Read level sensor active zone maximum in selected units
	0x002D	2 bytes	0 → mm 1 → cm 2 → m 3 → in 4 → ft	Read level sensor unit type
	0x002E	2 bytes	0 → m^3/s 1 → L/s 2 → ft^3/s	Read discharge unit type
	0x002F	2 bytes	0 → maximum peak 1 → last peak 2 → first peak	Read peak detector type for level sensor
	0x0030	2 bytes	0 – 65335	Read level spectrum amplitude threshold
	0x0031	2 bytes	Standard deviation	Read standard deviation of measurement
	0x0032	2 bytes	0 – 360	Read level sensor x-axis tilt angle
	0x0033	2 bytes	0 – 360	Read level sensor y-axis tilt angle
	0x0034	2 bytes	239	Read level sensor firmware code
	0x0035	2 bytes	0 – 65335	Read sensor height
	0x0037	2 bytes	0 – 65335	Read cross-section area in selected unit (integer part)
	0x0038	2 bytes	0 – 65335	Read cross-section area in selected unit (decimal part * 1000)
	0x0039	2 bytes	0 – 65335	Read total flow volume in selected units - first 16 bits. (For value 0x123456789ABCDEF0 this register is showing 0xDEF0)

Fun	Register Address	Data Length	Data Range	Details
0x03	0x003A	2 bytes	0 – 65335	Read total flow volume in selected units - second 16 bits
	0x003B	2 bytes	0 – 65335	Read total flow volume in selected units - third 16 bits
	0x003C	2 bytes	0 – 65335	Read total flow volume in selected units - fourth 16 bits
	0x003D	2 bytes	0 – 65335	Read totalizer active time - first 16 bits. (For value 0x12345678, this register is showing 0x5678)
	0x003E	2 bytes	0 – 65335	Read totalizer active time - second 16 bits
	0x003F	2 bytes	0	Reserved, always 0
	0x0040	2 bytes	0 → m^3 1 → L/s 2 → ft^3	Read totalizer unit type
	0x0041	2 bytes	0 → mm^2 1 → cm^2 2 → m^2 3 → in^2 4 → ft^2	Read area unit type
	0x0042	2 bytes	0 → disabled 1 → enabled	Read totalizer calculation
	0x0043	2 bytes	0 → disabled 1 → enabled	Read totalizer hard save setting
	0x0044 – 0x0049	2 bytes	0	Reserved, always 0
	0x004A	2 bytes	0 → disabled 1 → enabled	Dynamic flow profiler functionality
	0x004B – 0x0050	2 bytes	0	Reserved, always 0
	0x0051	2 bytes	0 → turned off 1 → turned on	Read low power mode
	0x0052 – 0x07FF	2 bytes	0	Reserved, always 0
	0x0800	2 bytes	0 – 30000	Minimum DFP level
	0x0801	2 bytes	0 – 30000	Maximum DFP level
	0x0802	2 bytes	0 – 65335	DFP level SNR threshold
	0x0803	2 bytes	0 – 65335	DFP velocity SNR threshold
	0x0804	2 bytes	0 → average velocity value 1 → DFP velocity value	Use DFP velocity value as main value

Fun	Register Address	Data Length	Data Range	Details
0x03	0X0805	2 bytes	0 → disabled 1 → enabled	Ratio filter
	0X0806	2 bytes	0 – 100	Ratio
	0X0807	2 bytes	0 → disabled 1 → enabled	Use below minimum threshold velocity

Table 8. Writing Data to the Sensor

Fun	Register Address	Data Length	Data Range	Details
0x06	0X0000	2 bytes	1 – 247	Change device ID
	0X0001	2 bytes	0 → 9600 1 → 38400 2 → 57600 3 → 115200 4 → 19200	Change baud rate
	0X0002	2 bytes	0 → mm/s 1 → m/s 2 → mph 3 → km/h 4 → fps 5 → fpm 6 → cm/s	Change velocity unit type
	0X0007	2 bytes	1 – 512	Change filter length
	0X0008	2 bytes	0 – 8	Change PGA gain sensitivity
	0X0009	2 bytes	0 → both 1 → incoming 2 → outgoing	Change flow direction filter type
	0X000A	2 bytes	0 – 100	Change sensitivity level
	0X000C	2 bytes	0 – 3840	Change SNR threshold (dBm * 256)
	0x001B	2 bytes	0 → very narrow 1 → narrow 2 → normal 3 → wide	Change peak width
	0x001C	2 bytes	0-15000	Change velocity min. (mm/s)
	0x001D	2 bytes	0-15000	Change velocity max. (mm/s)
	0x001F	2 bytes	0 → turned off 1 → turned on	Change extra fast setting
	0x0028	2 bytes	0 – 200	Change number of frames for level sensor window filtering

Fun	Register Address	Data Length	Data Range	Details
	0x0029	2 bytes	0 → no filter 1 → IIR filter 2 → moving average 3 → median filter 4 → standard deviation	Change level sensor filter type
	0x002A	2 bytes	0 – 1000	Change level sensor IR filter constant $IR_{const} = \frac{value_{int}}{1000}$
	0x002B	2 bytes	0 – level range	Change level sensor active zone minimum in defined units
	0x002C	2 bytes	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
	0x002E	2 bytes	0 → m^3/s 1 → L/s 2 → ft^3/s	Change discharge unit type
	0x002F	2 bytes	0 → maximum peak 1 → last peak 2 → first peak	Change peak detector type for level sensor
	0x0030	2 bytes	0 – 65335	Change level spectrum amplitude threshold
	0x0035	2 bytes	0 – 65335	Change sensor height
	0x0036	2 bytes	0 – 65335	Enter staff gauge
	0x0040	2 bytes	0 → m^3 1 → L/s 2 → ft^3	Change totalizer unit type
	0x0041	2 bytes	0 → mm^2 1 → cm^2 2 → m^2 3 → in^2 4 → ft^2	Change area unit type
	0x0042	2 bytes	0 → disabled 1 → enabled	Enable/disable totalizer calculation
	0x0043	2 bytes	0 → disabled 1 → enabled	Enable/disable totalizer hard save setting
	0x0044	2 bytes	1	Totalizer reset
	0x004A	2 bytes	0 → disabled 1 → enabled	Dynamic flow profiler functionality
	0x0051	2 bytes	0 → turned off 1 → turned on	Change low power mode

Fun	Register Address	Data Length	Data Range	Details
0x06	0x0800	2 bytes	0 – 30000	Minimum DFP level
	0x0801	2 bytes	0 – 30000	Maximum DFP level
	0x0802	2 bytes	0 – 65335	DFP level SNR threshold
	0x0803	2 bytes	0 – 65335	DFP velocity SNR threshold
	0x0804	2 bytes	0 → average velocity value 1 → DFP velocity value	Use DFP velocity as main value
	0x0805	2 byte	0 → disabled 1 → enabled	Ratio filter
	0x0806	2 bytes	0 – 100	Ratio
	0x0807	2 bytes	0 → disabled 1 → enabled	Use below minimum threshold velocity
	0x0850	2 bytes	1234	Reset DFP setup
	0x0851	2 bytes	Level value in mm	Reset DFP measurements for a specific level

Table 9. shows the registers used to obtain the saved DFP measurements over the RS-485 interface (Modbus). The user must issue the request to read the measurements for a specific level by writing the value in millimetres to register 0x860 and then read the registers 0x861 to 0x879:

Table 9. Obtaining the Saved DFP Measurements

Register	Value	Register	Value
0x0861	<def_value_mm>	0x0870	<incoming_msr_cnt>
0x0862	<threshold_min_write>	0x0871	<incoming_min_val>
0x0863	<threshold_max_write>	0x0872	<incoming_max_val>
0x0864	<threshold_min>	0x0873	<incoming_mean>
0x0865	<threshold_max >	0x0874	<incoming_std_dev>
0x0866	<measurement_cnt>	0x0875	<outgoing_msr_cnt>
0x0867	<history_id_used_curent>	0x0876	<outgoing_min_val>
0x0868	<history_id_cnt>	0x0877	<outgoing_max_val>
0x0869	<age_of_current_history_block>	0x0878	<outgoing_mean>
0x086A - 0x086F	0	0x0879	<outgoing_std_dev>

The descriptions of the values in registers 0x861 to 0x879 in Table 9. are as follows:

<*def_value_mm*> - The defined value used for the DFP functionality

<*threshold_min_write*> - Minimum value, corresponding to the defined value, that will be used for the DFP funcionality. Values below this threshold will not be stored for the DFP functionality.

<*threshold_max_write*> - Maximum value, corresponding to the defined value, that will be used for the DFP funcionality. Values above this threshold will not be stored for the DFP functionality.

<*threshold_min*> - Minimum value corresponding to the defined value.

<*threshold_max*> - Maximum value corresponding to the defined value.

<*measurement_cnt*> - Measurement count.

<*history_id_used_curent*> - ID of the current block.

<*history_id_cnt*> - Number of predefined blocks used for the defined value.

<*age_of_current_history_block*> - Relative age of DFP points.

<*msr_cnt*> - Number of velocity measurements.

<*min_val*> - Minimum velocity measurement value.

<*max_val*> - Maximum velocity measurement value.

<*mean*> - Mean velocity measurement value.

<*std_dev*> - Standard deviation of velocity measurements.

7.4.1. Modbus Input Registers

Modbus input registers are read-only registers. By reading the Modbus input registers the user can view the device type and the firmware version, as well as real-time measurement values in 32-bit integer or 32-bit float format. Since the native Modbus registers are 16-bit registers, to store 32-bit values, two subsequent registers are used. In order to easily check the byte-order and word-order, two pairs of test registers with fixed constant values are provided. One register pair containts a fixed value of 1234567 in 32-bit integer format, and the other register pair contains a fixed value of -123.4567 in 32-bit float format.

Table 10 defines the data returned by the instrument when the master requests that the input register is read (Modbus function code 0x04). Rows highlighted in blue denote the values of interest, while the rows highlighted in green represent reserved registers which can be read but the returned value will always be equal to 0.

Table 10. Retrieving Data from Modbus Input Registers

Fun	Register Address	Data Length	Data Format	Details
0x04	0x0001	2 bytes	16-bit integer	Device type ID
	0x0002	2 bytes	16-bit integer	Firmware version
	0x0003	2 bytes		Reserved - always 0
	0x0004, 0x0005	2 bytes, 2 bytes	32-bit integer	32-bit integer control register pair containing a fixed value of 1234567
	0x0006, 0x0007	2 bytes, 2 bytes	32-bit float	32-bit float control register pair containing a fixed value of -123.4567
	0x0008 - 0x0009	2 bytes		Reserved - always 0
	0x0010, 0x0011	2 bytes, 2 bytes	32-bit float	Water level
	0x0012, 0x0013	2 bytes, 2 bytes	32-bit float	Distance to water
	0x0014, 0x0015	2 bytes, 2 bytes	32-bit float	Average surface velocity
	0x0016, 0x0017	2 bytes, 2 bytes	32-bit float	Current surface velocity
	0x0018, 0x0019	2 bytes, 2 bytes	32-bit float	Discharge
	0x001A, 0x001B	2 bytes, 2 bytes	32-bit float	Area under water
	0x001C, 0x001D	2 bytes, 2 bytes	32-bit float	Level sensor tilt angle, x-axis
	0x001E, 0x001F	2 bytes, 2 bytes	32-bit float	Level sensor tilt angle, y-axis
	0x0020, 0x0021	2 bytes, 2 bytes	32-bit float	Surface velocity sensor tilt angle
	0x0022, 0x0023	2 bytes, 2 bytes	32-bit float	Level SNR
	0x0024, 0x0025	2 bytes, 2 bytes	32-bit float	Surface velocity SNR
	0x0026, 0x0027	2 bytes, 2 bytes	32-bit float	Surface velocity signal strength
	0x0028, 0x0029	2 bytes, 2 bytes	32-bit float	Surface flow direction
	0x002A, 0x002B	2 bytes, 2 bytes	32-bit float	Internal temperature
	0x002C-0x007F	2 bytes		Reserved - always 0

Fun	Register Address	Data Length	Data Format	Details
0x04	0x0080, 0x0081	2 bytes, 2 bytes	32-bit integer	Water level
	0x0082, 0x0083	2 bytes, 2 bytes	32-bit integer	Distance to water
	0x0084, 0x0085	2 bytes, 2 bytes	32-bit integer	Average surface velocity
	0x0086, 0x0087	2 bytes, 2 bytes	32-bit integer	Current surface velocity
	0x0088, 0x0089	2 bytes, 2 bytes	32-bit integer	Discharge
	0x008A, 0x008B	2 bytes, 2 bytes	32-bit integer	Area under water
	0x008C, 0x008D	2 bytes, 2 bytes	32-bit integer	Level sensor tilt angle, x-axis
	0x008E, 0x008F	2 bytes, 2 bytes	32-bit integer	Level sensor tilt angle, y-axis
	0x0090, 0x0091	2 bytes, 2 bytes	32-bit integer	Surface velocity sensor tilt angle
	0x0092, 0x0093	2 bytes, 2 bytes	32-bit integer	Level SNR
	0x0094, 0x0095	2 bytes, 2 bytes	32-bit integer	Surface velocity SNR
	0x0096, 0x0097	2 bytes, 2 bytes	32-bit integer	Surface velocity signal strength
	0x0098, 0x0099	2 bytes, 2 bytes	32-bit integer	Surface flow direction
	0x009A, 0x009B	2 bytes, 2 bytes	32-bit integer	Internal temperature

7.5. SDI-12 Protocol

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 11. SDI-12 Commands

Name	Command	Response	Details
Address Query	?!	a<CR><LF>	Device will identify using its SDI-12 address, default address is 1
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	aI!	a13GEOLUX 2300WLfff<CR><LF>	a – address SDI-12 version – 1.3 vendor identification – GEOLUX sensor model – 2300WL 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

Name	Command	Response	Details
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
Send Data	aD0! aD1!	a<val0><CR><LF> a<val0><CRC><CR><LF> a<val1><CR><LF> a<val1><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 ° +d - signal quality (3->unacceptable, 2 ->low, 1->good, 0->excellent)
Additional Data	aD1! .. aD9!	a0<CR><LF> a0<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>	
Send Data	aD0! aD1! aD2!	a<val0><CR><LF> a<val0><CRC><CR><LF> a<val1><CR><LF> a<val1><CRC><CR><LF> a<val2><CR><LF> a<val2><CRC><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
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 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 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

Name	Command	Response	Details
Set Direction Filter Factor	aXGDFT+d!	a+d<CR><LF>	+d – direction filter for velocity 0 – both, 1 – incoming, 2 – outgoing*
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 discharge 0 – m^3/s, 1 – L/s, 2 – ft^3/s
Set Measurement Unit for Discharge	aXGDUN+d!	a+d<CR><LF>	+d – measurement unit for discharge 0 – m^3/s, 1 – L/s, 2 – ft^3/s

** When the direction filter is set to outgoing (2), the return values will be negative indicating outgoing flow.*

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 Dynamic Flow Profiler

The Dynamic Flow Profiler (DFP) is a key feature of the RSS-2-300WL flow meter. It enables the correlation between level and velocity measurements. This correlation is established within the sensor under favourable conditions for both the level and velocity measurements. Sufficient data allows for precise prediction of velocity measurements based on accurate level measurements. By employing DFP, the flow meter generates additional measurement values related to velocity and discharge.

The user can define a range of water levels, referred to as the DFP range, and with a combination of the water level defined for the k-factors, initialize the DFP level points. When properly configured, every level measurement should have a corresponding DFP level point. Velocity measurements are stored for each DFP level point when certain conditions, such as the SNR threshold values for level and velocity measurements, are met. Over time, a certain number of velocity measurements is accumulated for every DFP level point. When the velocity cannot be directly measured due to certain conditions, the flow meter can use these measurements to extract the velocity measurement as a mean value of the past values accumulated for the DFP level point corresponding to the measured water level.

When the velocity measurement SNR in not sufficient, the sensor can use the mean DFP output value (or a percentage of said value) as the main sensor value and use it for discharge calculations. If the measured water level lies between two defined DFP points, the current DFP velocity value is computed using interpolation based on the mean velocities derived from each respective DFP level point.

The DFP velocity values can be used in combination with the current measured velocity value, with each contributing to the final output proportionally based on its designated ratio. For instance, if a ratio of 80 percent is defined, the resultant output value will be composed of 80 percent of the measured value and 20 percent of the DFP value associated with the current water level.

To ensure that the DFP can genetare accurate velocity data, the user must define the operational range of the DFP, i.e. the range in which the water flow is stable, by defining the DFP minimum and maximum levels. By defining the DFP range, the user can optimize the usage of the DFP feature and ensure accurate and reliable velocity measurements within the specified range. It allows for better control over when to rely on the DFP velocity values for discharge calculation, and when to switch to other measurement sources if the water level is outside of the DFP range.

The minimum and maximum DFP levels represent the minimum and maximum water levels for which the DFP will be active. Below the minimum DFP level, the terrain might be rocky or containg other obstacles which would make the velocity measurements unreliable. On the other hand, beyond the maximum DFP level, the flow conditions may change significantly, leading to unreliable velocity measurements. Moreover, the DFP range parameters can be adjusted according to the requirements of the monitoring site. Factors such as channel characteristics, flow dynamics, and environmental conditions can influence the selection of the minimum and maximum DFP levels. Careful consideration and understanding of the hydraulic behaviour of the water system are crucial for effectively utilizing the DFP feature and obtaing accurate velocity measurements used for discharge calculation. This feature enhances the accuracy of discharge calculations and allows for efficient monitoring of water flow dynamics in rivers and channels.

9 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. Clicking the *Start recording data* starts recording the most important data which is initially displayed and saves it to a .csv file.

If RS-232 interface is selected and too many checksum errors are detected, the interface, COM port and baud rate text on the device icon under *Connected devices* will turn red indicating a communication error.



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* as show in Picture 9. 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:

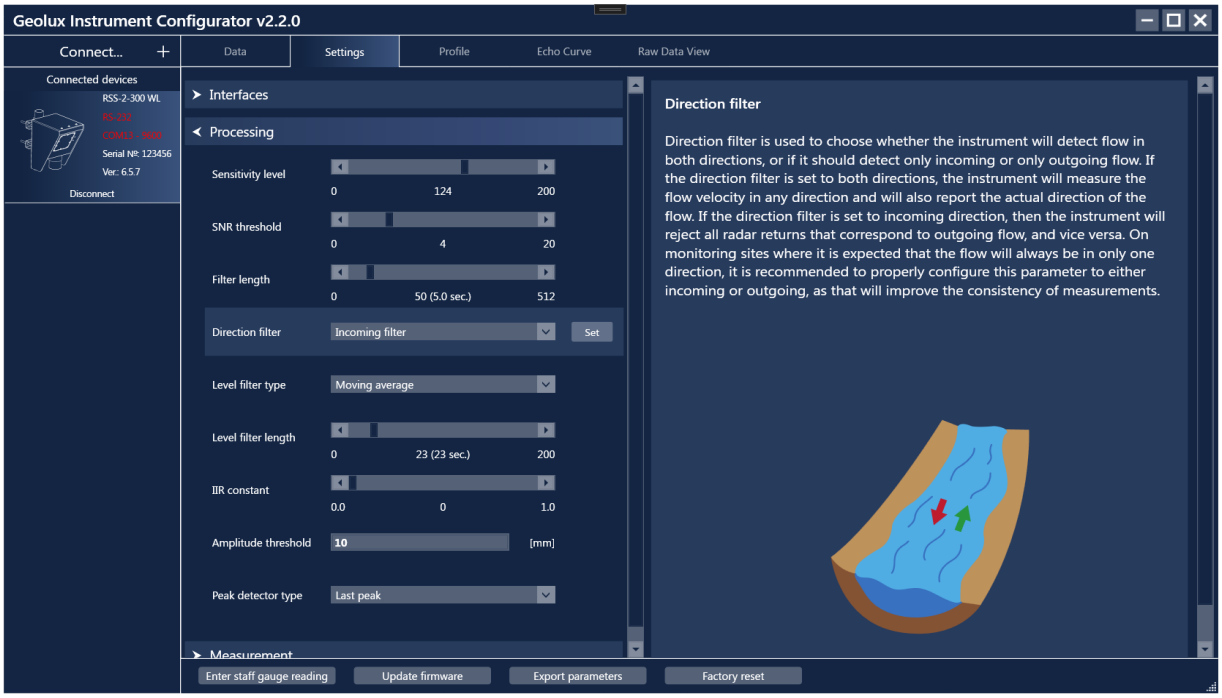
Interfaces
Baud rate
RS-232 protocol
RS-485 protocol
Device ID
Modbus settings
Warm up time
4-20 mA output
4-20 mA min.
4-20 mA max.
Level 4-20 mA min.
Level 4-20 mA max.

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

Measurement
Discharge unit
Velocity unit
Level unit
Totalizer unit
Area unit
PGA sensitivity
Velocity min.
Velocity max.
Level active zone min.
Level active zone max.
Level sensor hight
Power management
Totalizer calculation
Totalizer hard save
Dynamic flow profiler
Main output value

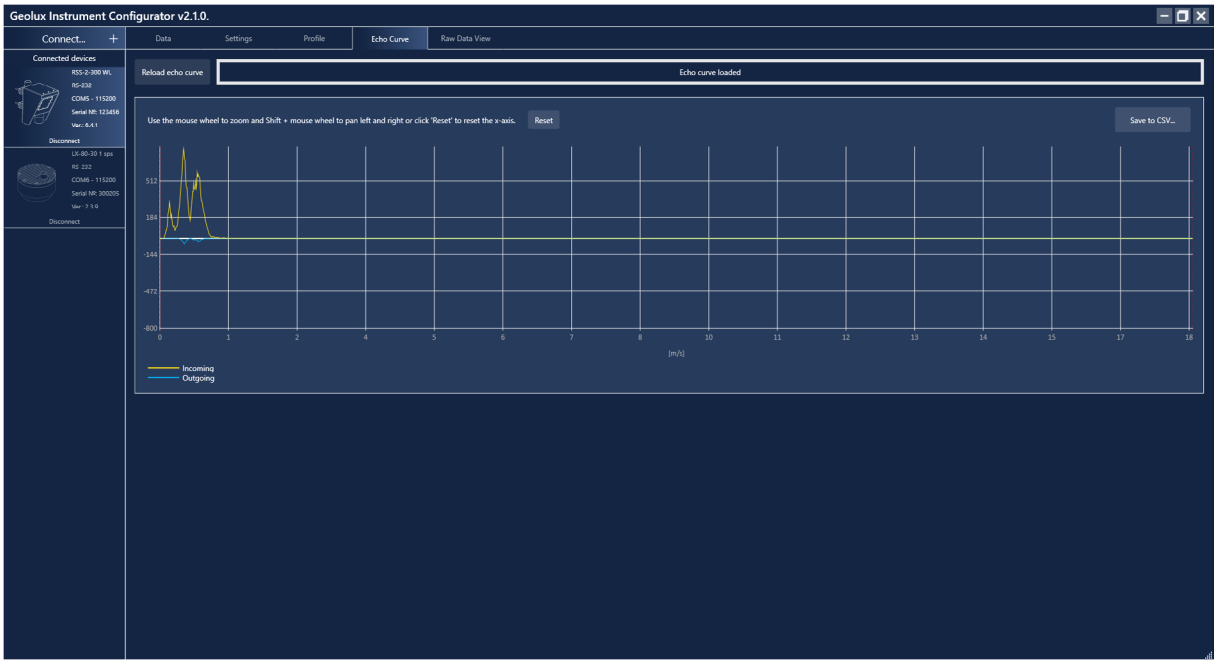
A detailed description (as described in chapter 5 of this user manual) of the selected setting appears on the right side of the window when the user clicks on, or begins to change, a specific setting. When a setting is changed, the *Set* button will appear next to the setting. By clicking the *Set* button,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

By clicking the *Enter staff gauge* button on the bottom of the *Settings* tab, the user can enter the staff gauge reading if a staff gauge is present on the site. The *Update firmware* button allows the user to update the firmware of the device. The *Export parameters* button exports the current settings to .txt file while the *Factory reset* button reverts all the settings to their default values.



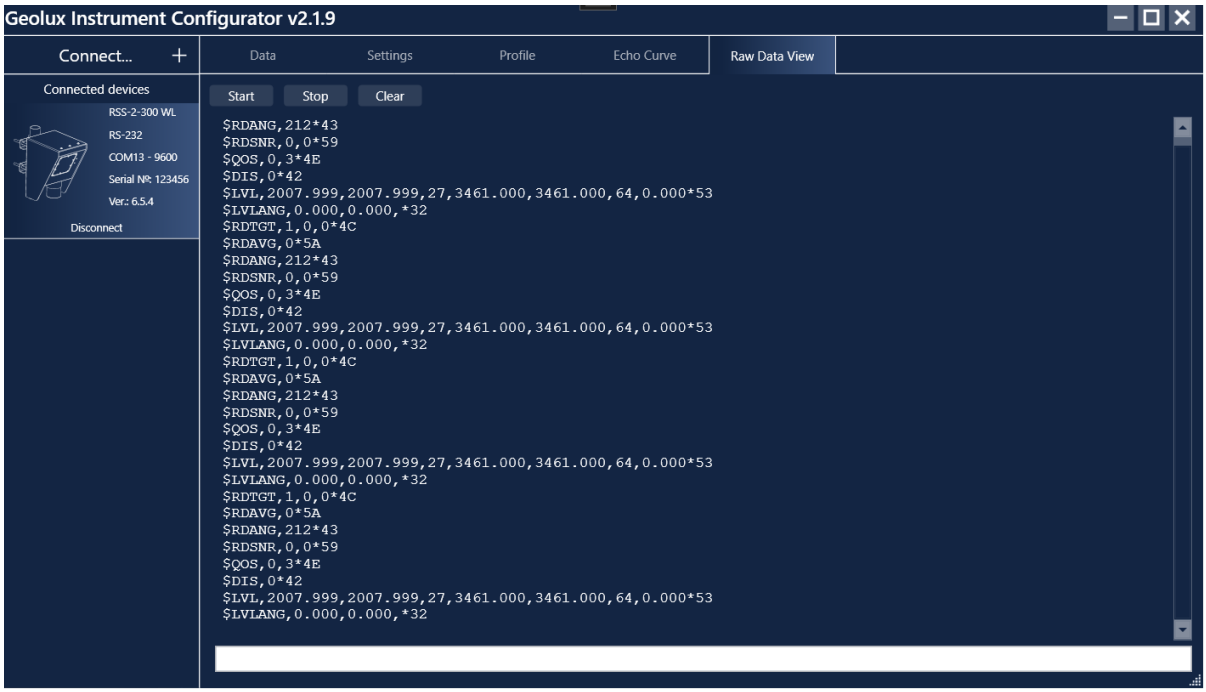
Picture 9. Geolux Instrument Configurator – Settings View

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.



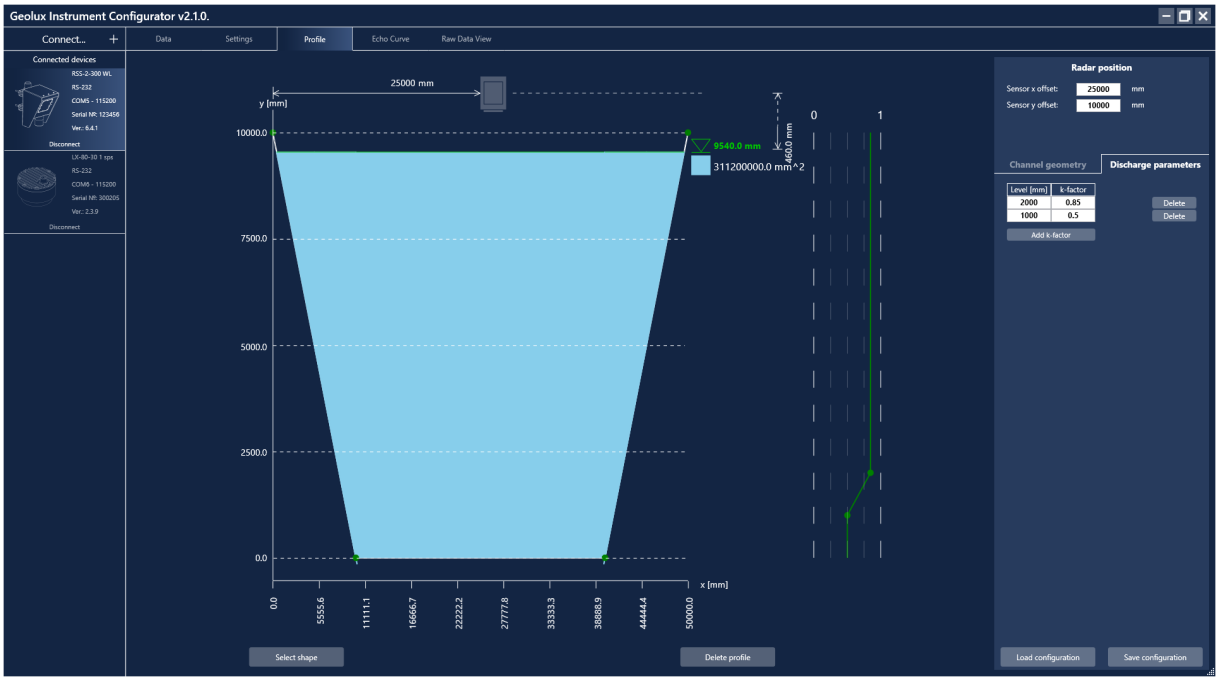
Picture 10. Geolux Instrument Configurator – Echo Curve View

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. The *Raw Data View* tab includes a command line at the bottom so the user can manually send commands to the device.



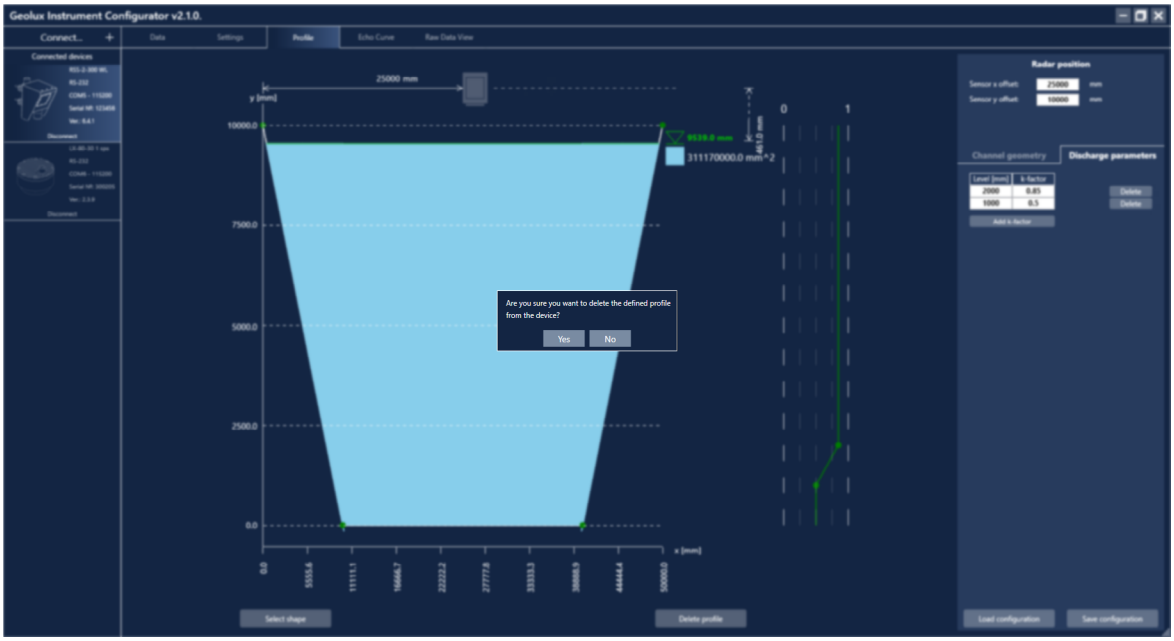
Picture 11. Geolux Instrument Configurator – Raw Data View

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

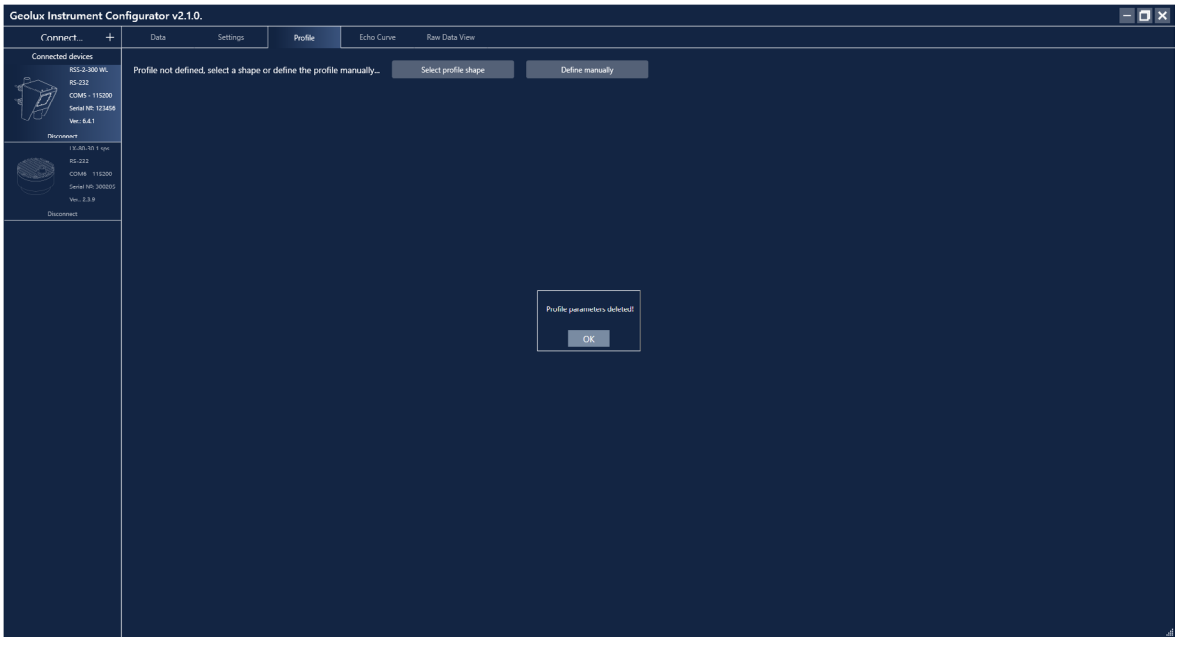
By clicking the *Delete profile* button the user can delete the channel profile geometry which was saved on the device.



Picture 13. Deleting the Existing Channel Profile Geometry

9.1. Configuring the Unit for Discharge Calculation

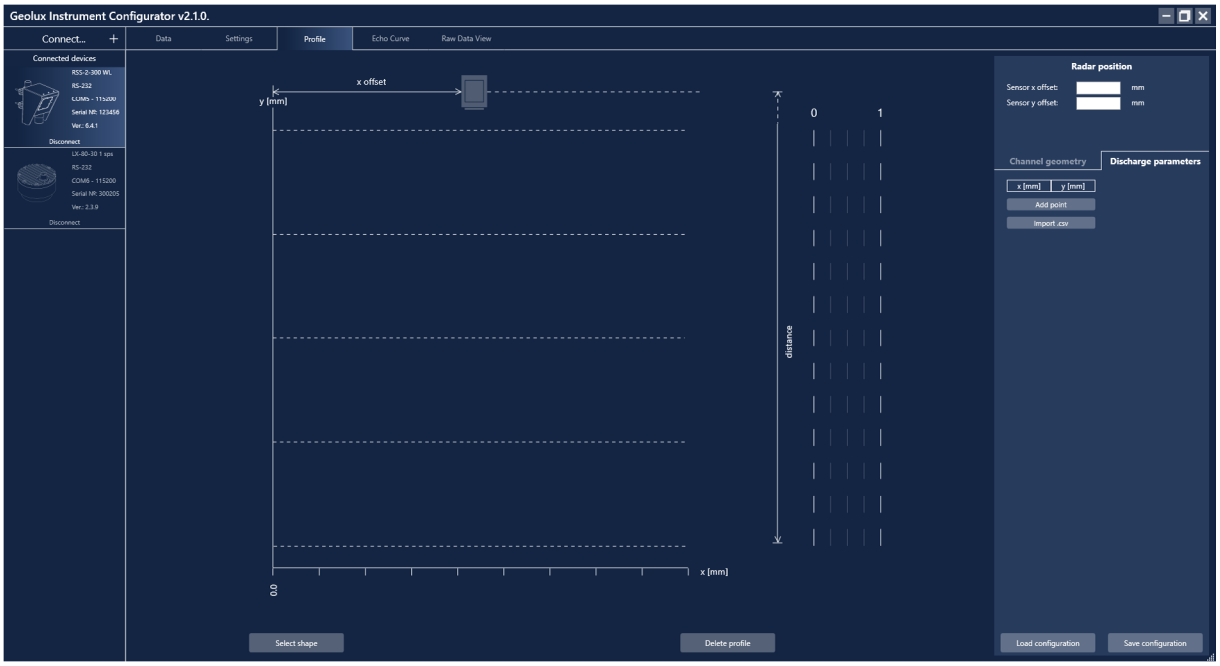
If there is no channel profile geometry saved on the device, or if the user has deleted the defined geometry and wants to define a new one, the geometry can be manually defined, or a predefined shape can be selected to define the channel profile geometry, as described in chapters 9.1.1. and 9.1.2.



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

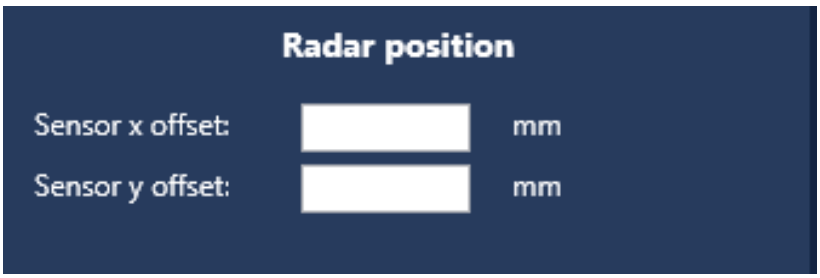
9.1.1. Defining the Channel Profile Geometry Manually

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



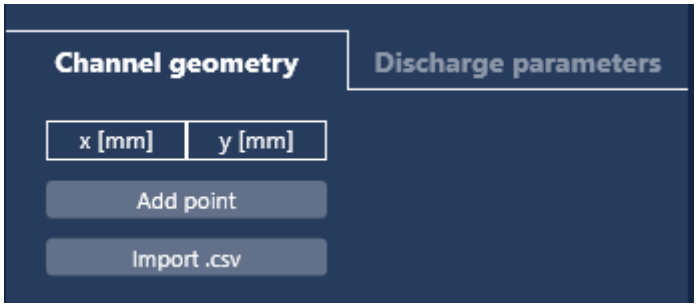
Picture 15. Channel Profile Geometry Definition Page

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.



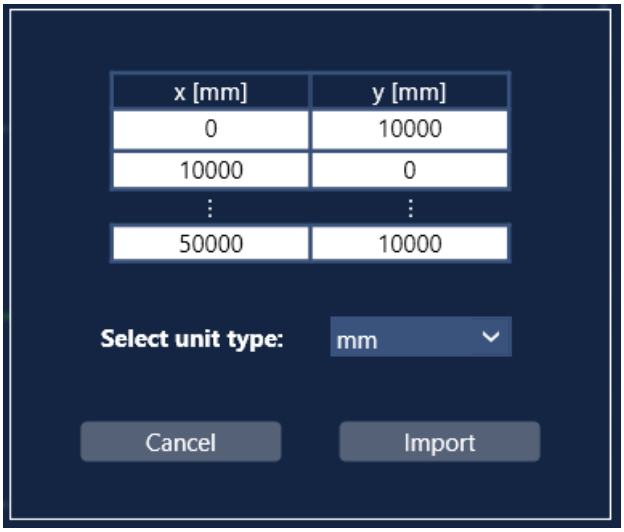
Picture 16. Radar Position

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.



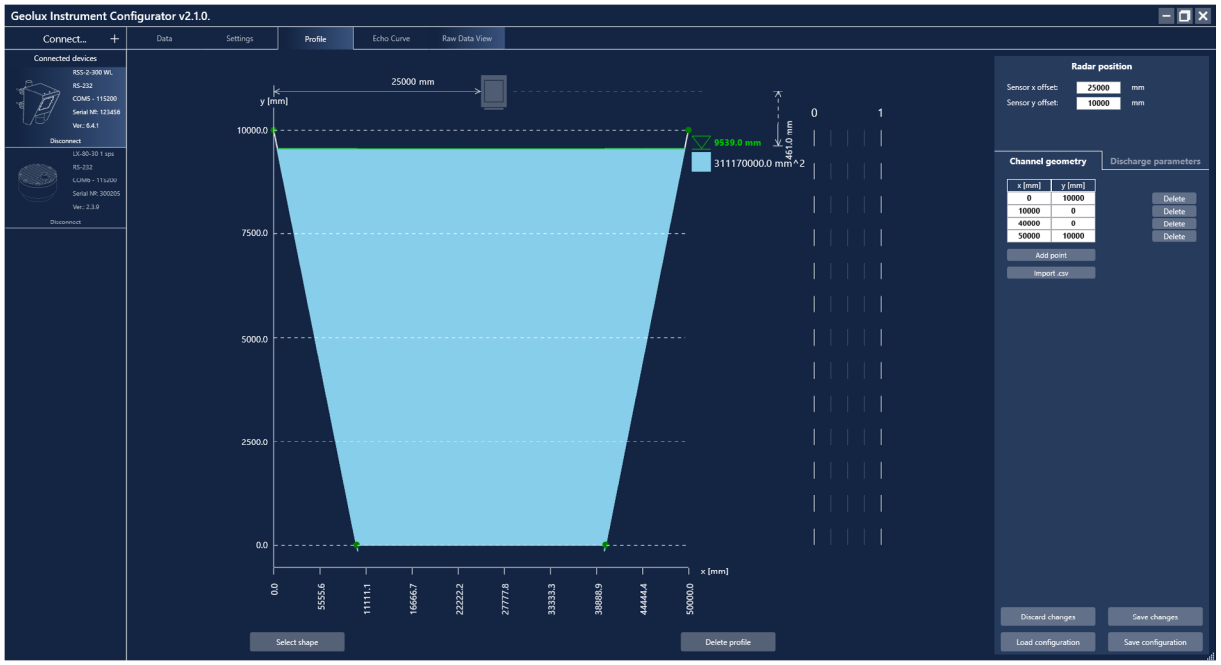
Picture 17. Channel Geometry

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.



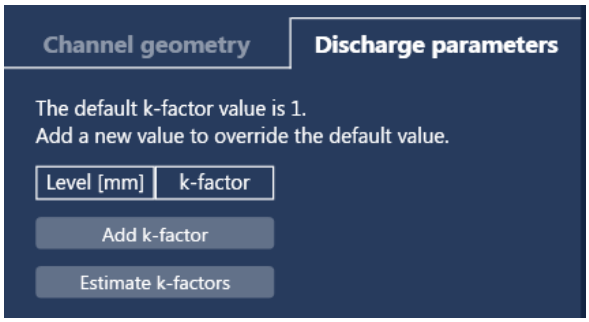
Picture 18. Import .csv File Preview Window

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.



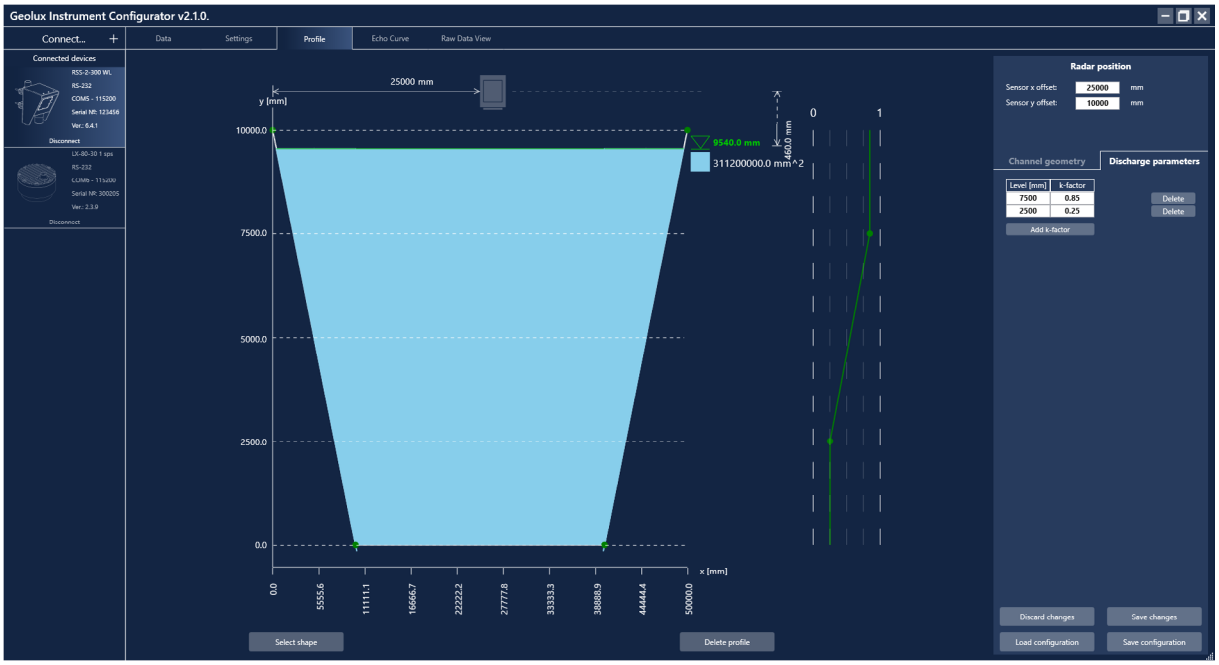
Picture 19. Defined Channel Profile Geometry

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. The k-factor values can also be estimated by clicking the *Estimate k-factors* button. Estimation of k-factor values will be described in chapter 8.1.3. If the user does not define at least one k-factor value, a default value of 1 will be used for discharge calculation.



Picture 20. Discharge Parameters

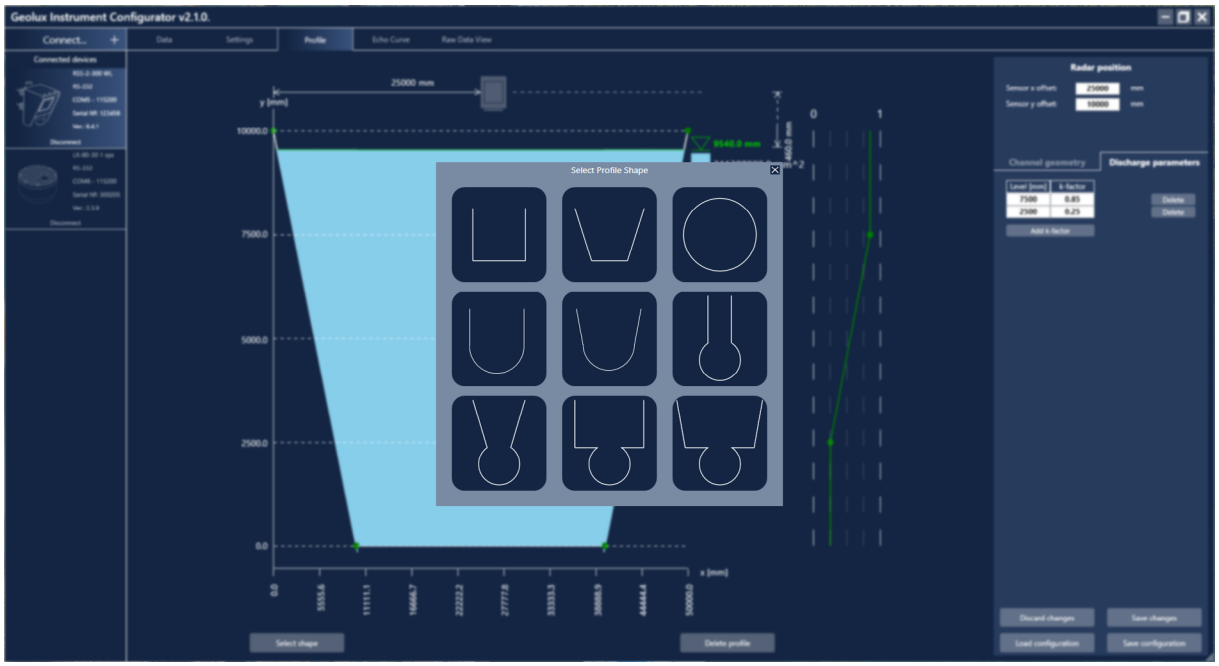
After the discharge parameters have been defined, the values will be drawn on a graph next to the defined channel profile geometry picture.
After defining the channel geometry and discharge parameters, the changes need to be saved to the device. This is done by clicking the *Save changes* button. If 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

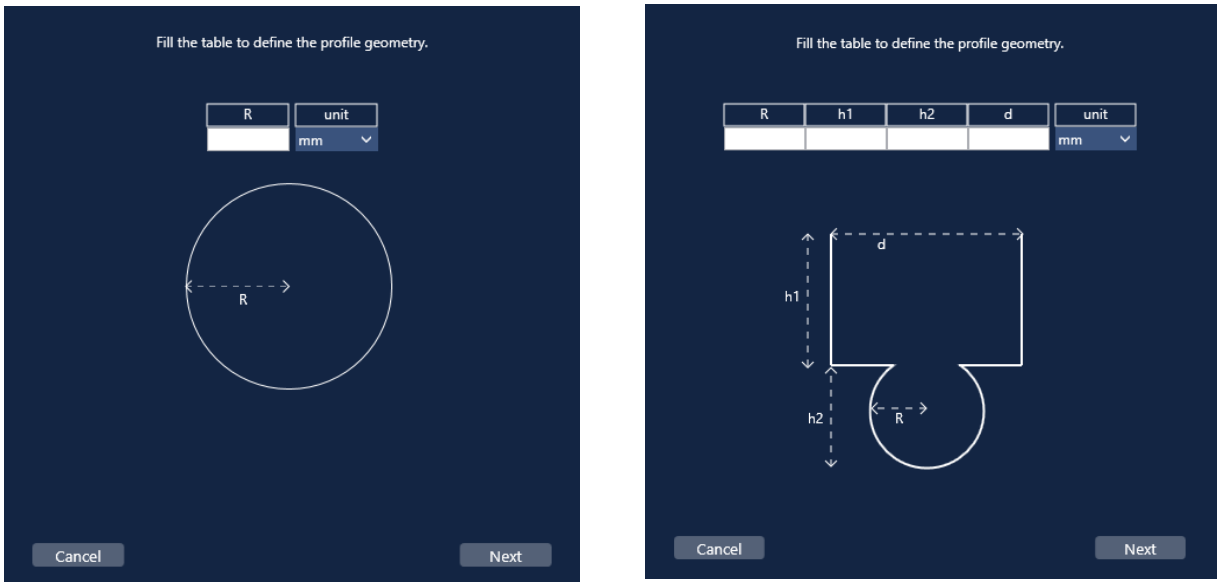
9.1.2. Selecting a Predefined Channel Profile Shape

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.



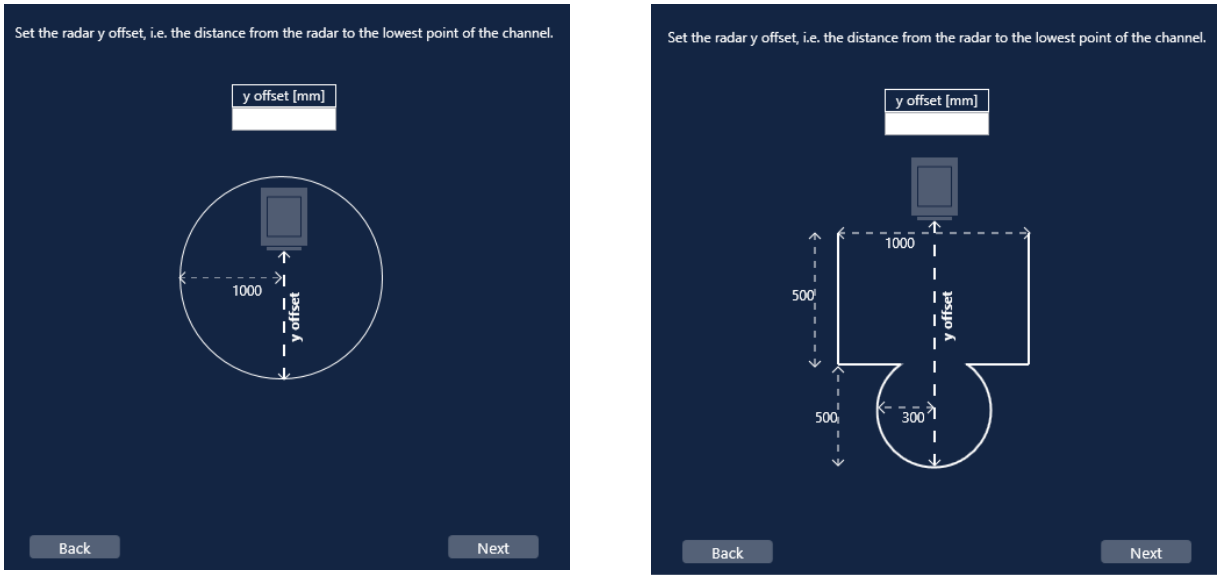
Picture 22. Predefined Shapes

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 (23. – 28.) show the definition of 2 different channel shapes.



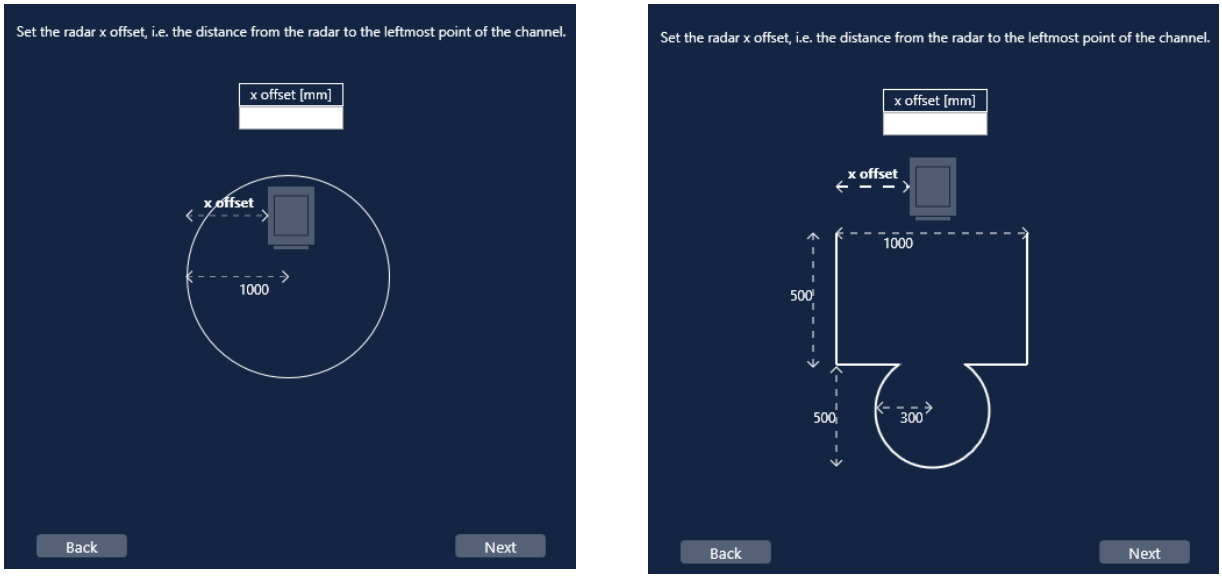
Picture 23. Defining the Channel Geometry of a Predefined Shape

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.



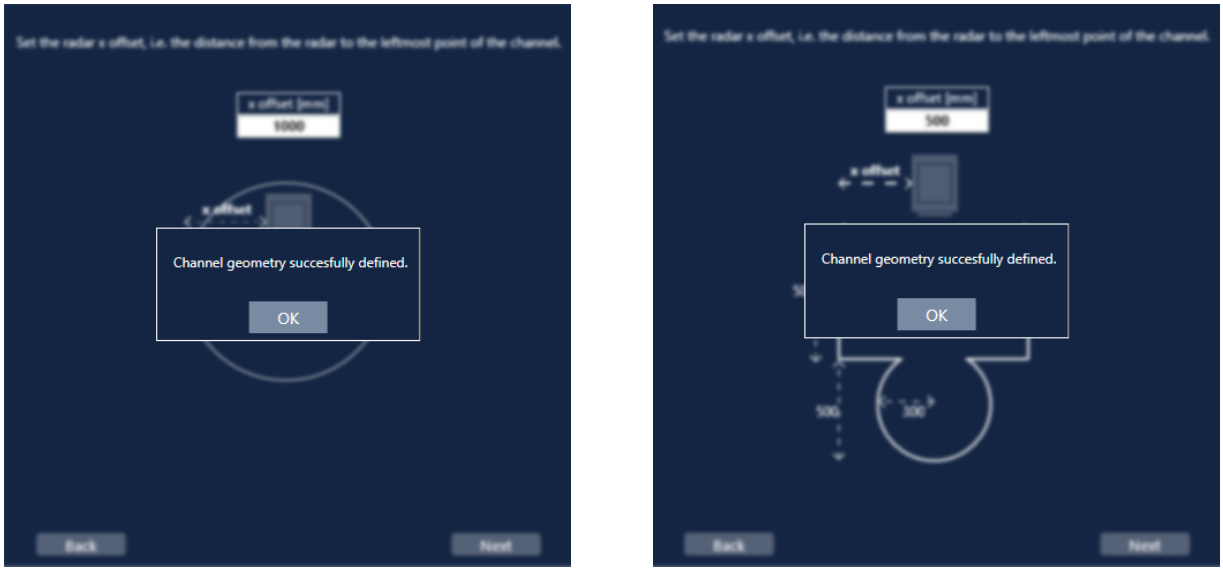
Picture 24. Defining the y Offset of the Radar

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



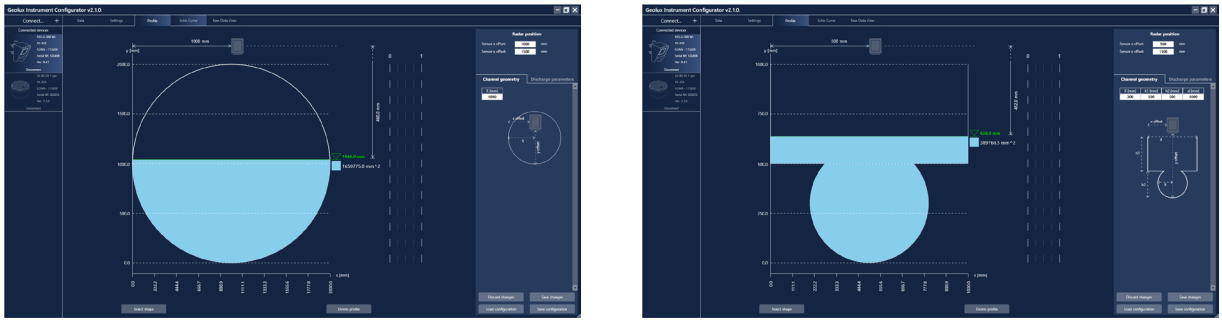
Picture 24. Defining the x Offset of the Radar

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



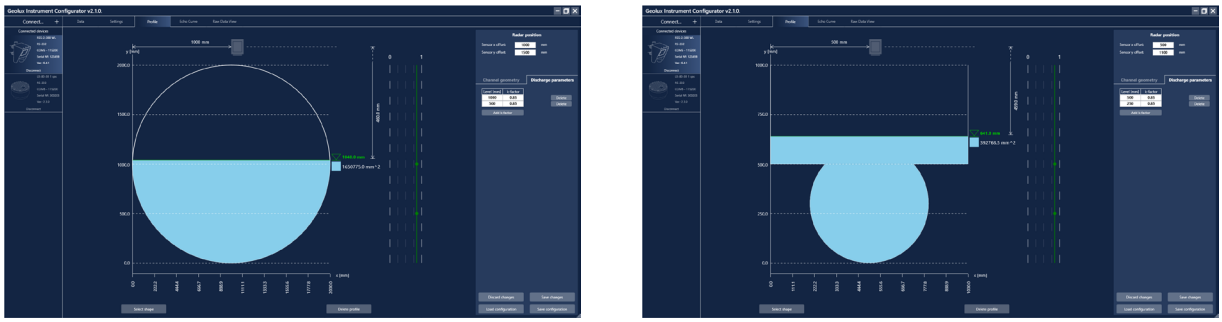
Picture 26. Channel Geometry Defined

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

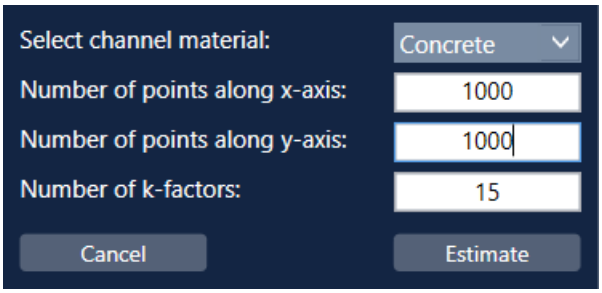
The last step is to define the discharge parameters as described in chapter 8.1.1., Picture 20 or in chapter 8.1.3. After setting the discharge parameters, the values will appear in green on the graph next to the channel geometry picture as seen in Picture 28.



Picture 28. Defining the Discharge Parameters

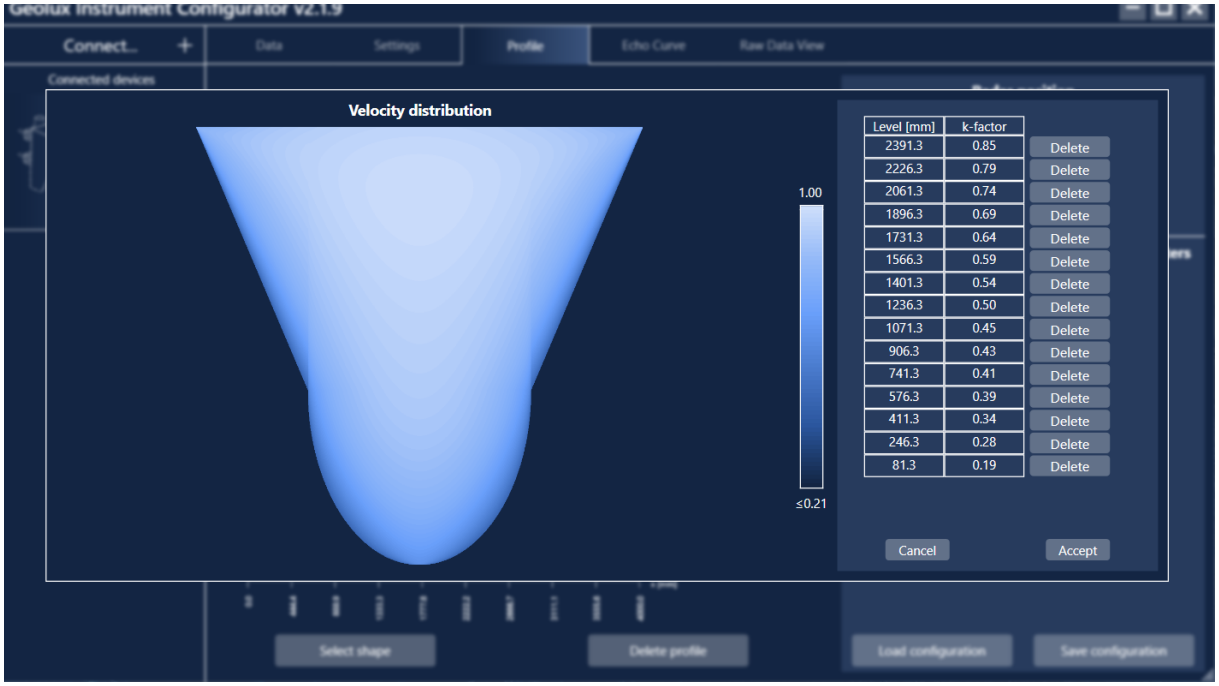
9.1.3. Discharge Parameters Estimation

After clicking the *Estimate k-factors* button, a new window appears (Picture 29.) in which the user can choose from 3 different channel materials - concrete, gravel and grass. The user can also define the mesh used for estimating the velocity distribution i.e. the number of points along the x and y axes, which can be between 100 and 1000 for each axis, as well as the number of k-factor values which will be calculated at depths distributed evenly along the channel profile.



Picture 29. Discharge Parameters Estimation - Input Parameters Window

After clicking the *Estimate* button, the velocity distribution in the channel and the k-factor values at different depths in the channel are calculated. The velocity distribution is represented by a heat map on the left side of the window which appears, while the k-factor values at corresponding levels can be seen on the right side of the window as seen in Picture 30.

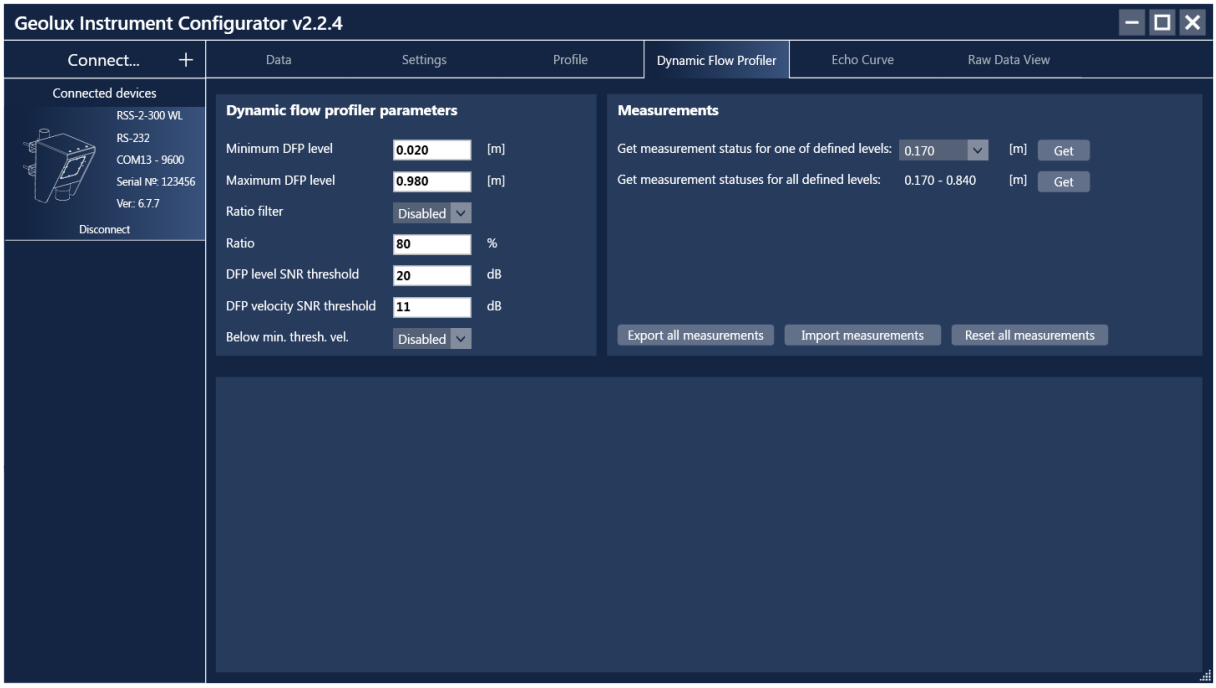


Picture 30. Velocity Distribution and Calculated k-factor Values

After the calculation is performed, the user can choose to delete certain k-factor values before clicking the *Accept* button which returns the user to the *Profile* tab where the discharge parameters can be saved to the device or to an .xml file as described in previous chapters.

9.2. Dynamic Flow Profiler

After defining the channel geometry and the discharge parameters, and if the *Dynamic flow profiler* setting in the *Settings* tab is enabled, the user can navigate to the *Dynamic Flow Profiler* tab, seen in Picture 31, to setup the dynamic flow profiler (DFP) parameters.



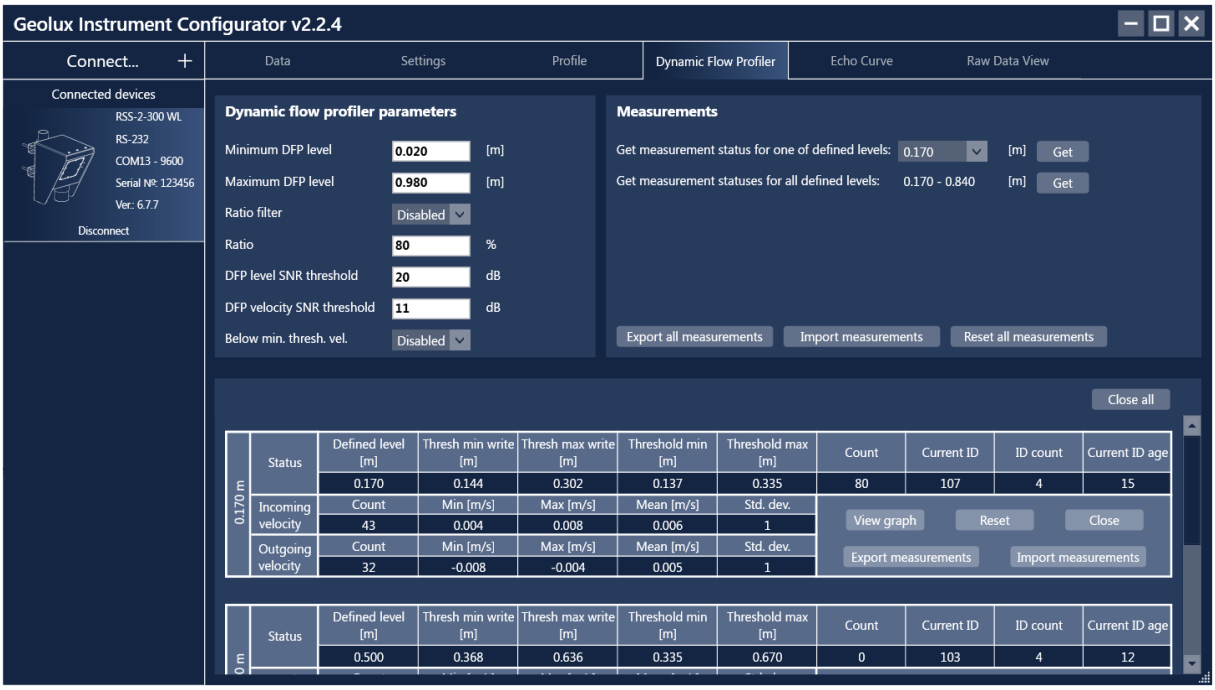
Picture 31. Geolux Instrument Configurator - Dynamic Flow Profiler View

On the left side, in the *Dynamic flow profiler parameters* section, the user can define the dynamic flow profiler parameters such as the DFP range defined by the minimum and maximum level values, the ratio filter settings, and the DFP level and velocity SNR thresholds. A description of each DFP parameter can be viewed by hovering the mouse over the parameter.

9.2.1. Getting the DFP Measurements Status

On the right side, in the *Measurements* section, the user can request the status of saved DFP measurements for each level in the DFP range separately, or for all the levels at once. The levels shown here are the same levels defined in the *Profile* tab in the *Discharge parameters* section. Only the levels which are greater than or equal to the *Minimum level* and less than or equal to the *Maximum level* will be shown. If the discharge parameters are not defined, the DFP functionality cannot be used.

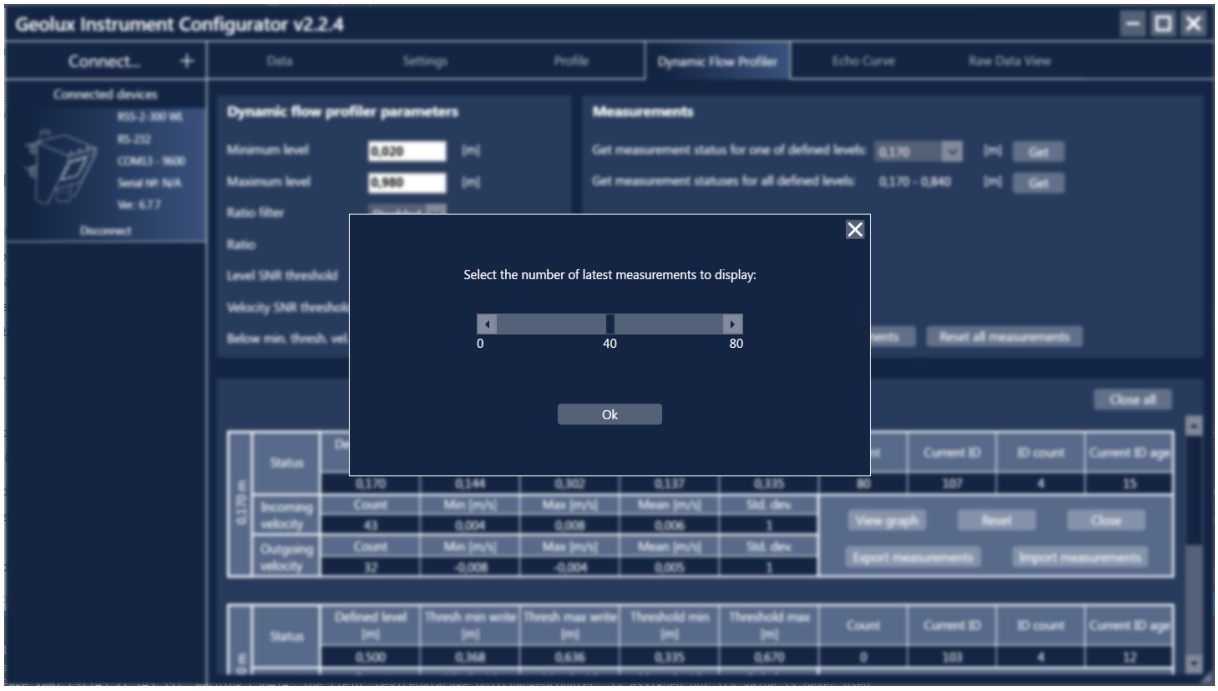
By selecting a level and clicking the *Get* button, or clicking the *Get* button for all levels, the bottom part of the *Dynamic Flow Profiler* tab will be filled with tables containing the measurement status, as seen in Picture 32. A description of the values in the table can be viewed by hovering the mouse above the header of a specific value in the table.



Picture 32. Measurement Status Table

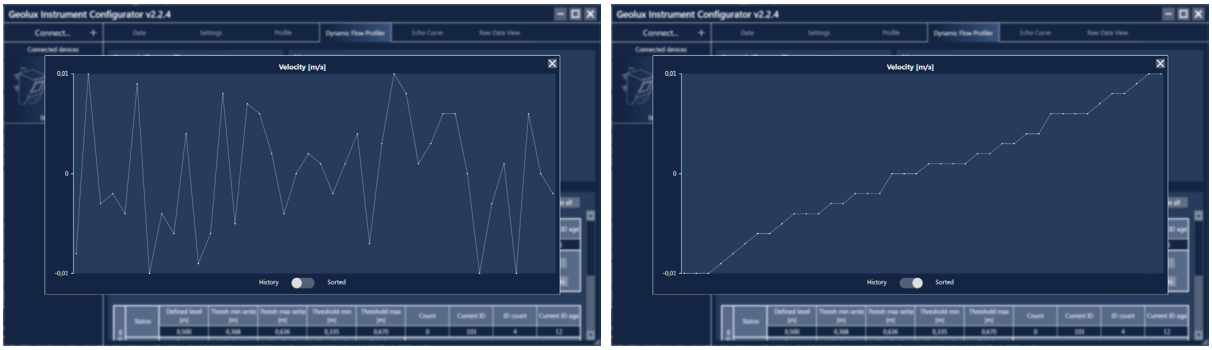
9.2.2. Displaying the Saved DFP Measurements

Once the measurement status table is shown, the user can view a graph of the saved measurements by clicking the *View graph* button in the table and selecting the number of latest measurements to display.



Picture 33. Selecting the Number of Measurements to Display

After selecting the number of latest measurements to display and clicking the *Ok* button, the *History* view of the graph will be shown. The user can toggle between the *History* or *Sorted* views of the graph, as shown in Picture 34.

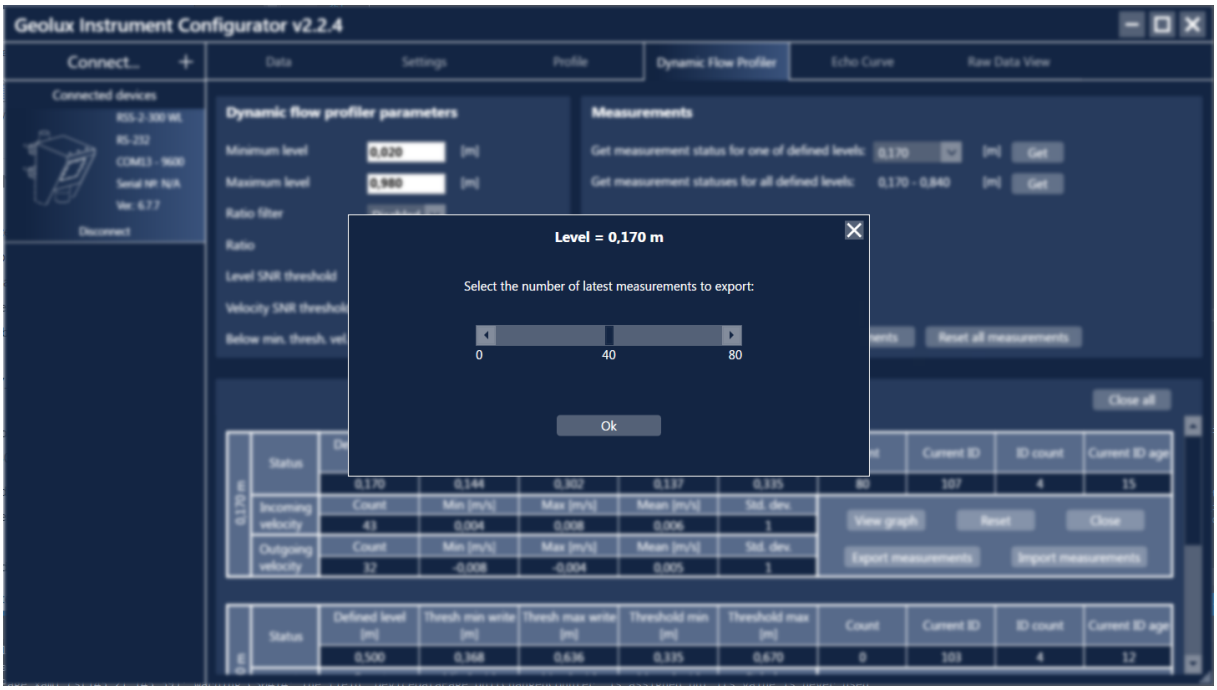


Picture 34. The History and Sorted View of the Latest Measurements Graph

The *History* view of the graph represents the latest measurements in the order in which they were saved while the *Storted* view shows the measurements sorted in ascending order so the user can view the distribution of the measurements more easily.

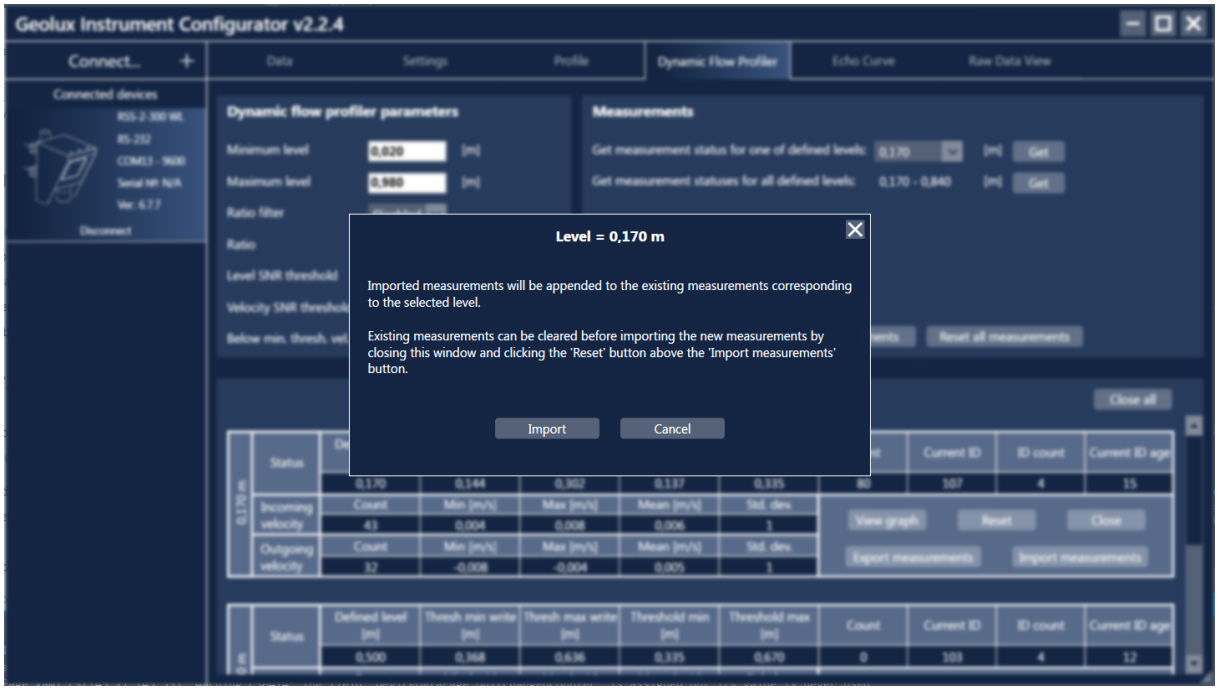
9.2.3. Importing/Exporting Measurements for a Specific Level

By clicking the *Export mesurements* button in the measurements status table, the user can export the saved DFP measurements corresponding to that level to an .xml file by selecting the number of latest measurements to export and clicking *Ok* in the window which appears, Picture 35.



Picture 35. Exporting Measurements for a Specific Level

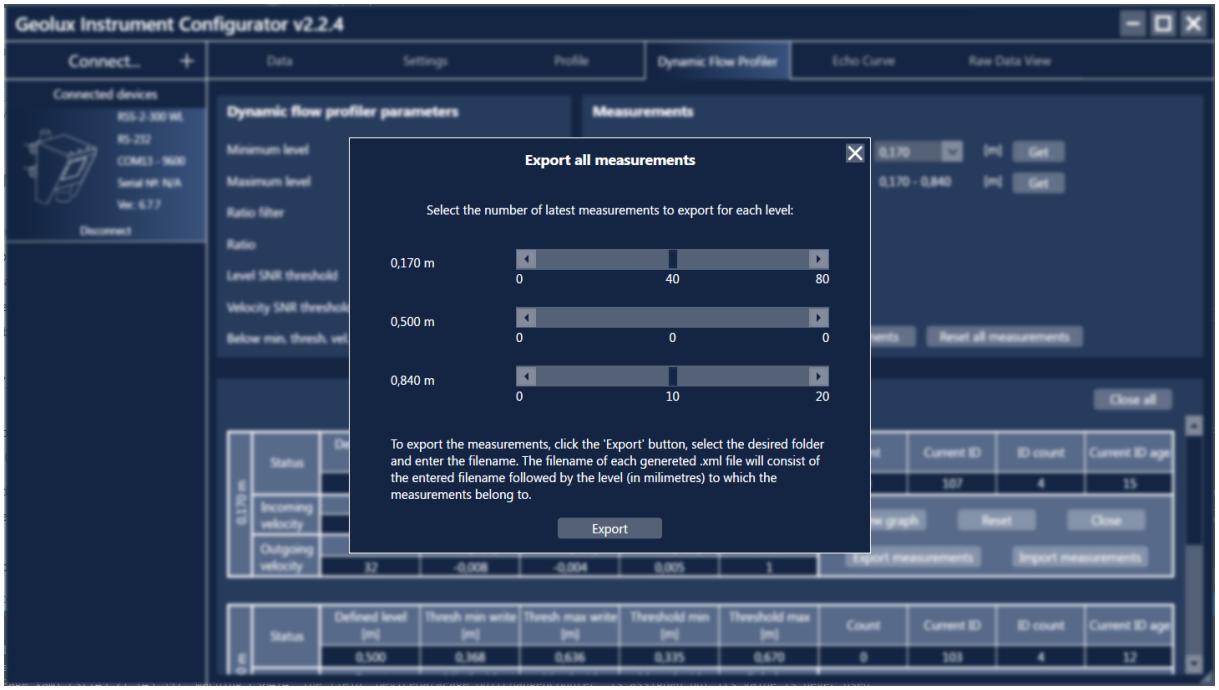
The exported measurements can later be imported by clicking the *Import measurements* button and selecting the appropriate .xml file. Imported measurement will be appended to the existing measurements corresponding to the level defined in the .xml file. Existing measurements can be cleared before importing the new measurements by clicking the *Reset* button in the measurement status table. Be careful when resetting the measurements, it would be wise to export the existing measurements before resetting.



Picture 36. Importing Measurements for a Specific Level

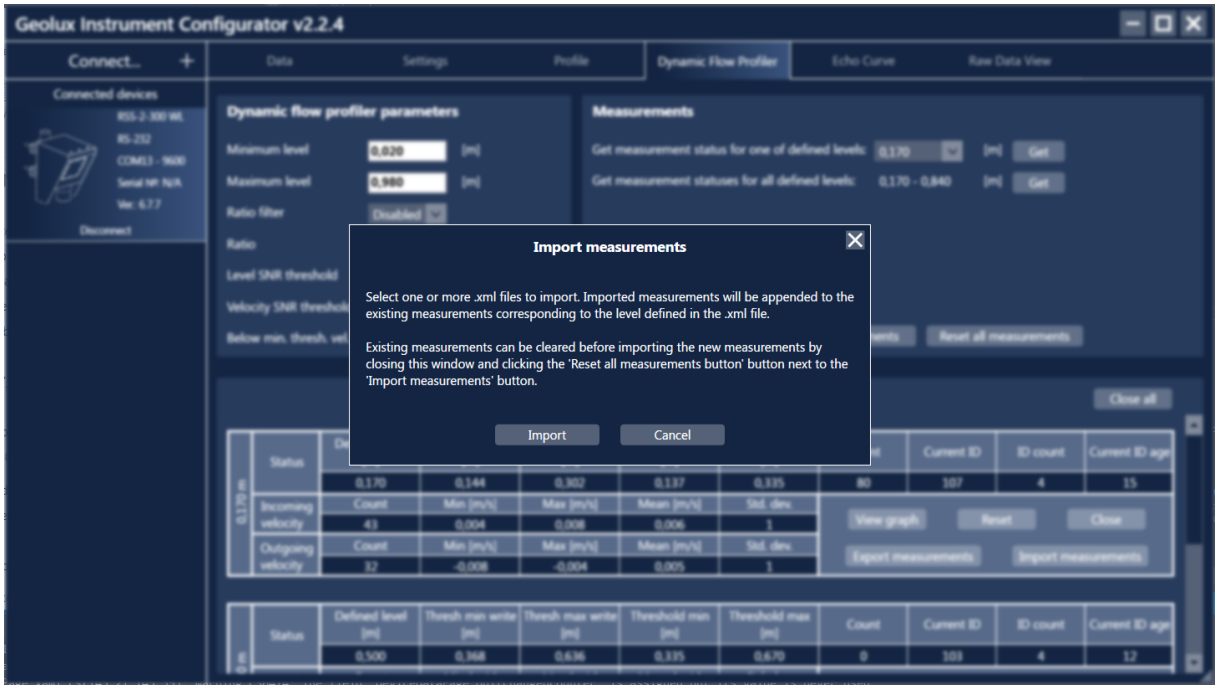
9.2.4. Importing/Exporting Measurements for All Defined Levels

The user can also export the saved measurements for all of the defined levels at once by clicking the *Export all measurements* button in the *Measurements* section of the *Dynamic Flow Profiler* tab. The measurements for each level will be exported to a separate .xml file. In the window which appears after clicking the button (Picture 37), the user can select the number of latest measurements to export for each level individually. After selecting the number of measurements for each level, click the *Export* button, select the desired folder and enter the filename. The filename of each generated .xml file will consist of the entered filename followed by the level (in millimetres) to which the saved measurements belong to.



Picture 37. Exporting Measurements for All Defined Levels

Clicking the *Import measurements* button in the *Measurements* section of the *Dynamic Flow Profiler* tab allows the user to import measurements by selecting one or more .xml files. As in the case of importing measurements for a single level, the imported measurements will be appended to the existing measurements corresponding to the level defined in the .xml file(s). The existing measurements can be cleared before importing the new measurements by clicking the *Reset all measurements* button in the *Measurements* section of the *Dynamic Flow Profiler* tab. Be careful when resetting the measurements, it would be wise to export the existing measurements before resetting.



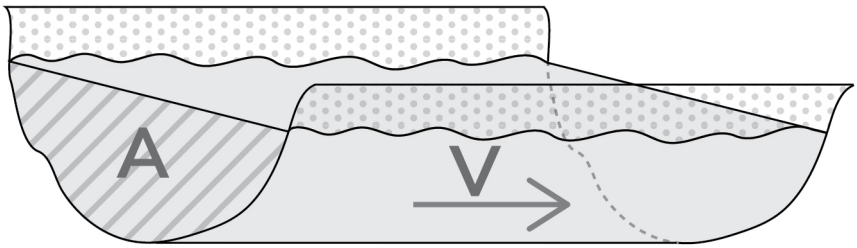
Picture 38. Importing Measurements for Multiple Levels

10 Calculating Discharge from Surface Velocity and Liquid Level

Geolux RSS-2-300WL 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 31.



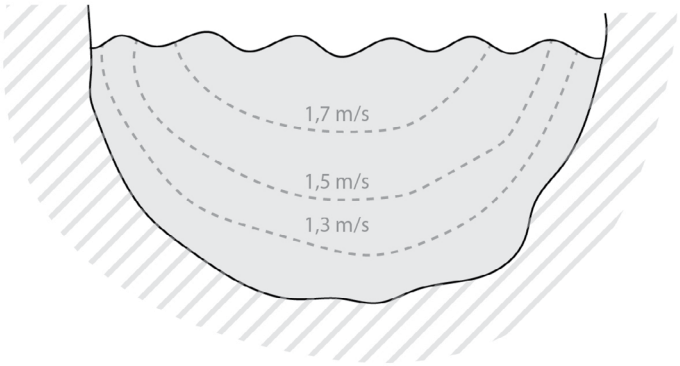
Picture 31. Simple Channel Diagram

The discharge can be calculated according to the formula:

Q=V*A

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

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 32.



Picture 32. 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:

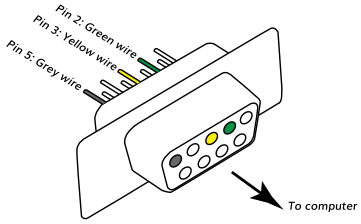
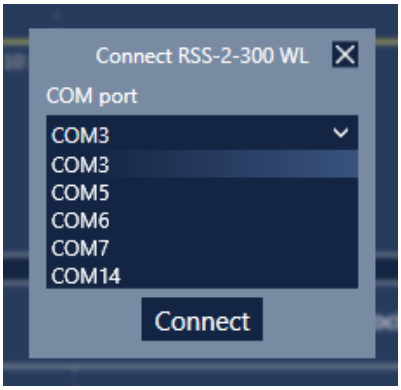
Q=0.85*V*A

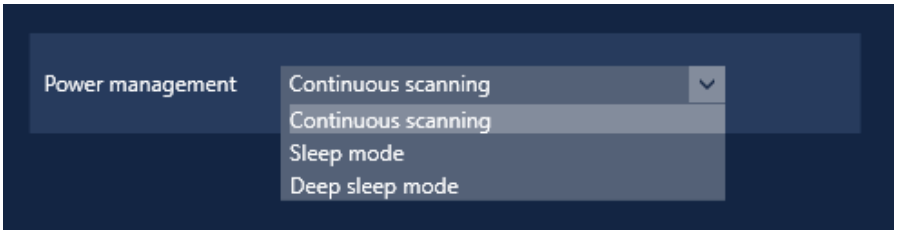
More details about water flow measurements can be found in the following technical note:

https://geolux.ams3.digitaloceanspaces.com/documents/technote3_surface_flow.pdf

11 Troubleshooting

Geolux RSS-2-300WL 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.	**1. Make sure that the cable is properly connected to the instrument** 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. **2. Check power supply** 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. **3. Check RS-232 connector** 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:  **4. Make sure that you are using the correct COM port** 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. 

	5. Check that the device is not operating in low power 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.  **6. Make sure that the COM port is not already open** 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. **7. Try restarting the application and/or the computer** Close and reopen the configurator application and try to establish the connection again. Restart your computer and try to establish the connection to the instrument again.
The instrument does not respond over Modbus (RS-485) interface.	**1. Make sure that the cable is properly connected to the instrument** 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. **2. Check power supply** 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. **3. Check RS-485 connector** 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. Make sure that the D+ and D- lines are not swapped. 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.

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 *Device 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.

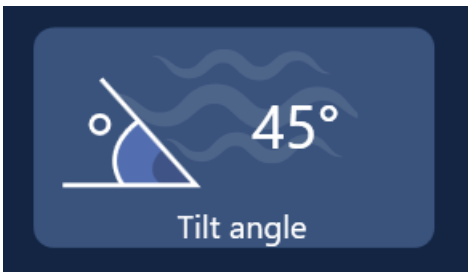
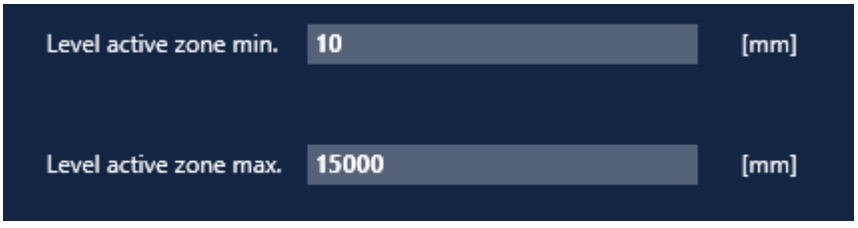
6. Check that you are using the correct Modbus connection parameters (baud rate, parity, stop bits)

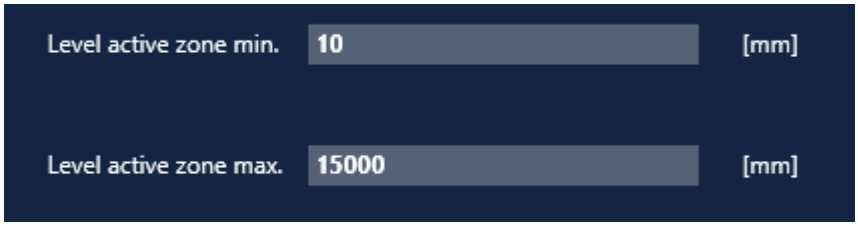
The default Modbus connection parameters are 9600 bps, even parity, 1 stop bit. These parameters can be changed by connecting the instrument to the PC application (over RS-232 connection).

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.

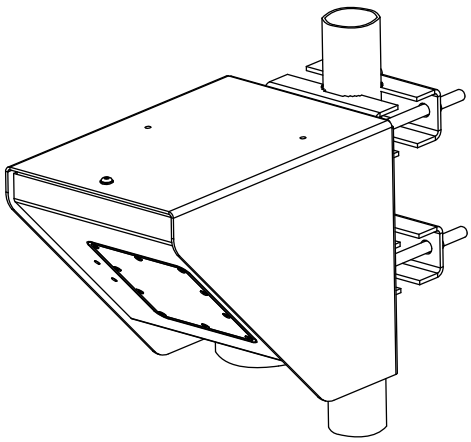


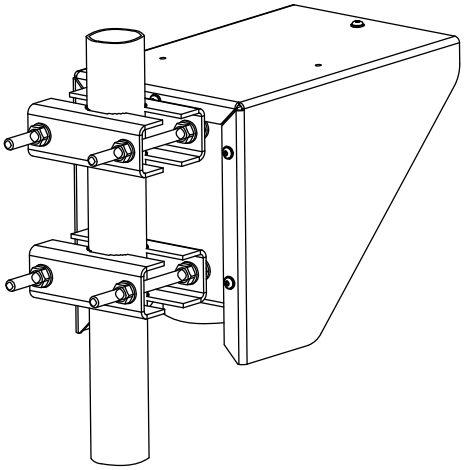
The instrument does not respond over SDI-12 interface.	**1. Make sure that the cable is connected properly to the instrument** Check that the cable M12 circular connector is firmly connected and screwed to the instrument. It is not sufficient to simply attach the cable connector to the instrument connector, the cable connector must be screwed into the instrument connector. **2. Check power supply** 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. **3. Check SDI-12 connection** Check and verify that the red 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.
The 4-20 mA output is not correct.	**1. Make sure that the cable is properly connected to the instrument** 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. **2. Check power supply** 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. **3. Make sure that the wires from the cable are properly connected** 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. **4. Check the instrument configuration parameters related to 4-20 mA output** 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. 

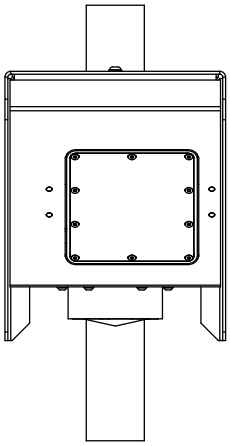
The instrument is operating, but: -it does not report surface velocity measurement, -it reports incorrect measurement -it does not report distance/level measurement, -it reports 0 (zero) distance, -it reports incorrect measurement	**1. Check that the instrument is positioned properly** Make sure that 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. 

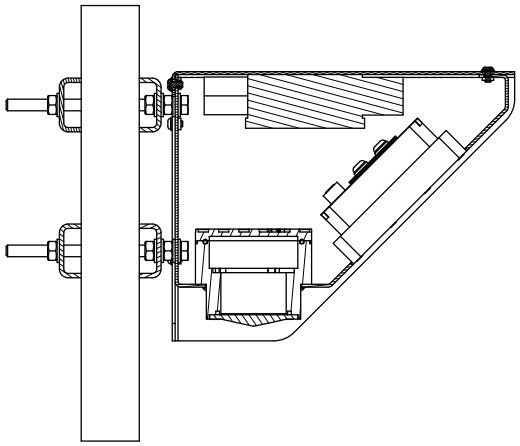
	3. Check that the distance between the instrument and the water surface is within the instrument's operating range. Use a tape measure or a similar tool to measure the distance between the instrument's antenna and the water surface. If the distance to the water surface is greater than the instrument's 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 zone, 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. 

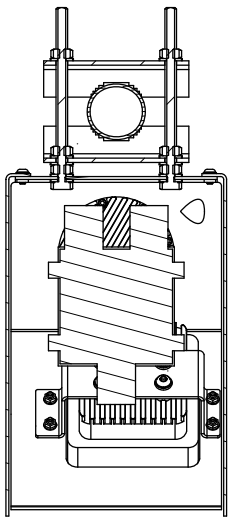
12 Appendix A – Mechanical Assembly













2023.