



GLX-RSS-2-300 WL

Non-Contact Flow Meter User Manual

Starting Point

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

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

Although we are certain that you are more than capable of connecting the Flow Meter to your system, we have created this User Manual to assist you in setting up and using Geolux flow meter device.

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

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1. Introduction

Geolux RSS-2-300 WL flow meter uses radar technology to provide precise contactless measurement of surface flow velocity and precise distance (level) measurement from the sensor to the water surface. All 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. Radar level measurement is achieved by transmitting modulated radar wave in 77 to 81 GHz frequency range (W-band) and observing returns. Due to the modulation and detection process in the sensor very precise measurements can be achieved and sensor is not dependent on the 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 0,01 m/s and distance can be measured in range from 0,2 m to 15 m with resolution of 0,1mm and accuracy of ± 3 mm. Integrated tilt sensor measures inclination angle of the sensors and the surface velocity measurement is automatically cosine-corrected according to the measured mounting tilt angle.

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

2. Electrical Characteristics

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

Table 1. Electrical characteristics

Parameter	MIN	TYP	MAX	Unit
Communication interface:				
RS-232 interface speed	1200		115200	bps
RS-485 interface speed	1200		115200	bps
Radar Surface Velocity Sensor				
Frequency		24.125		GHz
Radiated power (EIRP)	25	27	29	dBm
Sensitivity	-108	-110	-112	dBm
Beam-width (3dB) – Azimuth		12		°
Beam-width (3dB) – Elevation		24		°
Measurement range	0,02		15,0	m/s
Resolution	0,01			m/s
Accuracy		1		%
Maximal distance to water surface			50	m
Radar Level Sensor				
Frequency	77		81	GHz
Beam-width (3dB) – Azimuth		12		°
Beam-width (3dB) – Elevation		12		°
Resolution	1			mm
Accuracy		3		mm
Minimal distance	0,2			m
Maximal distance			15	m
Power supply voltage	9,0	12,0	27,0	V
Power		1200	1550	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.
Sample rate		10		sps
Ingress Protection Rating	IP68			
Mechanical		150x200x250		mm

3. Cable Pin-Out

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

Optional connectors are possible to be mounted on the cable end per user request. Connector specification and connection diagram in this case must be specified on order of the sensor.

Table 2. Cable pin-out

Pin No.	Wire Color	Pin Name	Pin Description
1	White	GND	This pin should be connected to the ground (negative) pole of the power supply
2	Brown	+Vin	The power supply for the Radar Speed Sensor is provided on this pin. The Radar Speed Sensor power supply voltage must be in the range 9 VDC to 22 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 (<i>optional</i>)
7	Blue	CAN – L	CAN2.0B low signal (<i>optional</i>)
8	Red	Interface V+	4 – 20 mA and Alarm V+
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	Alarm1 SW	Alarm 1 - open collector switch signal max. 60mA
12	Purple	4 – 20 mA Sink	Sink for 4 – 20 mA analog interface. Connect sensing device as pull-up to sink the current (<i>optional</i>)

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 device used for serial RS-232 communication.

In case 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 serial interface additional connection of signal GND (grey wire) is required on pin 5 of the DB-9 connector.

Optionally Geolux can supply cable with DB-9 connector connected to the cable but this must be specified as option on order of the sensors.

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

3.2. Serial RS-485 interface

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

Most common communication protocol used with RS-485 interface is Modbus-RTU but other protocols are also available. Details of communication protocols are described later in this manual.

3.3. CAN communication interface (optional)

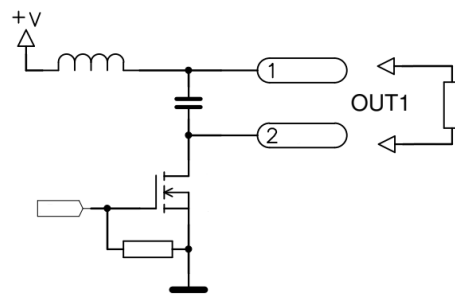
CAN communication interface is optional communication interface that can be used for special applications. This interface is higher speed interface (up to 1Mbps) than other serial communication interfaces so enables additional data transfer not possible with RS-232 and RS-485 interfaces.

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

3.4. Alarm output

Alarm output is designed to signal events and various conditions can be configured in the setup of the WL sensor. Electrically alarm output is implemented as open-collector transistor with high-impedance output when event is not active and signal pulled-down when event is active.

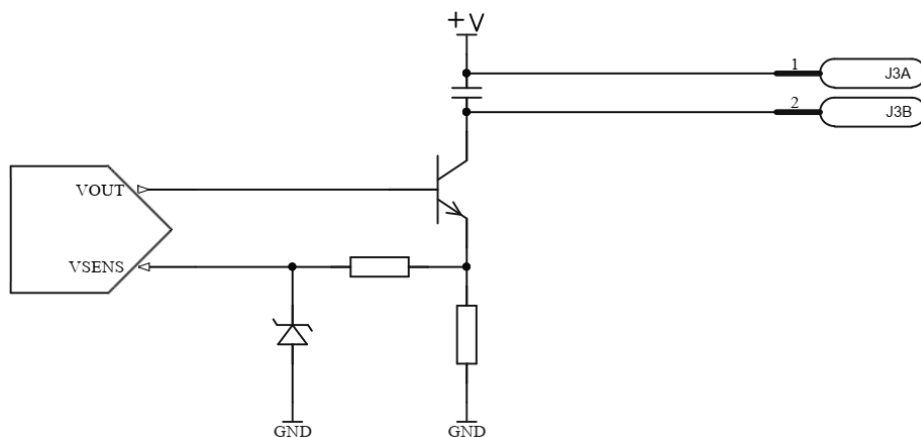
Interface V+ signal is provided to simplify connection of external relay or signaling bulb. V+ provides +5V stabilized power that can be used if external power is not available for the alarm output.



3.5. 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 connection of the sensor to PLCs, loggers, or data concentrators.

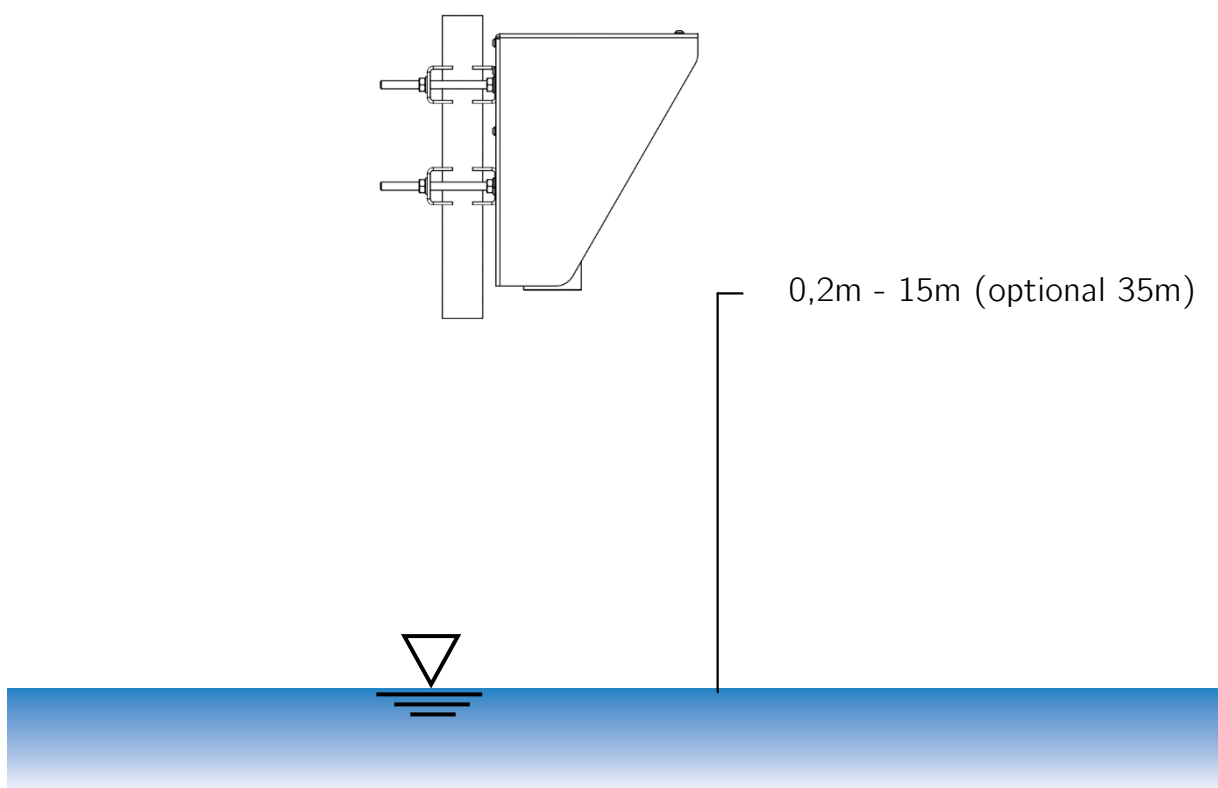
Signal range and function for 4 – 20 mA analog output can be configured in setup application so the sensor will be able to signal best suitable value range with available current range. Current step in the sensor is 0,3 μ A limiting resolution possible for the value signaling and care has to be taken in the setup of minimal value to be represented by 4 mA and maximal value to be represented by 20 mA so the resolution is sufficient for the system requirements.



4. Installing Flow Meter

The flow meter must be installed above the water surface, pointing toward the water surface at a vertical angle. Minimum height above the water surface is 0,2m and it is recommended to mount sensor 0,5 meter above the water or higher, with maximum height up to 15 meters (on request higher distances with slightly reduced resolution and accuracy are available). Sensor should be mounted on the vertical pole with inclination tolerance of $\pm 5^\circ$ to vertical plane reference.

Picture 2 shows how the radar should be positioned relative to the water surface.



Picture 2. Installing flow meter

When mounting WL sensor care must be taken that direct not obstructed line to the water surface is available both for surface velocity sensor and level sensor. Any close object in vicinity of the sensor can reduce accuracy and introduce offsets in measurements. The best practice is to have zone of 1m around the sensors empty on both sensors.

Vibrations of the mounting structure can also affect measurements and should be reduced by any applicable means.

4.1. Instrument mounting and location selection

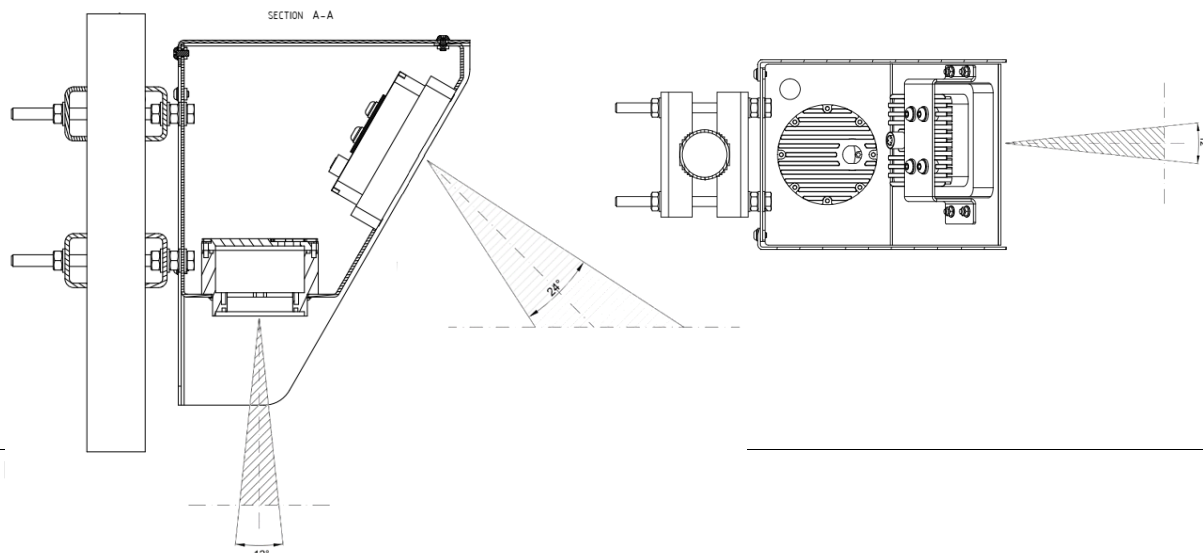
To achieve the specified accuracy, it is important to properly select measurement site and to install sensor with proper horizontal and vertical tilt angle. The tilt angle to horizontal plane for surface velocity sensor should be between 30° and 60°, and if instrument is mounted with reasonable tolerances to the pole this should be maintained.

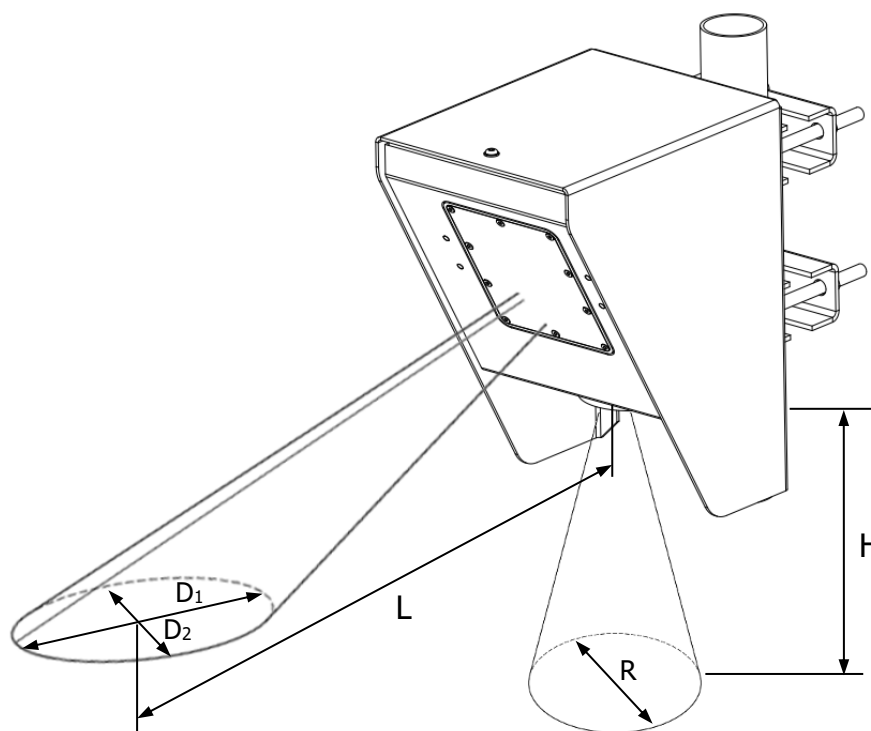
The instrument should be oriented in parallel with the water flow direction. For optimal operation, and best results. Any deviation from parallel water flow direction will introduce offset of the real measurement value, more precise value will be lower than actual surface velocity of the water. It is 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 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 direct below the sensor should be clean of vegetation, rocks, sand deposition or other obstacles that could affect measurement. Distance measuring sensor in the instrument is designed to detect and eliminate obstacles from the distance measurement signal spectrum but algorithm has limits and ability to discard obstacles are even more limited in presence of vibration on the instrument mounting. The best results will be achievable if measurement location is selected in the recommended way.

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





Height [H]	L [m]	D ₁ [m]	D ₂ [m]	R [m]
0.3 m	0.3	0.3	0.2	0.06
0.5 m	0.5	0.5	0.3	0.11
1 m	1.0	0.9	0.3	0.21
2 m	2.0	1.8	0.6	0.42
3 m	3.0	2.7	0.9	0.63
4 m	4.0	3.6	1.2	0.84
5 m	5.0	4.5	1.5	1.05
6 m	6.0	5.3	1.8	1.26
7 m	7.0	6.2	2.1	1.47
8 m	8.0	7.1	2.4	1.68
9 m	9.0	8.0	2.7	1.89
10 m	10.0	8.9	3.0	2.10
11 m	11.0	9.8	3.3	2.31
12 m	12.0	10.7	3.6	2.52
13 m	13.0	11.6	3.9	2.73
14 m	14.0	12.5	4.2	2.94
15 m	15.0	13.4	4.5	3.15

Lengths and diameters are calculated based on 3 dB signal drop (half signal power) due to the antenna pattern. For practical application 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 be also 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 sensors have internally implemented special signal processing algorithm to filter such reflections.

However, it is recommended to keep zone around the target shape of the radars as clean as possible to get best measurements accuracy.

4.2. Rain and wind

Geolux RSS-2-300WL instrument have 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 so 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 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. This can affect surface measurement accuracy.

4.3. Measurement quality indicator

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

For example, when radar is mounted on the railway bridge, one of common applications, measurements will be very good quality most of the time except when train is passing the bridge due to the extensive vibrations. In this case radar will still report measurements but values could be quite wrong, but also measurement quality indicator value will go up to the higher value. It is up to every user to interpret 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.

4.4. Interference and multiple radars

Surface velocity radar operates in K band, in frequency range around 24.125 GHz. Frequency stability and phase noise of the internal oscillator is very good and always trimmed in factory to 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 will be required to keep difference between central frequencies of two radars in the same range to get interference.

Distance measurement radar is operating in W-band from 77 GHz to 81 GHz with linear frequency modulation, modulating signal continuously in the mentioned frequency range. To get interference between two or more sensors it will be required to keep central frequencies very precise just like in surface velocity radar and additionally timing synchronization of radar 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 interference from two or more surface velocity and level radars on the same location it is very unlikely that other radiation sources in K band or W band will affect radar measurements also. It is possible that some wideband radiation sources can introduce small and impulse interference for the short period of time, but this should not, or it is very unlikely to affect measurements reported by radar sensor.

4.5. Fogging and evaporation

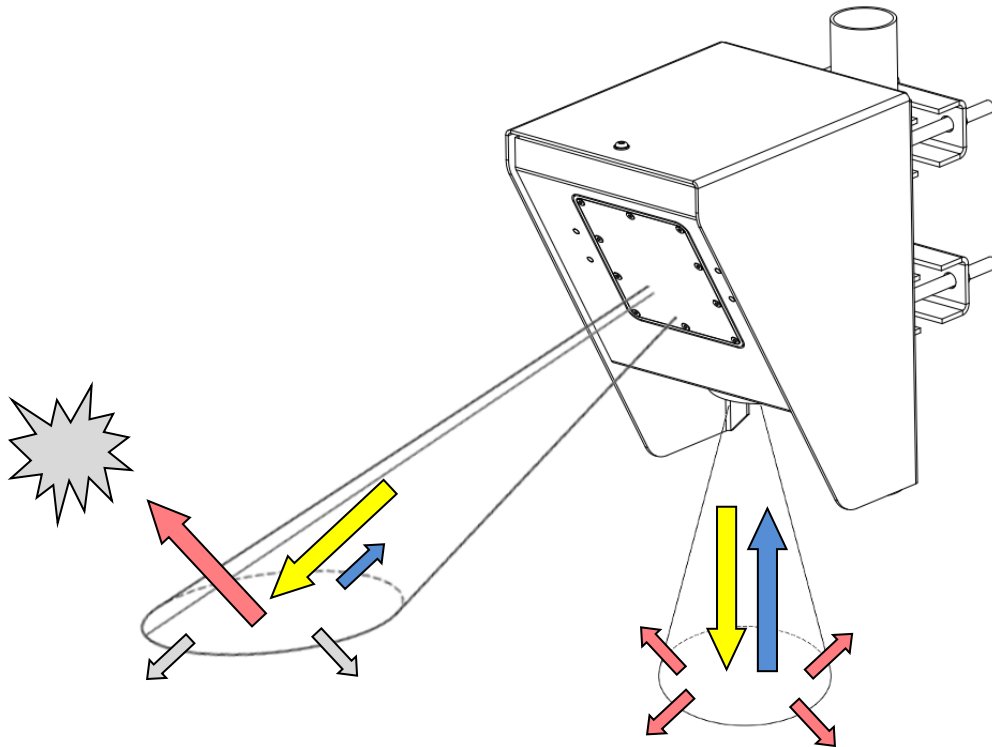
Generally, radar sensors are not affected by fog or evaporation of water unless very heavy evaporation is present and water density in the air is very high. Very high amount of evaporation can introduce reflections and can affect measurement on distance measurement sensor and even more on surface velocity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

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

4.6. Reflections

Water is very reflective medium for the radar waves and most of the power transmitted from radar transmitter will be reflected from the water surface. Reflections of the radar transmitted power beam follow the same physical laws as in optics and every time radar beam hits the 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 power is absorbed by the water. Depending on the surface roughness and incident angle ratio between power reflected in the direction away from the radar and direction back towards the radar can significantly vary. As incident angle for radars is fixed, only the roughness is determining the ratio in our case.



In the case of level meter where incident angle of transmitted radar beam (yellow arrow) to the water is around 90° most of the power is reflected back to the sensor (blue arrow) and only small portion of the transmitter power will be dispersed in all directions (red arrows). Ratio between power reflected back to the sensor and power dispersed in all directions is dependent on the surface roughness but in general it is very small amount of the energy that is dispersed, and it is very unlikely that dispersed energy will cause additional multipath problems due to the more reflections from surrounding objects.

In the case of surface velocity situation is little more complex as angle between transmitted radar beam (yellow arrow) and water is around 45° and in general most of the power is reflected in the opposite direction from the radar (red arrow) again with angle around 45° . Reflection in the direction of the radar sensor (blue arrow) is always smaller and can be comparable with dispersed power in all direction (gray arrows). Ratio between reflections is determined by water surface roughness and rule of thumb can be applied where more rough water surface will lead to stronger reflection inbound the radar thus easier detection and greater SNR (signal to noise) ratio on the radar which enables more accurate measurement. Geolux surface velocity radar is designed with special techniques to achieve accurate measurements even in the very small SNR

environments so the required surface roughness of 1mm is usually enough for the precise measurements.

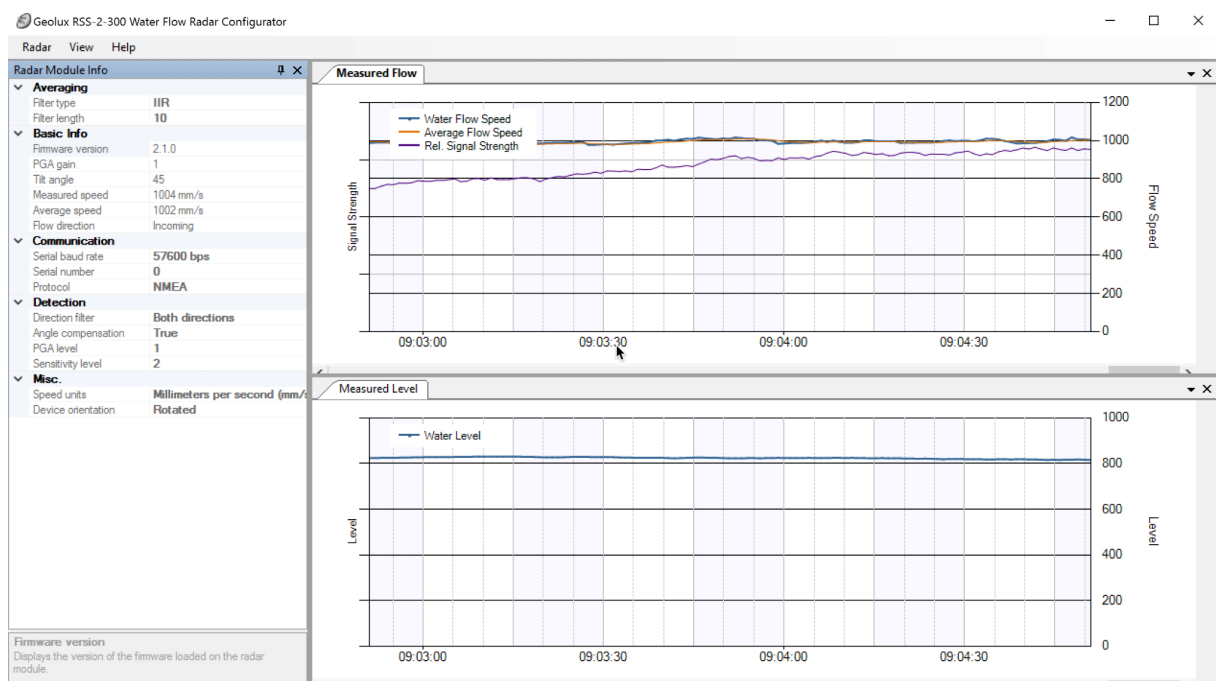
When selecting location for surface velocity sensor additional care must be taken to avoid reflected power away from the radar (red arrow) to hit moving objects (gray cloud) on the side of water channel as this can cause additional reflection to inbound the radar and can significantly affect measurement accuracy. Installations where pedestrians, cars or other objects are moving in front of the sensor closer than 50 m should be avoided as it is proven in practice that it can cause problems.

5. Radar Configurator Utility

Geolux provides a user-friendly PC application for configuring the flow meter operating parameters. Additionally, the Configurator Utility displays current flow measurements.

When started, the Configurator Utility displays its main window. Initially, no flow data is displayed, as the connection to the flow meter device is not established.

To connect the Configurator utility with the flow meter, connect your PC to the speed radar using an RS-232 serial cable connection. Then, select the *Radar* → *Connect* menu option in the Configurator Utility, and choose the appropriate COM port number. The Configurator will try to establish a data link between your PC and the flow meter device. After the data link is established, active device parameters will be displayed, and the flow velocity measurements will be displayed:



Picture 3. Configurator main window with device connected

The utility window is divided into two panes, that can be manually re-arranged. The first panel (at the left part of the screen) is the Radar Module Info pane that displays the radar flow meter information and operating parameters. Some of these parameters can be changed by editing the values directly inside the Radar Module Info pane. The following information is displayed:

<i>Filter type</i>	select filtering algorithm to use for flow measurement averaging; available are IIR and (moving) average
<i>Filter length</i>	if moving average filter is used, select the averaging window length
<i>Firmware version</i>	the version of the firmware running in the radar sensor device
<i>PGA gain</i>	the current gain value of the analog radar signal amplifier; the gain is automatically adjusted to provide maximum possible dynamic range
<i>Tilt angle</i>	the measured tilt angle (in degrees) of the radar device
<i>Measured speed</i>	currently measured speed, in the currently active units
<i>Average speed</i>	the current value of averaged flow measurement; this value should be used as the flow meter readout
<i>Flow direction</i>	the direction of the detected water flow
<i>Serial baud rate</i>	the communication bitrate used for serial communication with the radar device
<i>Serial number</i>	the device identifier, used if multiple devices are connected together over RS-485 interface
<i>Direction filter</i>	select whether any flow direction is reported, or only incoming or outgoing flow are reported
<i>Angle compensation</i>	select whether automatic angle compensation is used or not
<i>Sensitivity level</i>	radar sensor sensitivity – maximum level provides furthest detection range, decreasing this level decreases the detection range
<i>Speed units</i>	select if the speed is reported in metric (km/h) or imperial (mph) units
<i>Device orientation</i>	select if the device is normally oriented, or if it is sidewise rotated for 90 degrees

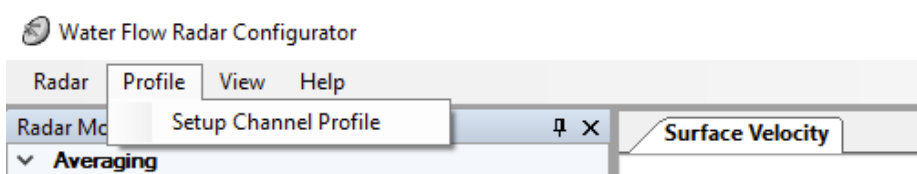
The second pane (in the right part of the window) displays the history graph showing the measured flow speed (both direct and averaged measurements) in the last 30 minutes.

For flow measurement, averaged flow speed reading should be used, to filter out fluctuations in direct measurement caused by waves on the fluid surface.

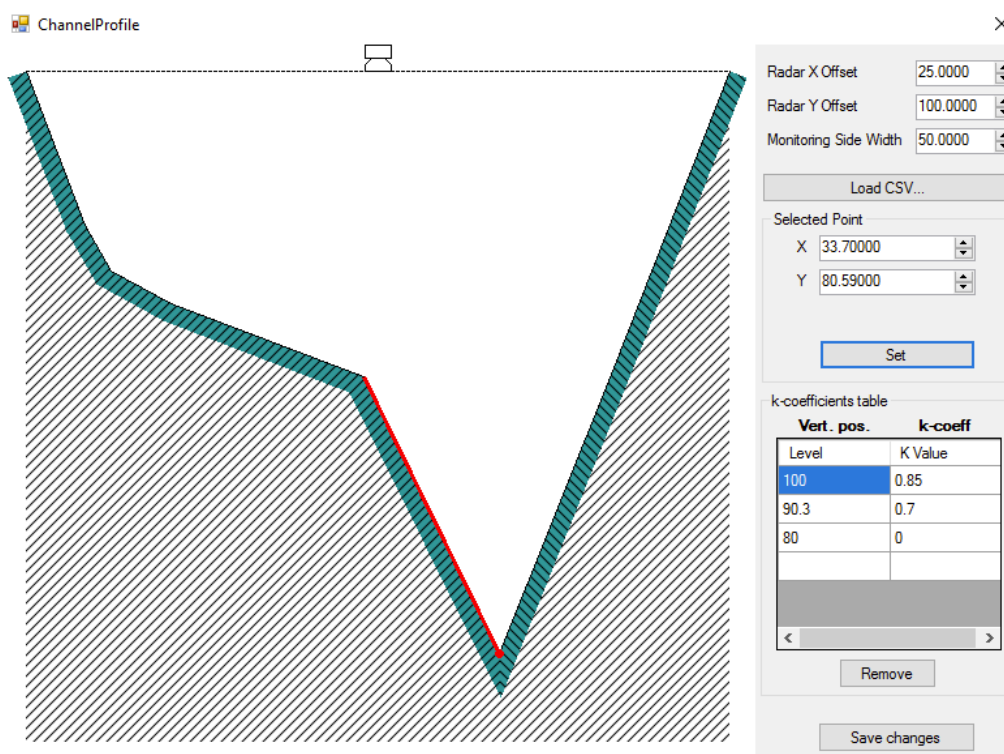
5.1. Configuring the unit for discharge calculation

RSS-2-300WL flow sensor has integrated computing module that can calculate the total discharge based on surface velocity and water level measurements. The theory of discharge calculation is described in more detail in Section 8 of this document. The current section details how to setup the unit for discharge calculation.

As described in the next section, in addition to surface velocity and water level measurement, it is required to enter the channel section profile geometry into the unit, and the correction coefficient which defines the ratio between surface and average velocity. To enter these parameters, select *Profile* → *Setup Channel Profile* menu item.

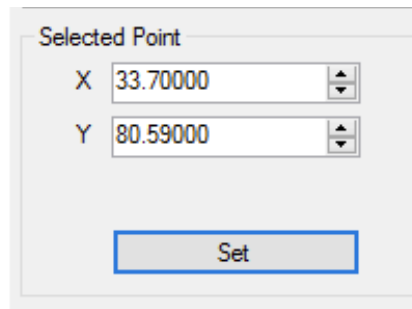


After clicking on the menu item, a new dialog window will be opened. This window allows the user to define the channel section profile, and to enter one or more velocity correction coefficients.



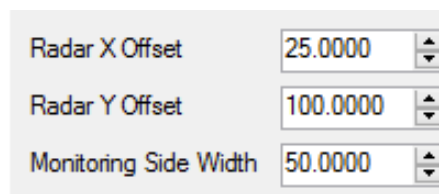
To define the channel profile, the user can click and drag on the green lines that show the shape of the profile. To precisely enter the coordinates for each profile point,

the user can click on the point along the profile, enter precise coordinates on the right side under Selected Point, and click “Set” button, to modify the point coordinates.



Easier method for defining the channel profile geometry is to import the point coordinates from CSV file, by clicking on *Load CSV...* button. The CSV file should have two columns, separated with semi-colon (;). The first value (column) in each line is X coordinate, in meters, and the second value represents the Y value of the point in the profile geometry. There can be no more than 24 points defined. The points should be ordered from left to right. The coordinate system used to define the points is in meters, lower X values start on the left, and lower Y values are lower. Any system can be used (for example, X value zero can be defined to start at the beginning of the channel, and Y values can be used as meters above the sea level).

It is also important to define the position of the radar unit, in the same coordinate system that is used to define the profile geometry:



Finally, one or more correction coefficients that define the ratio between the surface velocity and average velocity need to be defined in *k-coefficients table*:

k-coefficients table

Vert. pos.	k-coeff
Level	K Value
100	0.85
90.3	0.7
80	0

If multiple values are defined, then a water level is associated with each coefficient value. For example from the image, there are three values defined: 0.85 at 100 meters, 0.7 at 90.3 meters and 0 at 80 meters. If the radar Y offset is defined for example at 100 meters, then for water that is no more than 9.7 meters away from the radar unit,

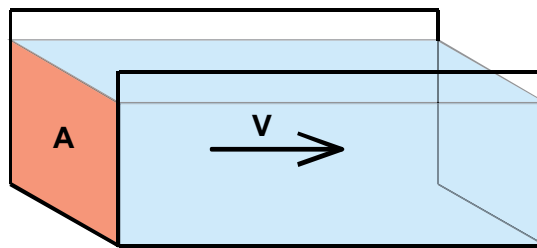
0.85 will be used; for water level that is from 9.7 to 20 meters away from the sensor, value of 0.7 will be used, and if the water is more than 20 meters away 0 will be used (dry waterbed). **The first vert. pos. in the table should always be the same or greater than the radar Y offset value!**

6. Calculating Discharge From Surface Velocity and Liquid Level

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

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

For ideal case, let us assume the rectangular channel profile, with constant flow velocity at all points, as in Picture 4.



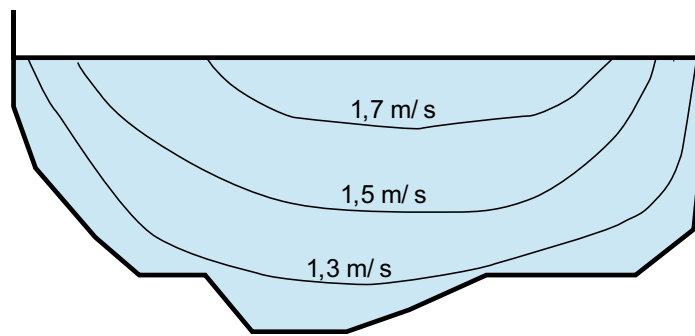
Picture 4. Simple channel diagram

The discharge can be calculated according to the formula:

$$Q = V * A$$

where Q is discharge (for example in m³/s), V is flow velocity (for example in m/s), and A is cross-section area (for example in m²).

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 5.



Picture 5. 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://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/TechNotes/technote3_surface_flow.pdf

7. Data Interface

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

7.1. Serial RS-232 interface

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

Default communication parameters are:

Bitrate:	57600 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 the Chapter 6 of the User Manual.

7.2. 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 flow meters 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 the Chapter 6 of this User manual.

Default communication parameters are:

Bitrate:	57600 bps
Data bits:	8
Stop bits:	1
Parity:	None

8. Data Protocols

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

- NMEA-like protocol on RS-232 interface that constantly outputs the detected speed and reflected signal power, and also the current measured tilt angle
- 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

Support for additional protocols is available upon customer request.

8.1. NMEA protocol (RS-232)

NMEA protocol is based on the standard protocol family widely used by the 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 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 on 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 (speed¹ is reported as speed*10).

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>`

¹ In the radar sensor setting it is possible to select km/h, mph, fps, fpm or mm/s for the speed reporting

\$RDAVG: The keyword sent on 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.

SI: The detected flow speed (speed² is reported as speed*10).

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 on the beginning of each angle report. The angle report is sent periodically, together with RDTGT 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.

Water level report

\$LVL,L*CSUM<CR><LF>

\$LVL: The keyword sent on the beginning of each level report. The level report is sent periodically.

L: The measured level value, in mm, 0 being sensor reference plane.

CSUM: The check sum of the characters in the report from \$ to * excluding these characters.

8.2. 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 a Configurator utility application. Regular users do not need to be concerned about the servicing protocol used between the Configurator utility and the flow meter device. The Configurator utility is described in the Chapter 7 of this manual.

² In the radar sensor setting it is possible to select km/h, mph, fps, fpm or mm/s for the speed reporting

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:

Change units type

```
#set _units=kmh  
#set _units=mph  
#set _units=fps  
#set _units=fpm  
#set _units=ms  
#set _units=mms
```

Sets the units type in which the target speed is reported.

Change radar sensitivity

```
#set _thld=<0-100>
```

Changes the sensitivity of the radar sensor.

Change detected targets direction

```
#set _direction=in  
#set _direction=out  
#set _direction=both
```

Changes the parameter that specifies which flow direction will be reported.

Change serial port baud rate

```
#set _baud _rate=9600  
#set _baud _rate=38400  
#set _baud _rate=57600  
#set _baud _rate=115200
```

Changes the parameter that specifies the baud rate speed used by serial communication line; the same value is used for both RS-232 and RS-485.

Change filter type

```
#set _filter _type=<1-2>
```

Changes the filter type used for flow averaging. 1=IIR filter; 2=moving average filter

Change filter length

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

Changes the window length (in samples) for moving average filter.

Change default device orientation

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

Configure whether the device is mounted normally (0), or it is rotated 90 degrees sideways (1).

Set device ID

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

Configure the device ID. The ID is used as device identifier for RS-485 protocol.

Enable automatic angle compensation

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

Enable (1) or disable (0) whether automatic compensation (cosine-correction) of the tilt angle is performed on the reported flow measurement.

Retrieve current device status

```
#get_info
```

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

```
# firmware:4.3.12
# pga_gain:2
# units:mph
# thld:64
# direction:both
# baud_rate:9600
# can_id:2
# angle_compensation:1
# filter_enable:1
# filter_type:1
# filter_len:5
# sensor_rotation:0
```

8.3. Request-response protocol (RS-485)

A different data protocol is used on RS-485 interface which allows connection of multiple units on the single RS-485 line. Before the units are connected on the single RS-485 bus, each unit must be configured with a different device identifier. The device identifier is configured by using the PC application. Please check Chapter 7 for instructions.

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

8.4. Modbus Protocol (RS-485)

When configured in Modbus operation mode, the unit responds to Modbus requests over RS-485 data line. The baud rate is 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 over Modbus.

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

In each request, the master can either ask the slave to retrieve 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	Addr	Fun	Data start Addr		Data#of regs		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 Addr	0X00	The address of the first register to read (HIGH)
	0X00	The address of the first register to read (LOW) – Sensor ID reg
Data of regs	0X00	High
	0X01	Low (read only 1 register)
CRC16	0X84	CRC Low
	0X0A	CRC High

Table 5. Slave (sensor) response format

Name	Addr	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

The table 7 defines the data returned by the unit when the master requests register read. The 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 could be changed in the field.

Table 7. Retrieving data from the sensor

Fun	Data start Addr	Data Length	Data Range	Detail
0X03	0X0000	2 byte	1~255	Read sensor id
	0X0001	2 byte	0→9600 1→38400 2→57600 3→115200	Read baud rate
	0X0002	2 byte	0→mm/s 1→m/s 2→other	Read set units type
	0X0003	2 byte	0-15000 (mm/s)	Read instantaneous speed
	0X0004	2 byte	0-15000 (mm/s)	Read averaged speed
	0X0005	2 byte	0-360	Read tilt angle
	0X0006	2 byte	0→IIR 1→Average	Read averaging type
	0X0007	2 byte	1-512	Read averaging length
	0X0008	2 byte	0→incoming 1→outgoing	Read flow direction

Fun	Data start Addr	Data Length	Data Range	Detail
0X03	0X0009	2 byte	0→both 1→incoming 2→outgoing	Read flow direction filter setting
	0000A	2 byte	0-100	Read sensitivity value
	0X000B	2 byte	0-2048	Read relative signal strength
	0X000C	2 byte	0→Normal 1→Rotated sideways	Read preconfigured device placement orientation (i fit is rotated sideways or not)
	0X000D	2 byte	451	Read firmware code 4.5.1
	0x000E	2 byte	0-8	Read defined gain sensitivity
	0x000F	2 byte	1,2,5,10,20,50,100,200	Read current gain level
	0x0010	2 byte	0 – 65536	Read calculated water discharge (in m ³ /sec), truncated to integer value. For higher resolution, check register at address 0x00221.
	0x0011	2 byte	0→ASCII64 1→NMEA 2→ASCIIV 3→AVIO 4→SDI12	Read RS-232 protocol type
	0x0012	2 byte	0→HS 1→MODBUS	Read RS-485 protocol type
	0x0013	2 byte	0 → Disabled 1 → Enabled	Is speed correction for tilt angle enabled
	0x0014	2 byte	0 → Sensor Err. 1 → Sensor OK	Level sensor health indicator
	0x0015	2 byte	0-15000	Read measured water level (in millimeters from the sensor)
	0x0016	2 byte	From -32768 To 32,767	Read predefined radar height (in cm, relative to arbitrary position)
	0x0017	2 byte	0-65535	Radar predefined radar horizontal offset (in cm, from left shore)

Fun	Data start Addr	Data Length	Data Range	Detail
0x03	0x0018	2 byte	0-128	Read number of predefined points that define channel geometry
	0x0019	2 byte	0-128	Read number of k-coeff values
	0x001A ... 0x0099	128*(2 byte)	From -32768 To 32,767	Relative height (in cm) for each point that defines a channel geometry/profile (Y coordinate)
	0x009A ... 0x0119	128*(2 byte)	0-65535	Relative vertical offset (in cm) for each point that defines a channel geometry/profile (X coordinate)
	0x011A ... 0x0199	128*(2 byte)	From -32768 To 32,767	Relative height (in cm) of the water level for each defined k-coeff value
	0x019A ... 0x0219	128*(2 byte)	0-65535	k-coeff values Each k-coeff value is stored as (val * 10000); so for k-coeff of 0.85, the register would hold 8500.
	0x0221	2 byte	0-1000	Discharge in liters per second. This value should be read together with the value stored at address 0x010, which returns calculated discharge in m ³ /sec, (truncated to integer value). The total discharge in m ³ /sec can be calculated by: $Q = val[0x10] + val[0x221] * 0.001$

Table 8. Writing data to the sensor

Fun	Data start Addr	Data Length	Data Range	Detail
0x06	0x0000	2 byte	1~255	Change sensor id
	0x0001	2 byte	0→9600 1→38400 2→57600 3→115200	Change baud rate
	0x0002	2 byte	0→mm/s	Change data unit
			1→m/s	
	0x0003	2 byte	0→IIR 1→Average	Change averaging type
	0x0004	2 byte	1-512	Change averaging length

Fun	Data start Addr	Data Length	Data Range	Detail	
0x06	0X0005	2 byte	0→both 1→incoming 2→outgoing	Change flow direction filter type	
	0X0006	2 byte	0-100	Change sensitivity level	
	0X0007	2 byte	0→Normal 1→Rotated sideways	Change device orientation	
	0X0008	2 byte	0→ASCII64 1→NMEA 2→ASCIIV 3→AVIO 4→SDI12	Change RS-232 protocol type	
	0X0009	2 byte	0→HS 1→MODBUS RTU	Change RS-485 protocol type	
	0X000A	2 byte	0 – 8	Change PGA sensitivity	
	0X000B	2 byte	0 → Disabled 1 → Enabled	Enable / disable tilt angle compensation for surface velocity reading	
	0x000C	2 byte	0→Writ params 1→Write points 2→Write k-coeffs	Change configured channel profile info. Initiates writing buffered data into device flash.	
	0x000D	2 byte	From -32768 To 32,767	Radar height (Y)	Profile params buffer.
	0x000E	2 byte	0-65535	Radar Offset (X)	
	0x000F	2 byte	0-128	Number of geometry points	
	0x0010	2 byte	0-128	Number of k-coeffs	
	0x0011 ... 0x0090	128*(2 byte)	From -32768 To 32,767	Point Heights buffer OR k-coeffs height levels buffer	
	0x0091 ... 0x0110	128*(2 byte)	0-65535	Point X offsets buffer OR k-coeffs buffer	

9. Appendix A – Mechanical Assembly

