



GLX-RSS-2-300 W

# Non-Contact Flow Meter User Manual



## Starting Point

Thank you for purchasing Geolux RSS-2-300 W 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:

Geolux d.o.o.  
Ljudevita Gaja 62  
10430 Samobor  
Croatia

E-mail: [geolux@geolux.hr](mailto:geolux@geolux.hr)  
Web: [www.geolux.hr](http://www.geolux.hr)

## 1. Introduction

Geolux RSS-2-300 W flow meter uses radar technology to provide precise contactless measurement of surface flow velocity. Contactless radar technology enables quick and simple sensor installation above the water surface, and requires minimum maintenance. This 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 flow velocity.

The flow meter is able to detect water flow traveling at speeds ranging from 0,02 m/s to 15,0 m/s with precision of 0,01 m/s. Integrated tilt sensor measures inclination angle of the sensor and the flow velocity measurement is automatically cosine-corrected according to the measured mounting tilt angle.

## 2. Electrical Characteristics

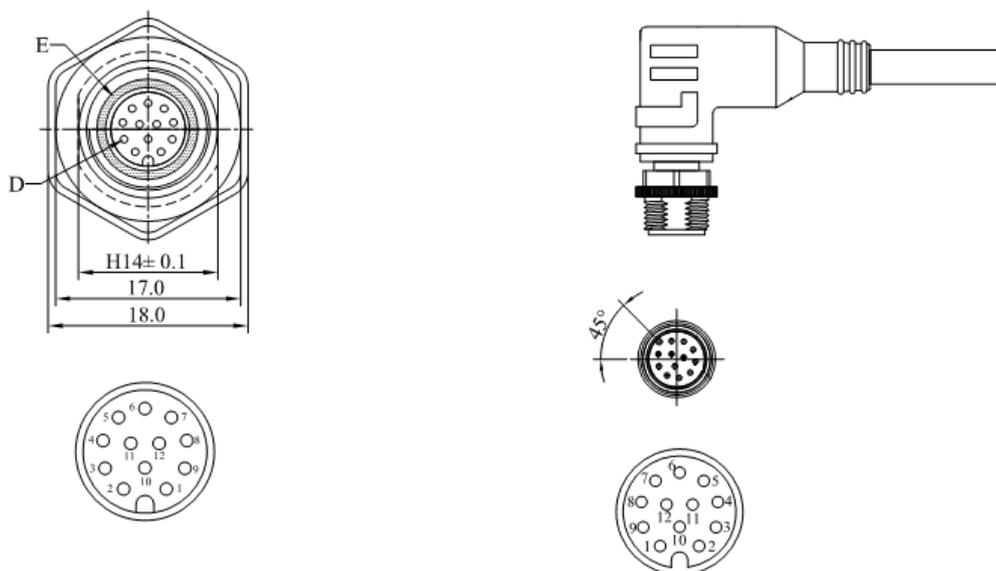
The electrical characteristics of the Geolux RSS-2-300 W flow meter are given in the Table 1.

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 Sensor				
Frequency	24.075	24.125	24.175	GHz
Radiated power (EIRP)			20	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		%
Installation height above the water			15	m
Power supply voltage	9,0	12,0	27,0	V
Power				
Operational mode		950		mW
Sleep mode		85		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
Measurement range	0,02		15,00	m/s
Resolution		0,001		m/s
Accuracy		1		%
Angle compensation	0	30	75	deg.
Installation height above the water	0,1		20	m
Sample rate		10		sps
Ingress Protection Rating	IP68			
Mechanical		110x90x50		mm

### 3. Connector Pin-Out

The flow meter uses robust IP66 circular M12 connector with 12 positions and the mating cable is also delivered with the flow meter. The connector and cable details are shown on Picture 1. The Table 2 gives detailed description for each pin.



Picture 1. Flow meter connectors

Table 2. Connector and 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 least 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	Reserved	Reserved
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	Alarm - open collector switch signal max. 60mA ( <i>optional</i> )
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 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

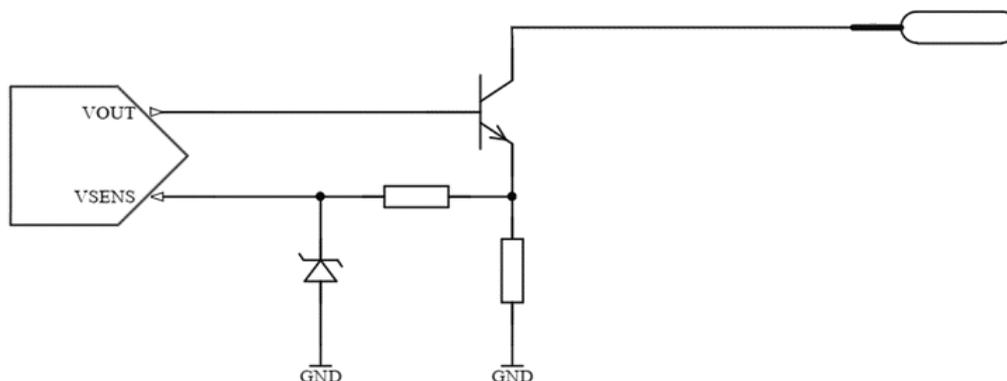
Serial RS-485 interface is implemented as standard industrial half-duplex communication interface. Communication interface is short-circuit and overvoltage internally protected. Depending on the receiving device interface can be used with only two wires (D+ dark red wire & D- orange wire) or in some 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. 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.

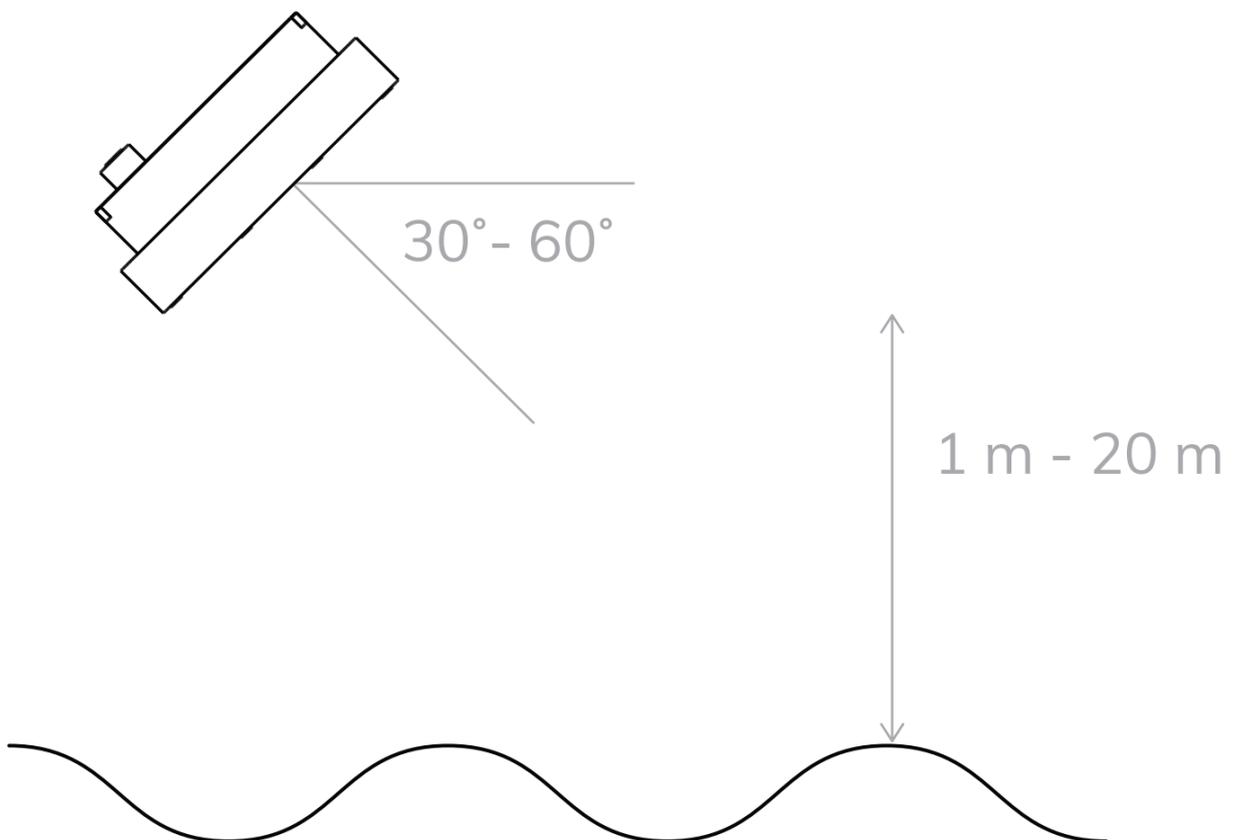
Signal range and function for 4 – 20 mA analog output can be configured in setup application so the sensor will be able to signal best suitable value range with available current range. Current step in the sensor is  $0,3 \mu\text{A}$  limiting resolution possible for the value signaling and care has 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. Recommended minimum height above the water surface is 1 meter, with maximum height up to 20 meters. Recommended vertical angle is 45 degrees.

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



Picture 2. Installing flow meter

### 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  $30^{\circ}$  and  $60^{\circ}$ , 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.

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.

## 4.2. Measurement quality indicator

Geolux RSS-2-300W 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.

## 4.3. 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.

#### 4.4. 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.

Similarly, as interference from two or more surface velocity radars on the same location it is very unlikely that other radiation sources in K 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 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 measurement 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.

#### 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.

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) ration 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 75 m 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 and hitting any moving or rotating object which could cause false readings.

## 5. Data Interface

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

### 5.1. 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: 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 the Chapter 6 of the User Manual.

### 5.2. 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 than 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: 9600 bps, data bits: 8, stop bits: 1, parity: none**

## 6. Data Protocols

Geolux GLX-RSS-2-300 W 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
- 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.

### 6.1. 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.

*DI*: The detected flow direction (1 approaching, -1 receding).

*SI*: 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).

*LI*: 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 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 (speed is reported as speed\*10 for m/s, km/h, mph, fps, fpm and as speed\*1 for mm/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 on the beginning of each 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 on 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 on the beginning of each quality of signal report.

*Q1:* Quality of signal estimate based on sensor vibration.

*Q2:* Quality of signal estimate signal quality.

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

## Quality of signal factor:

0 – Excellent measurement quality

1 – Good measurement quality

2 – Low measurement quality

3 – Unacceptable measurement quality

## 6.2. 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.

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 <CL>, <LF> or <CR><LF> (enter):

Change velocity 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 velocity is reported.

Change radar sensitivity

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

Changes the sensitivity of the radar sensor.

Change SNR threshold

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

Changes the minimum threshold SNR. It is set as value in dBm \* 256. If the current SNR is below the defined threshold, the instrument will not report any velocity and will assume there is no water movement.

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=19200
#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 RS485 protocol

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

```
#set_485_proto=geolux
```

Changes the parameter that specifies the protocol on RS-485.

Change filter length

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

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

Set device ID

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

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

Set output type for 4-20mA

```
#set_420_type=none  
#set_420_type=velocity
```

Configure the 4-20mA output type.

Set output value for 4-20mA

```
#set_420_min=<value>  
#set_420_max=<value>
```

Configure the 4-20mA output minimum value for 4mA and maximum value for 20mA. Value is set for currently configured unit. Value number is accepted as float.

Set dead time

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

Configure dead time in seconds which ensures no signals will be taken in consideration after power up.

Sleep mode/power save

```
#set_power_save=1 (go to power save)  
#set_power_save=0 (left power save)
```

Command for entering power save mode in which power consumption lowers significantly and is use for battery save management.

Retrieve current device status

#get\_info

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

```
# firmware:6.2.1
# serial:222312
# sensor_type:W
# direction:both
# baud_rate:9600
# dead_time:6
# can_id:1
# angle:89
# filter_len:50
# pga_gain:200
# proto:nmea
# 485_proto:modbus_rtu
# units: mms
# sensitivity:8 (Auto)
# thld:124
# thld_snr:1024
# an420_type:9
# an420_min:0
# an420_max:10000
# level_sensor:0
```

### 6.3. 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 measurement.

#### 6.3.1. HS protocol

---

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

<0x25> ID CSUM

- 0x25:* The first byte sent in the request is ‘%’ character. Its ASCII value in HEX is 0x25.
- ID:* Exactly two bytes long. This is the unit ID written as two ASCII characters. For example, if the polled unit ID is 2, then ID will be sent as “02”. In HEX representation it is the following two bytes: <0x30><0x32>.
- CSUM:* Checksum, calculated by adding in modulo 256 the two byte values of the ID. If the device ID is 2, then ID was sent as <0x30><0x32>. Checksum is then  $0x30+0x32 = <0x62>$ .

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

<0xA5> ID SPEED 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>.
- CSUM:* Checksum, calculated by adding in modulo 256 the two byte values of the ID and all byte values from the SPEED.

Second possible command is send from the data logger to the flow meter:

<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, device goes to power safe mode

Third possible command is send from the data logger to the flow meter:

<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, device goes to normal operation mode from power safe mode.

### 6.3.2. Geolux protocol

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

<0x25> ID CSUM

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

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

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

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

<0xA5> ID#CSPEED#ASPEED#CDIR#SIGLEVEL#ANGLE#0#0\$ 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>.

*CSPEED:* The speed readout of current speed in currently selected units, formatted as real (float) number with exactly three digits after the decimal dot separator. For example, if the current speed is 5.7143, it will be reported as 5.714.

*ASPEED:* The speed readout of averaged speed in currently selected units, formatted same as current speed.

*CDIR:* -1 for outgoing, and 1 for incoming flow.

*SIGLEVEL:* The detected level of the signal reflection from the water surface.

*ANGLE* The measured tilt angle, in degrees, 0 being horizontal.

*CSUM:* Checksum, calculated by adding in modulo 256 the two byte values of the all byte values first byte.

## 6.4. 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 W 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	Address	Fun	Data start address		Count of registers		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 reg
Count of registers	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 Address	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 4→19200	Read baud rate
	0X0002	2 byte	0→mm/s 1→m/s 2→mph 3→km/h 4→fps 5→fpm	Read velocity unit type
	0X0003	2 byte	0-15000 (mm/s)	Read instantaneous speed
	0X0004	2 byte	0-15000 (mm/s)	Read averaged speed
	0X0005	2 byte	0-360	Read tilt angle
	0X0006	2 byte	0→incoming 1→outgoing	Read flow direction
	0X0007	2 byte	1-512	Read averaging length
	0X0008	2 byte	0-8	Read defined PGA gain sensitivity
	0X0009	2 byte	0→both 1→incoming 2→outgoing	Read flow direction filter setting
	0000A	2 byte	0-100	Read sensitivity value
	0X000B	2 byte	0	Read device type, always 0
	0X000C	2 byte	0-3840	Read SNR threshold (dBm * 256)
	0X000D	2 byte	621	Read firmware code 6.2.1
	0x000E	2 byte	1,2,5,10,20,50, 100,200	Read current gain level
	0x000F	2 byte	0-2047	Read relative signal strength

Fun	Data start Address	Data Length	Data Range	Detail
	0x0010	2 byte	0 - 65535	Read instantaneous speed in selected unit (integer part)
	0x0011	2 byte	0 - 65535	Read instantaneous speed in selected unit (decimal part * 1000)
	0x0012	2 byte	0 - 65535	Read averaged speed in selected unit (integer part)
	0x0013	2 byte	0 - 65535	Read averaged speed in selected unit (decimal part * 1000)
	0x0014	2 byte	0 - 10000	Read instantaneous SNR level (dBm * 256)
	0x0015	2 byte	0 - 10000	Read averaged SNR level (dBm * 256)
	0x0016 - 0x001F	2 byte	0	Reserved, always 0

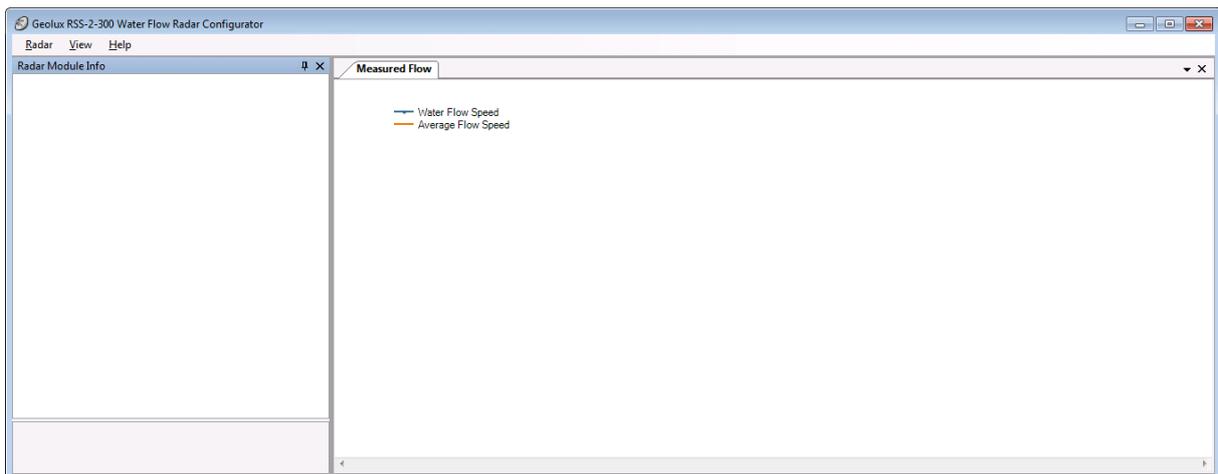
Table 8. Writing data to the sensor

Fun	Data start Addr	Data Length	Data Range	Detail
	0X0000	2 byte	1~255	Change sensor id
	0X0001	2 byte	0→9600 1→38400 2→57600 3→115200 4→19200	Change baud rate
	0X0002	2 byte	0→mm/s 1→m/s 2→mph 3→km/h 4→fps 5→fpm	Change velocity unit type
0X06	0X0007	2 byte	1-512	Change averaging length
	0X0008	2 byte	0-8	Change PGA gain sensitivity
	0X0009	2 byte	0→both 1→incoming 2→outgoing	Change flow direction filter type
	0X000A	2 byte	0-100	Change sensitivity level
	0X000C	2 byte	0-3840	Change SNR threshold (dBm * 256)

## 7. Radar Configurator Utility

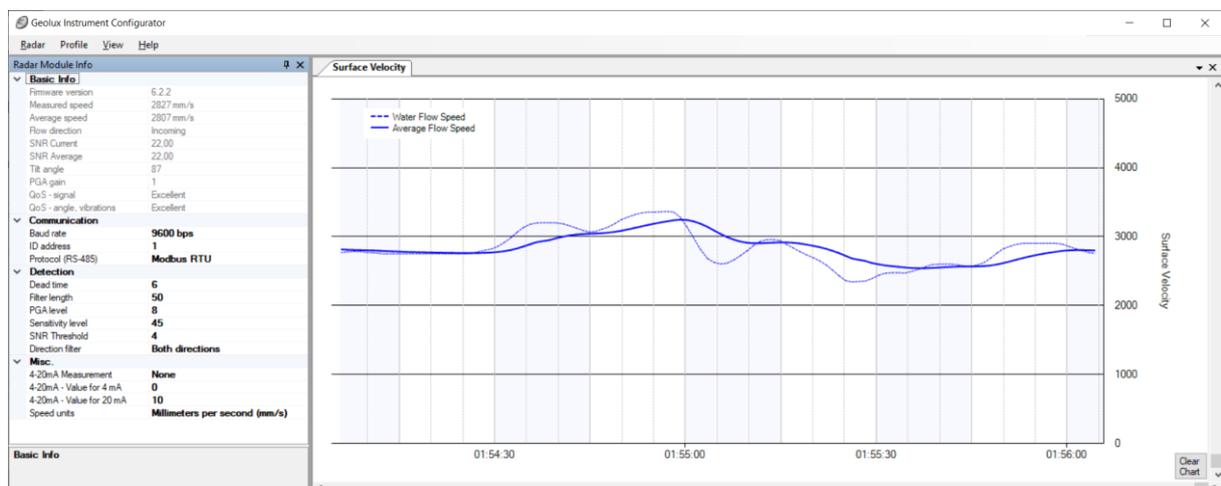
Geolux provides a user-friendly PC application for configuring the flow meter operating parameters. Additionally, the Configurator Utility displays current flow measurements.

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.



Picture 3. Flow Meter Configurator main window

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 4. 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:

#### Basic Info

<i>Firmware version</i>	the version of the firmware running in the radar sensor 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>SNR Current</i>	the SNR of current flow measurement
<i>SNR Average</i>	the SNR of averaged flow measurement
<i>Tilt angle</i>	the measured tilt angle (in degrees) of the radar 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>QOS - signal</i>	the quality of signal based on signal
<i>QOS - angle, vibr...</i>	the quality of signal based on vibrations

#### Communication

<i>Baud rate</i>	the communication bitrate used on RS-232 and RS-485 interfaces for communication with the radar device
<i>ID address</i>	the device identifier, used if multiple devices are connected together over RS-485 interface
<i>Protocol (RS-485)</i>	<i>used protocol on RS- 485 interface</i>

#### Detection

<i>Dead time</i>	dead time in which ensures no signals will be taken in consideration after power up
<i>Filter length</i>	if moving average filter is used, select the averaging window length
<i>Sensitivity level</i>	radar sensor sensitivity – maximum level provides furthest detection range, decreasing this level decreases the detection range
<i>SNR threshold</i>	if the current SNR is below this defined threshold, the instrument will not report any velocity and will assume there is no water movement.
<i>Direction filter</i>	select whether any flow direction is reported, or only incoming or outgoing flow are reported

#### Misc

<i>Speed units</i>	select if the speed is reported in mm/s, m/s, km/h, mph, fps or fpm
<i>4-20mA Measurement</i>	chooses measurement to output on 4-20mA sink
<i>4-20mA Value for 4mA</i>	value for 4mA in defined units
<i>4-20mA Value for 20mA</i>	value for 20mA in defined units

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.

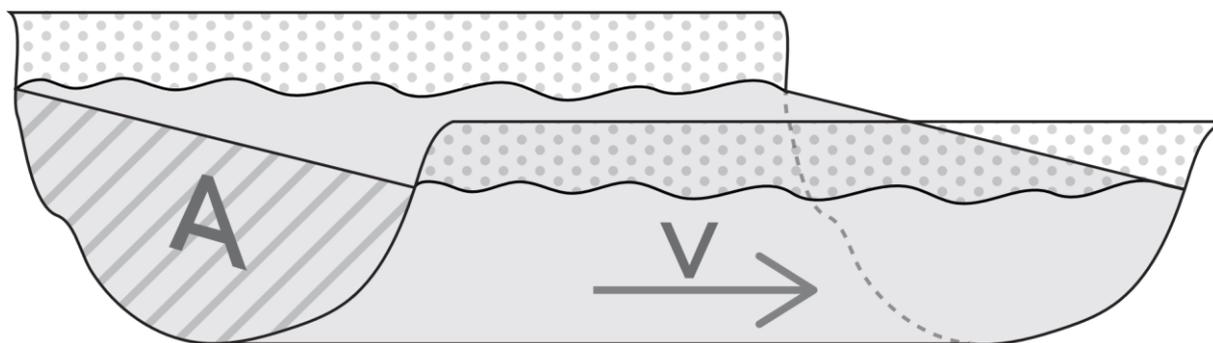
For flow measurement, averaged flow speed reading should be used, to filter out fluctuations in direct measurement caused by waves on the fluid surface.

## 8. Calculating Discharge from Flow Velocity

Geolux RSS-2-300 W flow meter measures flow velocity at the water surface. 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 5.



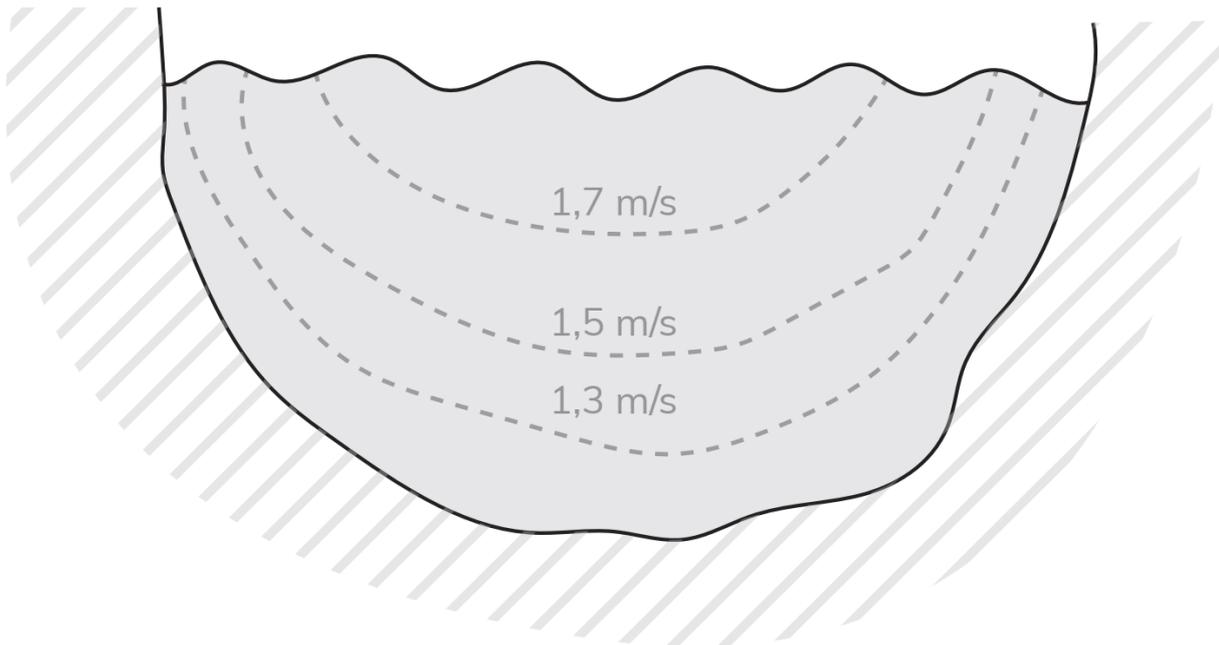
Picture 5. Simple channel diagram

The discharge can be calculated according to the formula:

$$Q = V * A$$

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

For real-world measurements it is important to understand that the velocity of the moving water varies both across the stream channel and from the surface to the bottom of the stream due to friction, as in Picture 6.



Picture 6. 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](https://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/TechNotes/technote3_surface_flow.pdf)

## 9. Appendix A – Mechanical Assembly

