GLX-RSS-2-300 W

Non-Contact Flow Meter User Manual

Revision History

Version	Date	Author	Approved by
1.0	2011-07-22	Tomislav Grubesa	Niksa Orlic
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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:

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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

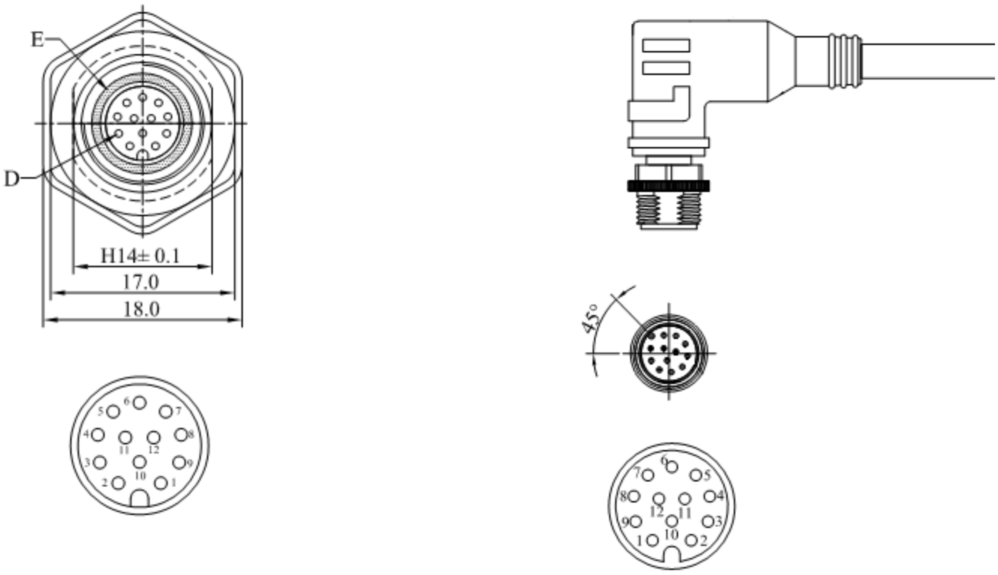
The electrical characteristics of the Geolux RSS-2-300 W flow meter are given in the Table 1.

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	24.125		24.200	GHz
Radiated power (EIRP)			20	dBm
Sensitivity	-108	-110	-112	dBm
Beam-width (3dB) – Azimuth		12		°
Beam-width (3dB) – Elevation		24		°
Power supply voltage	9,0	12,0	27,0	V
Power		1000	1350	mW
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.
Distance	0,1		50	m
Sample rate		20		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

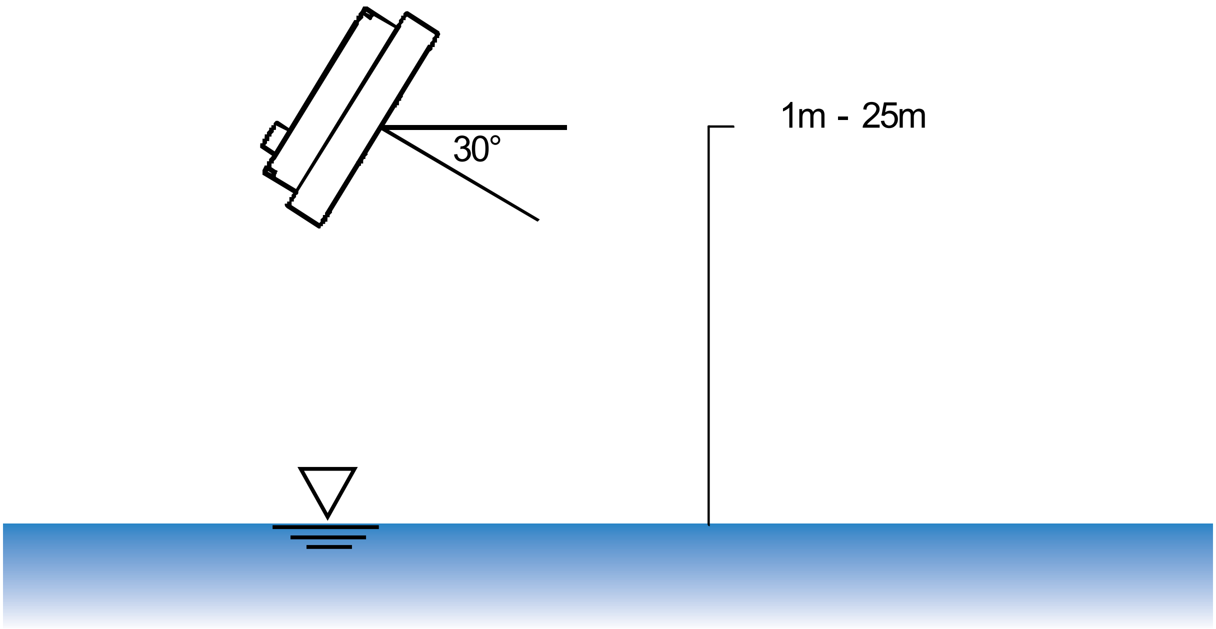
Table 2. Connector and cable pin-out

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 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.
7	Blue	CAN – L	CAN2.0B low signal.
8	Red	Alarm V+	Alarm – power supply +5V max. 100mA.
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	Alarm2 SW	Alarm 2 - open collector switch signal max. 60mA

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 25 meters. Recommended vertical angle is 30 degrees.

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



Picture 2. Installing flow meter

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:	**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.

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 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**

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

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 singe-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 (speed[1] 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.

S1: The detected flow speed (speed[2] 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.

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:

Change units type

#set_units=kmh
#set_units=mph
#set_units=fps
#set_units=fpm
#set_units=ms

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

#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 sidewise (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
```

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 form 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 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.

6.4. Modbus Protocol (RS-485)

When configured in Modbus operation mode, the unit responds to Modbus requests over RS-485 dana line. The baud rate id configured through the PC application, and 1 stop bit, even parity, 8 dana 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 paramters 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
	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.

Table 8. Writing dana to the sensor

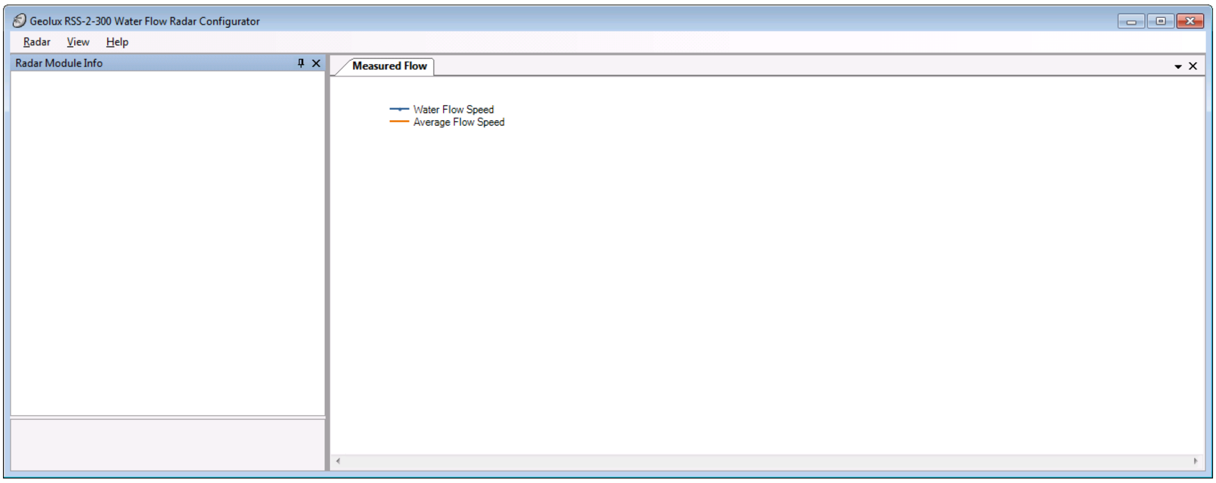
Fun	Data start Addr	Data Length	Data Range	Detail
0X06	0X0000	2 byte	1~255	Change sensor id
	0X0001	2 byte	0→9600 1→38400 2→57600 3→115200	Change baud rate
	0X0002	2 byte	0→mm/s 1→m/s	Change data unit
	0X0003	2 byte	0→IIR 1→Average	Change averaging type
	0X0004	2 byte	1-512	Change averaging length

<table>
<tr><th>Fun</th><th>Data start Addr</th><th>Data Length</th><th>Data Range</th><th colspan="2">Detail</th></tr>
<tr><td rowspan="16">0x06</td><td>0X0005</td><td>2 byte</td><td>0→both
1→incoming
2→outgoing</td><td colspan="2">Change flow direction filter type</td></tr>
<tr><td>0X0006</td><td>2 byte</td><td>0-100</td><td colspan="2">Change sensitivity level</td></tr>
<tr><td>0X0007</td><td>2 byte</td><td>0→Normal
1→Rotated sideways</td><td colspan="2">Change device orientation</td></tr>
<tr><td>0X0008</td><td>2 byte</td><td>0→ASCII64
1→NMEA
2→ASCIIV
3→AVIO
4→SDI12</td><td colspan="2">Change RS-232 protocol type</td></tr>
<tr><td>0X0009</td><td>2 byte</td><td>0→HS
1→MODBUS RTU</td><td colspan="2">Change RS-485 protocol type</td></tr>
<tr><td>0X000A</td><td>2 byte</td><td>0 – 8</td><td colspan="2">Change PGA sensitivity</td></tr>
<tr><td>0X000B</td><td>2 byte</td><td>0 → Disabled
1 → Enabled</td><td colspan="2">Enable / disable tilt angle compensation for surface velocity reading</td></tr>
<tr><td>0x000C</td><td>2 byte</td><td>0→Writ params
1→Write points
2→Write k-coeffs</td><td colspan="2">Change configured channel profile info. Initiates writing buffered data into device flash.</td></tr>
<tr><td>0x000D</td><td>2 byte</td><td>From -32768
To 32,767</td><td>Radar height (Y)</td><td rowspan="4">Profile params buffer.</td></tr>
<tr><td>0x000E</td><td>2 byte</td><td>0-65535</td><td>Radar Offset (X)</td></tr>
<tr><td>0x000F</td><td>2 byte</td><td>0-128</td><td>Number of geometry points</td></tr>
<tr><td>0x0010</td><td>2 byte</td><td>0-128</td><td>Number of k-coeffs</td></tr>
<tr><td>0x0011
…
0x0090</td><td>128*(2 byte)</td><td>From -32768
To 32,767</td><td colspan="2">Point Heights buffer
OR
k-coeffs height levels buffer</td></tr>
<tr><td>0x0091
…
0x0110</td><td>128*(2 byte)</td><td>0-65535</td><td colspan="2">Point X offsets buffer
OR
k-coeffs buffer</td></tr>
</table>

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:

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

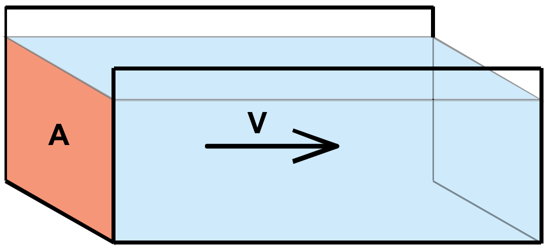
For flow measurement, averaged flow speed reading should be used, to filter out fluctuations in direct measurement caused by waves on the fluid surface.

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.



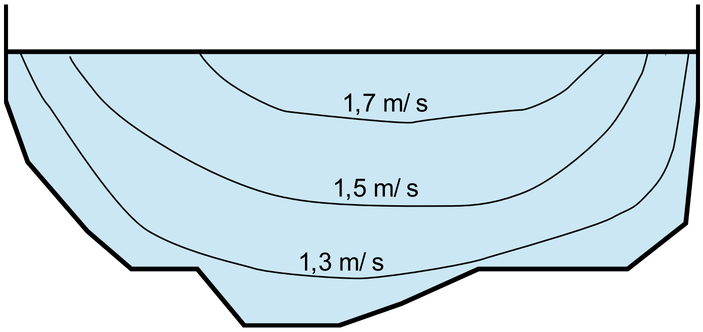
Picture 5. Simple channel diagram

The discharge can be calculated according to the formula:

$$Q = V * A$$

where Q is discharge (for example in m^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 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

9. Appendix A – Mechanical Assembly