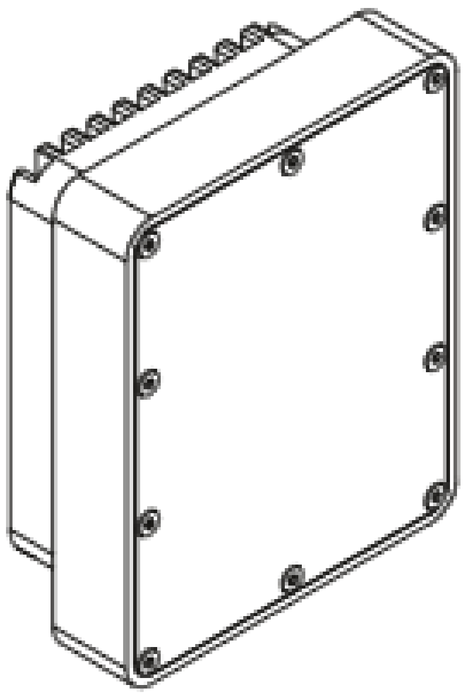
EXTREME ENVIRONMENTS. EXTREMELY RELIABLE.



SDI-RADAR-300W

Surface Flow Velocity Radar

Operating Manual

1.800.548.4264 | www.ftsinc.com

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Content

Chapter 1 SAFETY

1.1 APPROPRIATE USE

Operational reliability is ensured only if the instrument is properly used according to the specifications in this manual as well as possible supplementary instructions.

> WARNING: Inappropriate or incorrect use of the instrument can give rise to application specific hazards, e.g., damage to system components through incorrect mounting or adjustment.

1.2 GENERAL SAFETY INSTRUCTIONS

This is a state-of-the-art instrument complying with all prevailing regulations and guidelines.

During the entire duration of use, the user is obliged to determine the compliance of the necessary occupational safety measures with the current valid rules and regulations for their area.

The safety instructions in this manual, the national installation standards as well as the valid safety regulations and accident prevention rules must be observed by the user.

For safety and warranty reasons, any invasive work on the device beyond that described in the operating instructions manual may be carried out only by personnel authorized by the manufacturer. Arbitrary conversions or modifications are explicitly forbidden.

The safety approval markings and safety tips on the device must also be observed.

Chapter 2 PRODUCT DESCRIPTION

2.1 FUNCTIONAL PRINCIPLE

The SDI-RADAR-300W flow meter, referred to as the 300W in this manual, 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 the 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 300W reports the average surface velocity of the area covered by its beam and uses complex Kalman filters with physical modelling of the water flow to give stable measurements even under turbulent conditions. However, moderate waviness of the water surface will improve the measurement (see Section 3.4). In strongly turbulent water flow, 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.

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[1]. The integrated tilt sensor measures the inclination angle of the sensor and the flow velocity measurement is automatically cosine-corrected according to the measured mounting tilt angle.

2.2 INTERFERENCE AND MULTIPLE RADARS

The 300W 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 a precise central frequency making the likelihood of two devices working on the exact same frequency to cause interference highly unlikely. The Doppler frequency shift caused by water in the 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 the difference between central frequencies of two radars in the same range to get interference.

Similarly, is very unlikely that other radiation sources in the K band in the vicinity will affect the 300W measurements. Some wideband radiation sources can introduce small impulse interference for a short period of time, but this is very unlikely to affect measurements reported by the radar.

[1] 0.04 mph to 33.55 mph with a precision of 0.02 mph

2.3 *CONNECTOR PIN-OUT AND WIRING*

The sensor is supplied with an M12 connector and cable. The connector and cable details are shown on Figure 2-1. The user is responsible for connecting the sensor to the data collection platform using the flying leads. Users can attach their own connector, connect the cable via a terminal strip, or wire it directly to device electronics. Refer to Table 2-2 for wiring details.

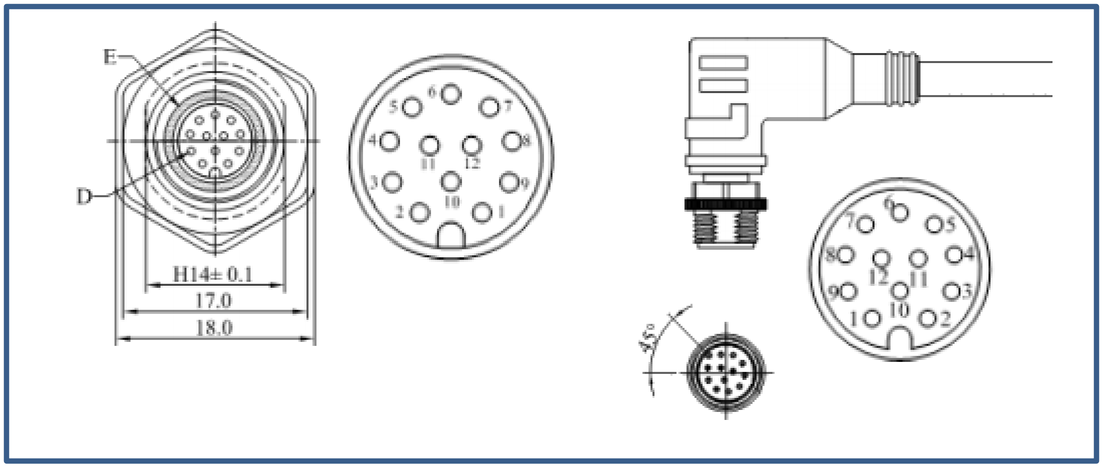


Figure 2-1: Flow meter connectors

Table 2-2: Connector and Cable Pin-out

PIN #	COLOUR	PIN NAME	PIN DESCRIPTION
1	**White**	GND	This pin should be connected to the ground (negative) pole of the power supply
2	**Brown**	+Vin	Power supply. Power supply voltage must be 9 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. } RS232 connections only used when configuring the 300W sensor with the Geolux Instrument Configurator software (see Chapter 5)
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**	V+	Output power supply (=Vin) for supply of external optional equipment and for use with analog 4-20 mA output
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 (optional)
12	**Purple**	4-20 mA	Sink for 4-20 mAanalog interface. Connect sensing device as pull-up to sink the current

2.4 ELECTRICAL CHARACTERISTICS

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

Table 2-1: Electrical Characteristics

PARAMETER	MIN	TYPICAL	MAX	UNIT
Communication interface: RS-232 interface speed RS-485 interface speed	 1200 1200		 115200 115200	 bps bps
Radar Sensor Frequency Radiated power (EIRP) Sensitivity Beamwidth (3dB) – Azimuth Beamwidth (3dB) – Elevation	 24.75 – -108 – –	 24.125 – -110 12 24	 24.175 20 -112 – –	 GHz dBm dBm degrees degrees
Power supply voltage	9.0	12.0	27.0	V
Power Operational Mode Sleep Mode	 – –	 950 85	–	mW mW
Alarm output maximal current	–	–	60	mA
Alarm output maximal voltage	–	–	30	VDC
Analog output maximal voltage	–	–	30	VDC
Operational temperature range	-40 (-40)	–	+85 (+185)	ºC °F
Measurement range	0.02 (0.04)	– –	15.00 (33.55)	m/s (mph)
Resolution	– –	0.001 (0.002)	– –	m/s (mph)
Accuracy	–	1	–	%
Angle compensation	0	30	75	degrees
Distance	0.1 (0.33)	– –	50 (164.04)	m (feet)
Sample Rate		10		sps
Ingress protection rating	IP68	–	–	
Mechanical	–	110 x 90 x50 (4.33 x 3.54 x 1.97)	–	mm (in)

Chapter 3 INSTALLATION

3.1 INSTALLATION POSITION

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. See Figure 3-1 for diagram and Imperial units.

When selecting the installation location 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 the water channel as this can cause additional inbound reflection to the radar and can significantly affect measurement accuracy (refer to Figure 3-2). 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.

To achieve the specified accuracy, it is important to properly select measurementsite 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.

The 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.

Additional information can be found at:
https://geolux.ams3.cdn.digitaloceanspaces.com/documents/Surface-Velocity-Measurement.pdf

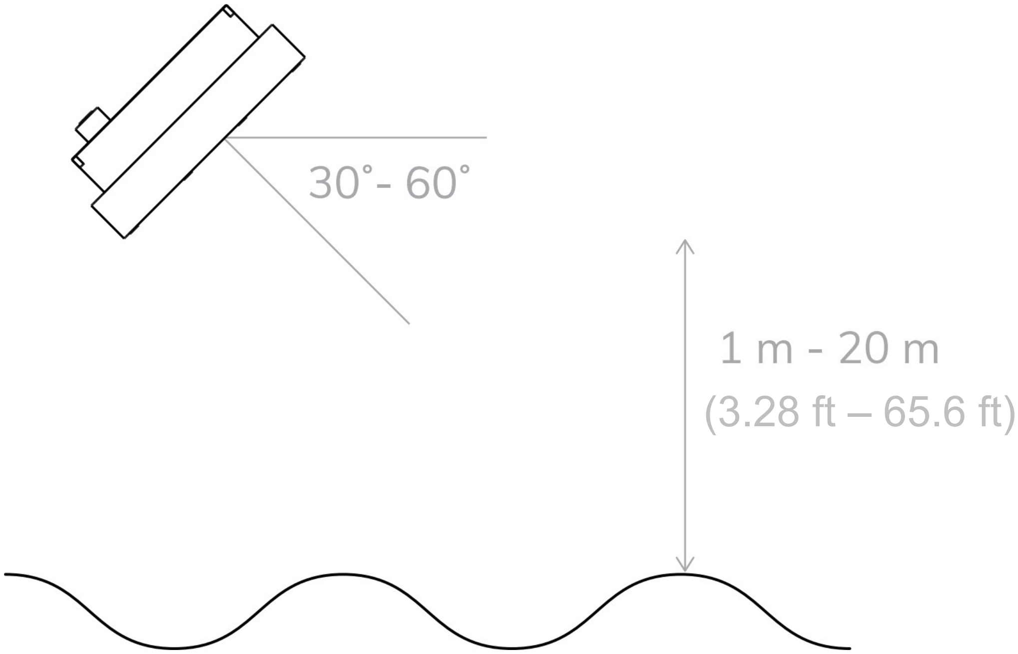


Figure 3-1: Flow meter installation position

3.2 RAIN AND WIND

The 300W has integrated internal software filters to filter out effects of rain, fog or wind. However, these filters have some limitations imposed by environmental conditions (i.e. precipitation). The 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 the flow meter 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.

The 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 a different direction from the water flow. This can affect surface measurement accuracy.

3.3 FOGGING AND EVAPORATION

Generally, radar sensors are not affected by fog or evaporation. However, heavy evaporation with high water density in the atmosphere can affect measurement accuracy. A very high amount of evaporation can introduce reflections and can affect surface velocity measurements.

The best solution for surface velocity measurements in heavy evaporation is to use the outbound flow direction and to configure the sensor with only the downstream directional filter. As evaporation is traveling upwards from the water surface, using the directional filter for water that is inbound or approaching to the radar will solve the problem in most of the cases.

3.4 REFLECTIONS

Water is very reflective medium for the radar waves and most of the power transmitted from the radar transmitter will be reflected from the water surface. Reflections of the radar transmitted power beam follow the same physical laws as in optics in that part of the power is reflected towards the radar, part of the power is reflected away from the radar, and a small part of power is absorbed by the water. Depending on the surface roughness, the incident angle ratio between power reflected away from the radar and towards the radar can significantly vary.

The situation for reflected power for the 300W radar is complex as it depends on the angle between the transmitted radar beam (yellow arrow) and the water. In calmer conditions, most of the power is reflected in the opposite direction from the radar (red arrow). Reflection in the direction of the radar sensor (blue arrow) is always smaller and can be comparable with the dispersed power in all directions (gray arrows). However, generally, a rougher water surface will lead to a stronger reflection being returned to the radar and a greater SNR (signal to noise) ratio which enables more accurate measurements. The 300W radar is designed to achieve accurate measurements even in environments with very small SNR so the required surface roughness of 1mm is usually enough for precise measurements.

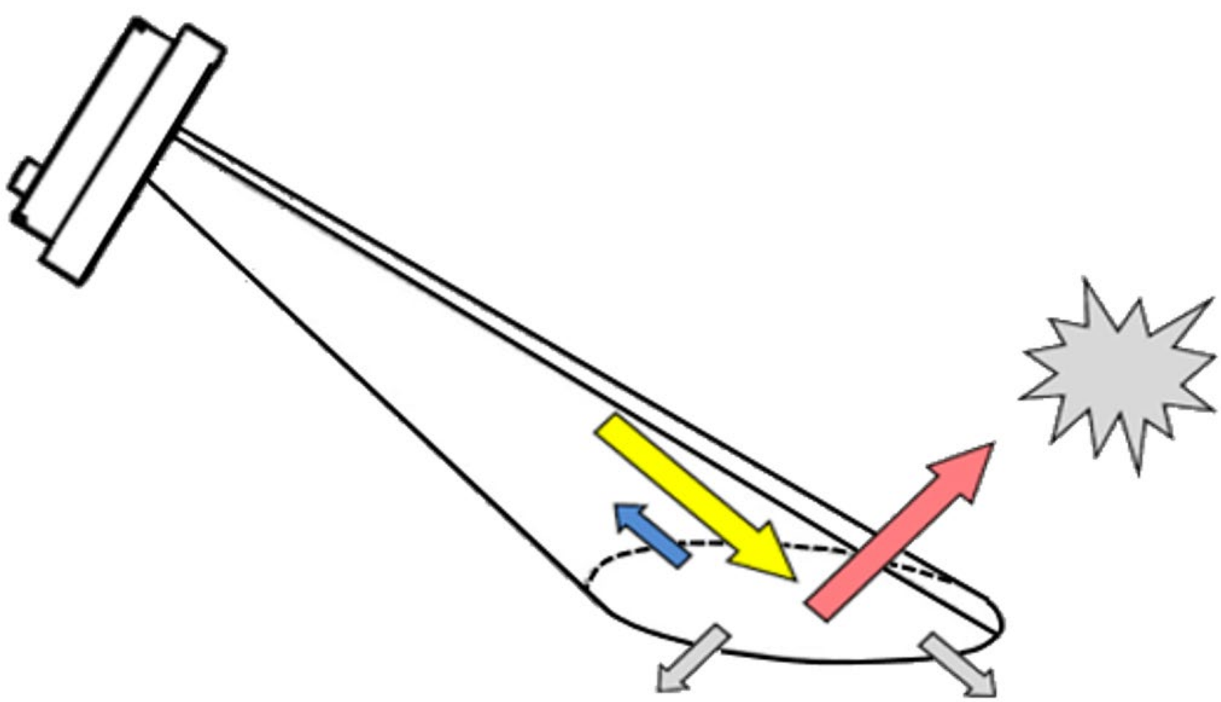


Figure 3-2: Reflected power

Chapter 4 DATA INTERFACES AND PROTOCOLS

4.1 SERIAL INTERFACES

The 300W Flow meter offers the following serial interfaces, for ease of integration with existing SCADA/telemetry:

1) Serial RS-232 interface
2) Serial RS-485 interface

4.1.1 SERIAL RS-232 INTERFACE

Serial RS-232 interface is used for direct connection of a single flow meter unit with a computer. The serial interface is used both for retrieving live flow measurements and for configuration of the flow meter device. Easy configuration can also be done with the PC application (see Chapter 6 for details).

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 4.

4.1.2 SERIAL RS-485 INTERFACE

Serial RS-485 interface is used for connecting multiple flow meters connected on a single RS-485 bus to a single data logger. 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 4.

Default communication parameters are:

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

4.2 DATA PROTOCOLS

The 300W supports the following data protocols

1) NMEA protocol on RS-232 interface that constantly outputs the detected speed and reflected signal power, and also the current measured tilt angle
2) Servicing protocol on RS-232 interface for configuring the unit
3) Request Response Protocol on RS-485 interface that allows multiple units to be used on a single RS-485 bus

4) Modbus Protocol which responds to Modbus requests over the RS-485 data line

4.2.1 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 the RS-232 interface the device periodically outputs the 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[2] 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>

$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[1] 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.

4.2.2 SERVICING PROTOCOL (RS-232)

The servicing protocol is used to retrieve and modify the 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.

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

Easy configuration is done using the PC application, Configurator utility. Details can be found in Chapter 6. The servicing protocol used between the Configurator Utility and the flow meter device is transparent to users.

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

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

Change radar sensitivity: Changes the sensitivity of the radar sensor.

#set_thld=<0-100>

Change detected targets direction: Changes the parameter that specifies which flow direction will be reported.

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

Change serial port baud rate: 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.

#set_baud_rate=9600
#set_baud_rate=38400
#set_baud_rate=57600
#set_baud_rate=115200

Change filter type: Changes the filter type used for flow averaging.

#set_filter_type=<1-2>

1=IIR filter;
2=moving average filter

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

#set_filter_len=<1-1000>

Change default device orientation: Configure orientation of device mounting.

#set_rotation=<0-1>

0 = standard orientation
1 = 90 degree rotation (i.e. sideways)

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

#set_can_id=<0-99>

Automatic angle compensation: Enable/ disable the automatic compensation (cosine-correction) of the tilt angle on the reported flow measurement.

#set_angle_compensation=<0-1>

0 = enable

1 = disable

Retrieve current device status: Requests the current device status.

#get_info

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
```

4.2.3 REQUEST-RESPONSE PROTOCOL (RS-485)

A different data protocol is used on the RS-485 interface which allows the connection of multiple units on a 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 Configurator Utility. Refer to Chapter 4 for instructions.

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

4.2.4 MODBUS PROTOCOL (RS-485)

When configured in Modbus operation mode, the unit responds to Modbus requests over the 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 4-1 through 4-4. In each request, the master can either ask the slave to retrieve the value of one or more registers, or the master can set the value of one or more registers. Each register holds one 16-bit value.

Table 4-1: 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 4-2: 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 4-3: Slave (sensor) Response Format

Name	Address	Function	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 4-4: 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	0X84	CRC Low
	0X0A	CRC High

Table 4-5 defines the data returned by the unit when the master requests register read. Table 4-6 defines how to write the device configuration. Rows highlighted in blue denote the important values measured by the sensor. Rows highlighted in red denote operating parameters that could be changed in the field.

Table 4-5: Retrieving Data from the Sensor

Function	Data start Addr	Data Length	Data Range	Detail
0X03	0X0000	2 bytes	1~255	Read sensor id
	0X0001	2 bytes	0→9600 1→38400 2→57600 3→115200	Read baud rate
	0X0002	2 bytes	0→mm/s 1→m/s 2→ other	Read set units type
	0X0003	2 bytes	0-15000 (mm/s)	Read instantaneous speed
	0X0004	2 bytes	0-15000 (mm/s)	Read averaged speed
	0X0005	2 bytes	0-360	Read tilt angle
	0X0006	2 bytes	0→ IIR 1→ Average	Read averaging type
	0X0007	2 bytes	1-512	Read averaging length
	0X0008	2 bytes	0 →incoming 1 →outgoing	Read flow direction
	0X0009	2 bytes	0→ both 1→ incoming 2→ outgoing	Read flow direction filter setting
	0000A	2 bytes	0-100	Read sensitivity value
	0X000B	2 bytes	0-2048	Read relative signal strength
	0X000C	2 bytes	0→ Normal 1→ Rotated sideways	Read preconfigured device placement orientation (if it is rotated sideways or not)
	0X000D	2 bytes	451	Read firmware code 4.5.1
	0X000E	2 bytes	0-8	Read defined gain sensitivity
	0X000F	2 bytes	1,2,5,10,20,50, 100,200	Read current gain level
	0X0010	2 bytes	0 – 65536	Read calculated water discharge
	0X0011	2 bytes	0→ ASCII64 1→ NMEA 2→ ASCIIV 3→ AVIO 4→ SDI12	Read RS-232 protocol type
	0X0012	2 bytes	0→ HS 1→ MODBUS	Read RS-485 protocol type
	0X0013	2 bytes	0 → Disabled 1 → Enabled	Is speed correction for tilt angle enabled
	0X0014	2 bytes	0 → Sensor Err. 1 → Sensor OK	Level sensor health indicator

Table 4-5: Retrieving Data from the Sensor (continued)

Function	Data start Addr	Data Length	Data Range	Detail
0X03	0X0015	2 bytes	0-15000	Read measured water level (in millimeters from the sensor)
	0X0016	2 bytes	From -32768 To 32,767	Read predefined radar height (in cm, relative to arbitrary position)
	0X0017	2 bytes	0-65535	Radar predefined radar horizontal offset (in cm, from left shore)
	0X0018	2 bytes	0-128	Read number of predefined points that define channel geometry
	0X0019	2 bytes	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 4-6: Writing Data to the Sensor

<table>
<tr><th>Function</th><th>Data start Addr</th><th>Data Length</th><th>Data Range</th><th colspan="2">Detail</th></tr>
<tr><td rowspan="7">0X06</td><td>0X0000</td><td>2 bytes</td><td>1˜255</td><td colspan="2">Change sensor id</td></tr>
<tr><td>0X0001</td><td>2 bytes</td><td>0→ 9600
1→ 38400
2→ 57600
3→ 115200</td><td colspan="2">Change baud rate</td></tr>
<tr><td>0X0002</td><td>2 bytes</td><td>0→ mm/s
1→ m/s</td><td colspan="2">Change data unit</td></tr>
<tr><td>0X0003</td><td>2 bytes</td><td>0→ IIR
1→ Average</td><td colspan="2">Change averaging type</td></tr>
<tr><td>0X0004</td><td>2 bytes</td><td>1-512</td><td colspan="2">Change averaging length</td></tr>
<tr><td>0X0005</td><td>2 bytes</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 bytes</td><td>0-100</td><td colspan="2">Change sensitivity level</td></tr>
<tr><td rowspan="12">0X06</td><td>0X0007</td><td>2 bytes</td><td>0→ Normal
1→ Rotated sideways</td><td colspan="2">Change device orientation</td></tr>
<tr><td>0X0008</td><td>2 bytes</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 bytes</td><td>0→ HS
1→ MODBUS RTU</td><td colspan="2">Change RS-485 protocol type</td></tr>
<tr><td>0000A</td><td>2 bytes</td><td>0-8</td><td colspan="2">Change PGA sensitivity</td></tr>
<tr><td>0X000B</td><td>2 bytes</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 bytes</td><td>0→ Write 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 bytes</td><td>From -32768
To 32,767</td><td>Radar height (Y)</td><td rowspan="4">Profile parameter buffer</td></tr>
<tr><td>0X000E</td><td>2 bytes</td><td>0-65535</td><td>Radar Offset (X)</td></tr>
<tr><td>0X000F</td><td>2 bytes</td><td>0-128</td><td>Number of geometry points</td></tr>
<tr><td>0X0010</td><td>2 bytes</td><td>0-128</td><td>Number of k-coeffs</td></tr>
<tr><td>0X0011 - 0X0090</td><td>2 bytes</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>2 bytes</td><td>0 – 65536</td><td colspan="2">Point X offsets buffer OR k-coeffs buffer</td></tr>
</table>

4.2.5 *SDI-12 PROTOCOL*

SDI-12 Protocol is achieved using the SDI-12 Adapter. Instructions to connect the radar to the SDI-12 adapter are contained in the Appendix.

4.2.5.1 *BASIC SDI-12 COMMANDS*

The following basic SDI-12 commands are implemented in the radar sensor.

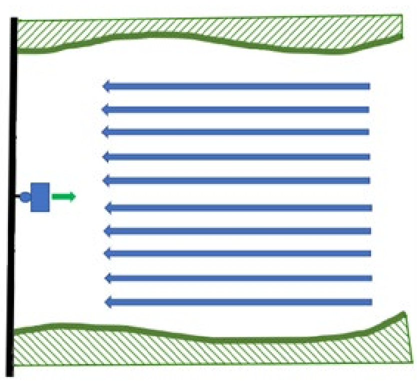
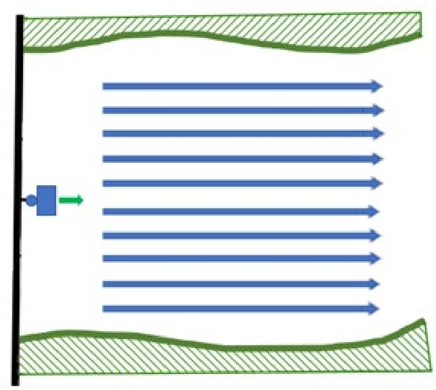
Note the following:

- The "a" in each command should be replaced with the sensor address number
- Every command must terminate with an exclamation mark (!)
- Measurement (M) commands and Concurrent measurement (C) commands are appended with a C to have the data returned with a cyclic redundancy check (CRC)
- The CRC is added at the end of the message for commands with CRC
- The measurement command must be followed by a Send Data command (**aD0!**) to view the data

Name	Command	Response and Details
Address Query	?!	a Device responds with its SDI-12 address. Default address is 0 (zero)
Acknowledge Active	a!	a Sensor at input address "a" is active
Address Change	aAb!	b Device at address "a" has changed address to "b"
Send Identification	aI!	a13GLX2300Wfff a = SDI-12address 13 = the SDI-12 version 1.3 GLX = vendor identification 2300W = sensor model fff = firmware version of the SDI-12 adapter
Start Verification Send Verification Data	aV! aD0!	a0002 a = SDI-12 address 000 = data is immediately ready (zero seconds until data is ready) 2 = two values are available Verification values can be retrieved by the Send Data Command a+d1+d2 a = SDI-12 address +d1 = adapter status 0 = error; 1 = OK +d2 = radar status 0 = error; 1 = OK

4.2.5.2 *MEASUREMENT COMMANDS*

The following SDI-12 measurement commands are implemented in the radar sensor. Note the “a” in each command should be replaced with the sensor address number and every command must terminate with an exclamation mark (!).

COMMAND(S)	RESULTS
aM! / aMC! aC! / aCC!	ammm4 ammm04 mmm = number of seconds before measurements will be ready 4 = 4 values will be returned
aD0!	Response: a±f1±f2=d3=d4 a=SDI-12 address ±f1 = average velocity in defined units ±f2 = current velocity in defined units +d3 = average SNR in dBm +d4 = instrument tilt angle in degrees NOTE: Velocity will be negative if the water is flowing away from the sensor face.  Water flow towards sensor (positive velocity readings)  Water flow away from sensor (negative velocity readings)

4.2.5.3 *X COMMANDS*

In addition to the standard set of commands the300W flow meter has an extension of custom SDI-12 commands called X commands that access specific features of the sensor.

Set commands should normally be followed by a get command to verify the parameter set was successful
In order for X commands to be valid, the following format conditions must be met:

1) Replace the “a” with the sensor address
2) Terminate every command with an exclamation mark (!)
3) The X and other mandatory characters must be capitalized as shown in the table
4) Do not place spaces within the command

See Table 4-7 for the most common SDI-12 read/Write commands.

Table 4-7: Common SDI-12 Read/Write Commands

NAME	COMMAND(S)	RESULTS
Get Readout Duration	aXGRRT!	ad1 a = sensor address d1 = Readout duration in seconds. The duration is the length of time the adapter will power on the sensor after an aM! command is received, before the data is ready for readout
Set Readout Duration	aXGWRT+d1!	ad1 a = sensor address +d1 = Readout duration in seconds to be set. See "Get Readout Duration" for explanation of duration
Change Unit Type	aXGWHR+2+d1!	ad1 a = sensor address +d1 = unit type 0: mm/s 4: fps 1: m/s 5: fpm 2: mph 6: cm/s 3: km/h
Read Unit Type Read last value	aXGRHR+2! then aXGRMV!	Response: a<val0> <val0> = number of seconds to wait until the holding register is available for reading Input "Read last value" command after waiting time indicated in the above response. Response: a<val> <val> = Unit type. See "Change Unit type" above for unit codes.
Change Direction Filter	aXGWHR+9+d1!	ad1 a = sensor address +d1 = direction filter type 0: both directions enabled 1: detect only incoming flow 2: detect only outgoing flow
Read Direction Filter Read last value	aXGRHR+9! then aXGRMV!	Response: a<val0> val0 = number of seconds to wait until the holding register is available for reading Input "Read last value" command after waiting time indicated in the above response Response: a<val> <val> = Direction filter type. See above for filter type codes.

Change Data Filter Length	aXGWHR+7+d1! then aXGWRT+d2!	Changes the length of the moving average filter which is used to smooth the data readings. To change the filter length, two SDI-12 commands need to be issued, with the following parameters: +d1 = the length of the averaging filter, in number of samples; (the radar makes 10 samples (readings) per second, so a filter length of 100 will take 10 seconds) The maximum value for d1 is 512 +d2 = this parameter should be calculated as: (d1/10)+1 For example: - if d1 is 20, then d2 is 3; - if d1 is 35, then d2 should be 4
Read Data Filter Length Read last value	aXGRHR+7! then aXGRMV	Response: a<val0> <val0> = number of seconds to wait until the holding register is available for reading Input "Read last value" command after waiting time indicated in the above response Response: a<val> <val> = Data filter length. See above for calculation of filter length.

Examples of the most common SDI-12 commands for various settings in the RSS-2- 300W senor:

Change velocity unit type:

aXGWHR+2+0! - set mm/s unit type

aXGWHR+2+1! - set m/s unit type

aXGWHR+2+2! - set mph unit type

aXGWHR+2+3! - set km/h unit type

aXGWHR+2+4! - set fps unit type

aXGWHR+2+5! - set fpm unit type

Change averaging length:

aXGWHR+7+1! - set averaging to 1 sample (minimal value)

aXGWHR+7+50! - set averaging to 50 samples

aXGWHR+7+250! - set averaging to 250 samples

aXGWHR+7+512! - set averaging to 512 samples (maximal value)

Change flow direction filter type:

aXGWHR+9+0! - both directions enabled

aXGWHR+9+1! - detect only incoming flow

aXGWHR+9+2! - detect only outgoing flow

4.2.5.4 *X COMMANDS WHICH USE THE MODBUS REGISTER*

There are several X-commands which can be used to read or write values directly from or to the Modbus register. In order to use these commands, refer to Table 4-5: Retrieving Data from the Sensor and 4-6: Writing Data to the Sensor to determine the Modbus address of the desired data.

> **IMPORTANT!** In the following commands the register address, denoted by “d” or “d1” must be replaced with a numeric value not the hexadecimal value listed in the “Data Start Addr” column of Tables 4-5 and 4-6.

To convert the hexadecimal value to the numeric value refer to Table 4-8 :

DEFINITION	X COMMAND	RESPONSE AND DETAILS
Read Modbus holding register	aXGRHR+d!	Response: a<val0> val0 = number of seconds to wait until the holding register is available for reading +d = register address
Read Modbus input register	aXGRIR+d!	Response: a<val0> val0 = number of seconds to wait until the input register is available for reading +d = register address
Read last value	aXGRMV!	Response: a<val0> val0 = the last received Modbus value requested by aXGRHR+d! or aXGRIR+d!
Write Modbus holding register	aXGWHR+d1+d2!	Response: a<val0> val0 = written value +d1 = holding register address +d2 = value

Table 4-8: Convert Hexadecimal Modbus Register to Numeric Value

Hexadecimal Modbus Register Address	Numeric Value	Hexadecimal Modbus Register Address	Numeric Value	Hexadecimal Modbus Register Address	Numeric Value
0X0000	0	0000A	10	0X0014	20
0X0001	1	0X000B	11	0X0015	21
0X0002	2	0X000C	12	0X0016	22
0X0003	3	0X000D	13	0X0017	23
0X0004	4	0X000E	14	0X0018	24
0X0005	5	0X000F	15	0X0019	25
0X0006	6	0X0010	16	0X001A - 0X0099	26-153
0X0007	7	0X0011	17	0X009A - 0X0119	154-281
0X0008	8	0X0012	18	0X011A - 0X0199	282-409
0X0009	9	0X0013	19	0X019A - 0X0219	410-537

Additional Addresses from the Write Register:

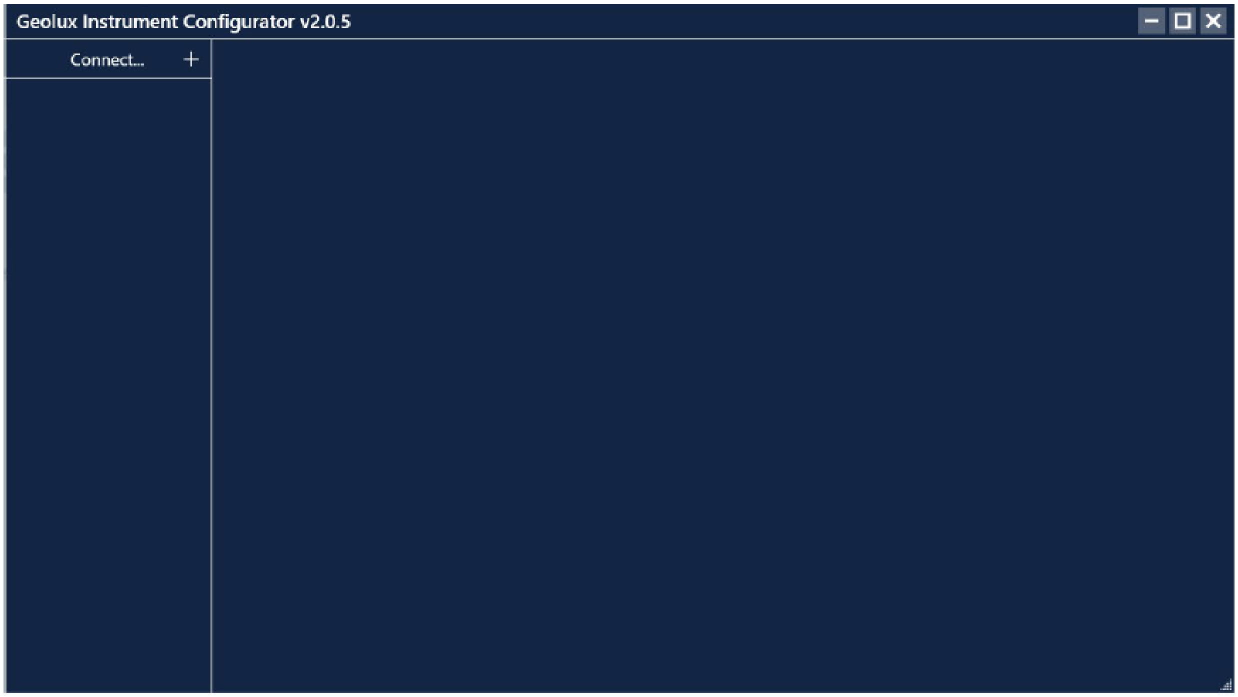
0X0011 - 0X0090	17-144
0X0091 - 0X0110	145-272

Chapter 5 RADAR CONFIGURATOR

The radar configurator is a user-friendly PC application for configuring the flow meter operating parameters. Additionally, the Configurator Utility displays current flow measurements. The configurator can be downloaded here under SOFTWARE:

https://www.geolux-radars.com/rss-2-300-w.html

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.



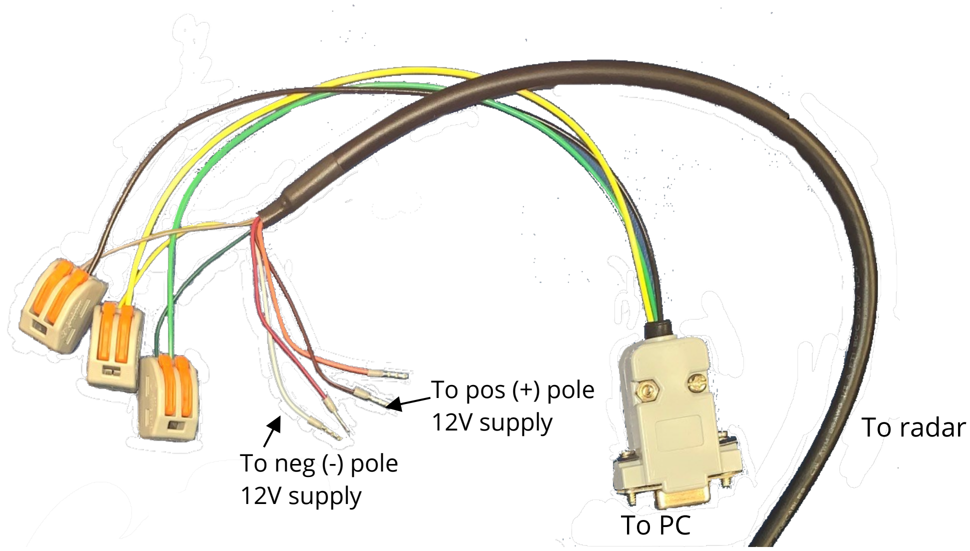
5.1 CONNECTING THE RADAR TO THE CONFIGURATOR

1) Connect the RS-232 serial cable to the radar cable as shown in Figure.5-1.

NOTES:

a) RS485 connections (orange and dark red wires) are not required for connection to the configurator software.

b) The radar should not be powered from the Geolux SDI interface as the interface turns the power to the radar off after a period of inactivity. Instead, the power connections should be made directly to a +12V supply as shown in Figure 5-1.



1) Connect the green wire (RS232 – TxD) from the radar to the green wired terminal clip
2) Connect the yellow wire (RS232 – RxD) from the radar to yellow wired terminal clip
3) Connect the grey wire (GND) from the radar to the black wired terminal clip
4) Connect the brown wire to the positive pole of a 12V power supply
5) Connect the white wire (Gnd) to the negative pole of a 12V power supply

Figure 5-1: Connecting RS-232 serial cable

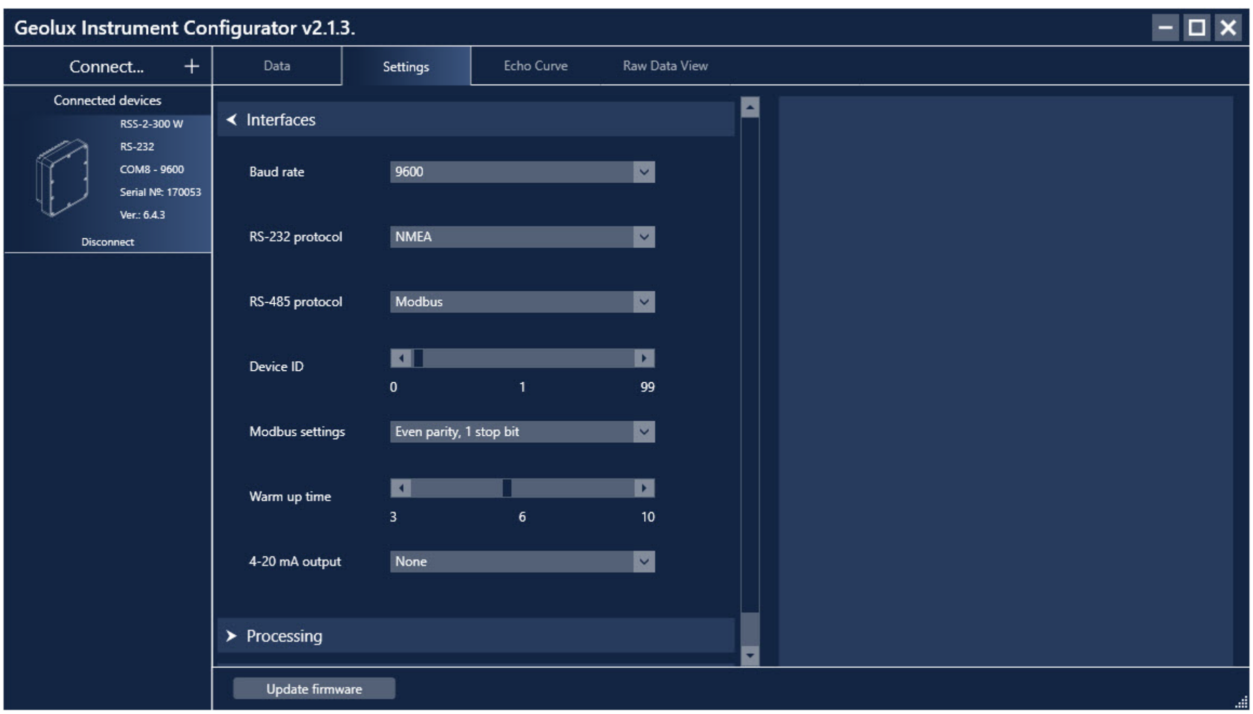
2) Connect the radar DB9 dongle to your PC comm port.

3) Select the *Radar* > *Connect* menu option in the Configurator and choose the appropriate COM port number.

4) 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:

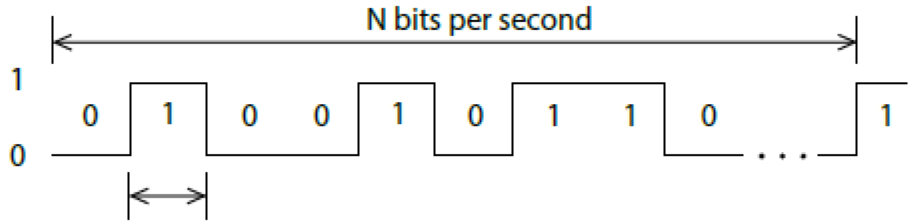
5.2 SURFACE VELOCITY RADAR SETTINGS

5.2.1 INTERFACES



Baud Ratel: Configures the setting controls how many bits are sent on the communication line in one second. The available values are standardized. Using higher baud rate over longer lines may introduce errors in transferred data. The default instrument baud rate is 9600 bps.

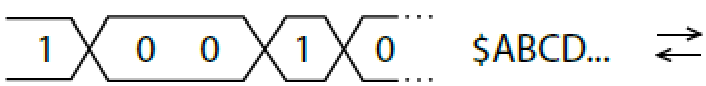
Baud rate



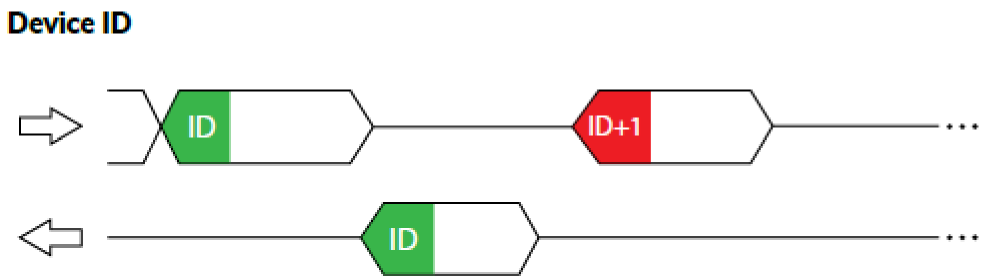
RS-232 protocol: Selects the communication protocol to be used for data communication on RS-232 interface. The NMEA protocol is a GPS-like human readable messaging protocol where each data packet contains a checksum for data integrity verification. SDI-12 protocol is used for interfacing older type of Geolux SDI-12 adapters. Unless the instrument is connected to an older Geolux SDI-12 adapter, NMEA protocol must be selected.

RS-232 protocol: Selects the communication protocol to be used on RS-485 half-duplex interface. HS protocol is a simple request-response protocol for the simplest applications. Modbus RTU protocol is a standardized protocol which is commonly used in automation and instrumentation as it provides all measurements with detailed diagnostics of device operation and the possibility to change the instrument's operating parameters

RS-232 and RS-485 Protocol

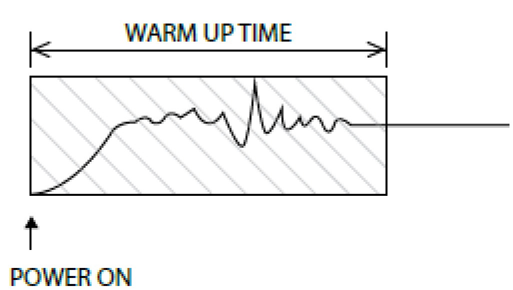


Device ID: Configures the device (slave) ID to be used on RS-485 interface protocols (Modbus RTU or HS). Both protocols use request/response format and allow multiple instruments to be connected on the same bus. When a remote master transmits the request message, it will use the device ID as a device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



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

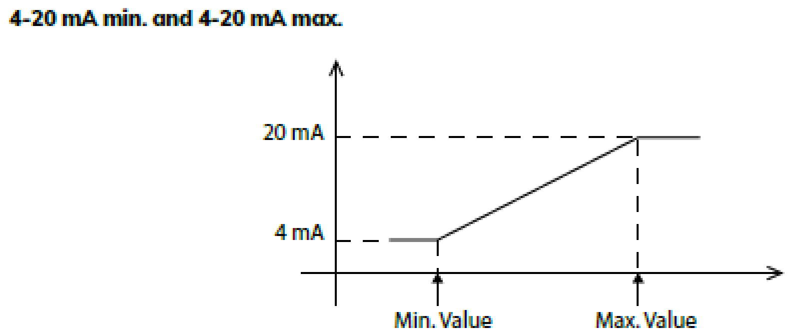
Warm Up Time: The time after sensor power-up, during which all measurements are ignored. This time is used to settle auto-gain parameters, Kalman filter values, averaging filter, and all other operational parameters. It is recommended to set this value to a minimum of 5 seconds. In extreme cases where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



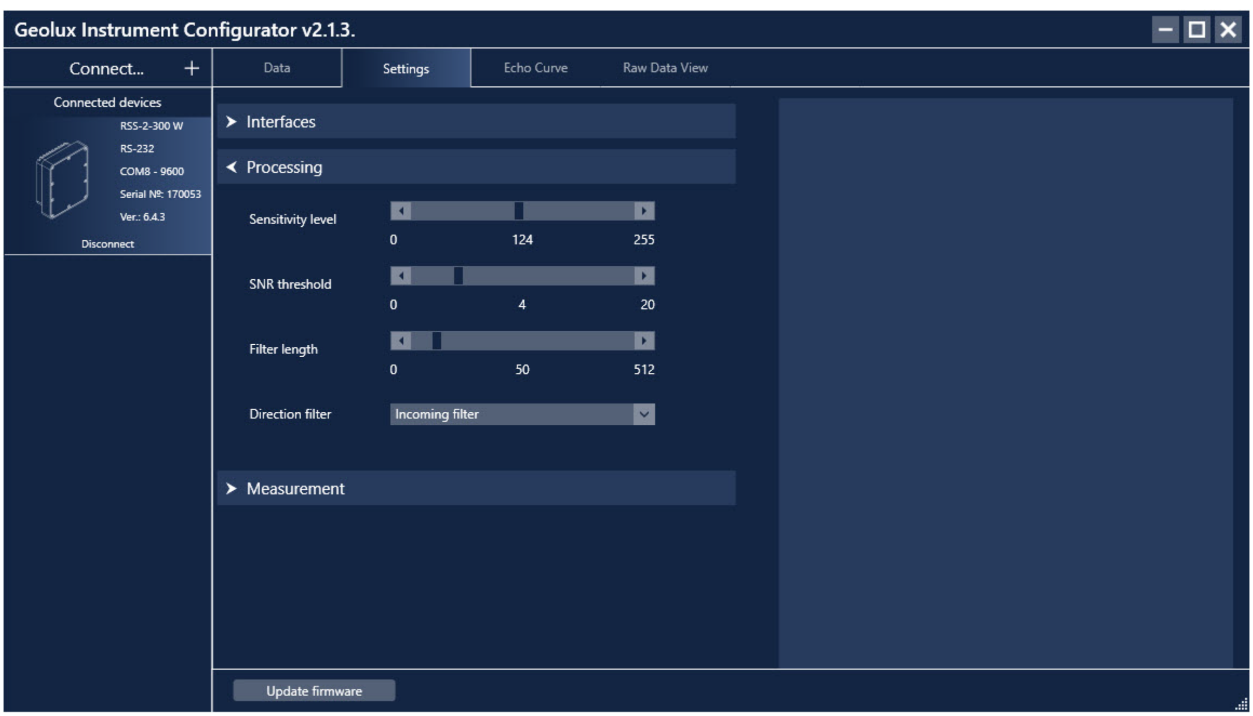
4-20 mA Output: This parameter is used to select the value that will be presented on the 4 – 20 mA output. When velocity is selected the output current will be proportional to the measured velocity. When none is selected 4 - 20 mA output will be disabled.

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

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

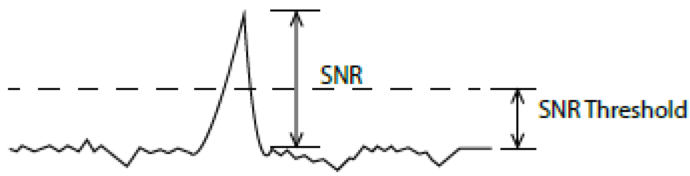


5.2.2 PROCESSES



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

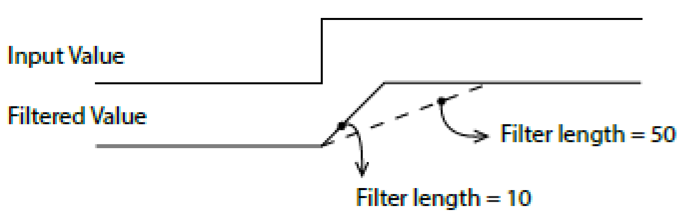
Sensitivity level



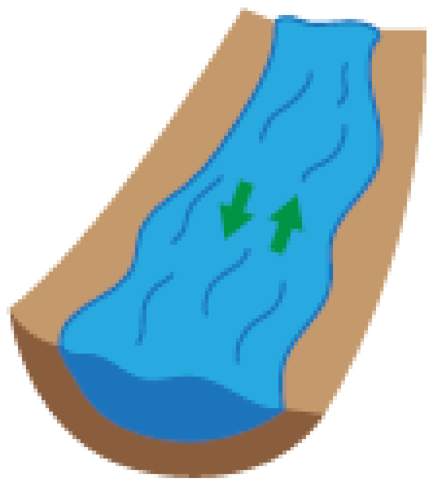
SNR threshold: The minimal Signal to Noise Ratio that is required to detect the water flow. If the actual measured SNR is lower than the threshold, the instrument will not report any flow. Setting SNR threshold to a higher value will result with more robust measurements but may also result with no measurements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

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

Filter Length



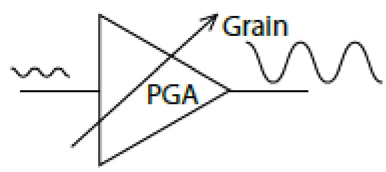
Direction filter: Direction filter is used to choose whether the instrument will detect flow in both directions, or if it should detect only incoming or only outgoing flow. If the direction filter is set to both directions, the instrument will measure the flow velocity in any direction and will also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



5.2.3 MEASUREMENT

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

PGA Sensitivity: This parameter limits the maximum gain (amplification level) of the internal programable gain amplifier. It is strongly recommended to use the default value 9, which allows the internal signal amplifier to use the maximum gain when the reflected radar signal is very low. Setting this value to a lower value is used only when the instrument is mounted very close to the water surface, typically less than 1 meter, and in that case this parameter should be set to a value 4 or 5.



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

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

Chapter 6 CALCULATING DISCHARGE FROM FLOW VELOCITY

The 300W 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 the 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 an ideal case, let us assume the rectangular channel profile, with constant flow velocity at all points, as in Figure 7-1.

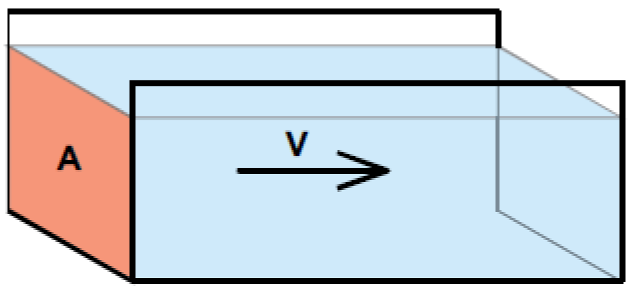


Figure 6-1: Simple Channel Diagram

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 figure 7-2.

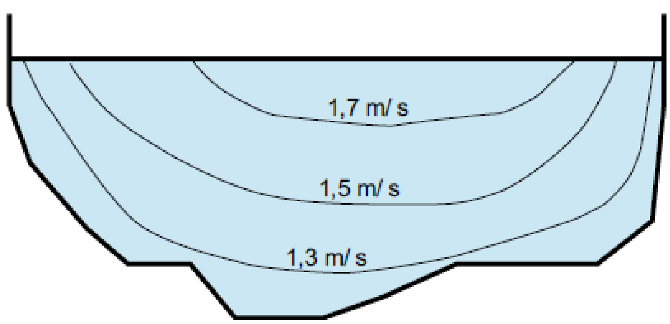


Figure 6-2: Flow Velocity in a Typical Cross-section

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 the 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://s3.amazonaws.com/Product_Sensors/701-Technotes3-Surface+Flow.pdf

Chapter 7 TECHNICAL SPECIFICATIONS

Characteristics and Performance Data	
Radar Type	Doppler
Measuring Frequency	24.075-24.175GHz (K band) 24.125 Ghz (typical)
Emitted HF Power (EIRP)	20 dBm
Beam Angle (3dB)	12º Azimuth 24⁰ elevation
Maximum Installation Height	15m (49.2ft)
Resolution	0.001 m/s (0.002 miles/h)
Accuracy	1%
Sampling Frequency	10 samples per second
Measurement Range	0.02 – 15.0 m/s (0.066 – 49.21 ft/s)
Angle compensation	0 - 75º 30º (typical)

Power	
Supply Voltage	9 – 27 VDC 12.0 (typical)
Power Consumption	950 mW operations 85 mW standby
Maximal Current	<250mA
Alarm output maximal current	60 mA
Alarm output maximal voltage	30 VDC
Analog output maximal voltage	30 VDC
SDI-12	6 mA typical @ 12 Vdc with 15 minute reading

Communication Interface	
Serial Interface	1 x serial RS-485 half-duplex 1 x RS-232 (two wire interface) SDI-12 (using the SDI-12 adapter)
Serial Baud Rate	9600 bps – 115,200 bps
Serial Protocols	ASCII-S GLX-NMEA Modbus-RTU SDI-12 (using the SDI-12 adapter)
Analog Output	1 x 4-20 mA
Alarm Output	1 x open collector, max 50V 200mA

Physical	
Operating Temperature Range	-40º - +85ºC (-40º - +185ºF) (without heating or coolers)
Ingress Protection Rating	IP68
Connector	M12 circular 12-pin
Enclosure Dimensions	110mm x 90mm x 50mm (4.33in x 3.54in x 1.97in)

Appendix A SDI-12 ADAPTER

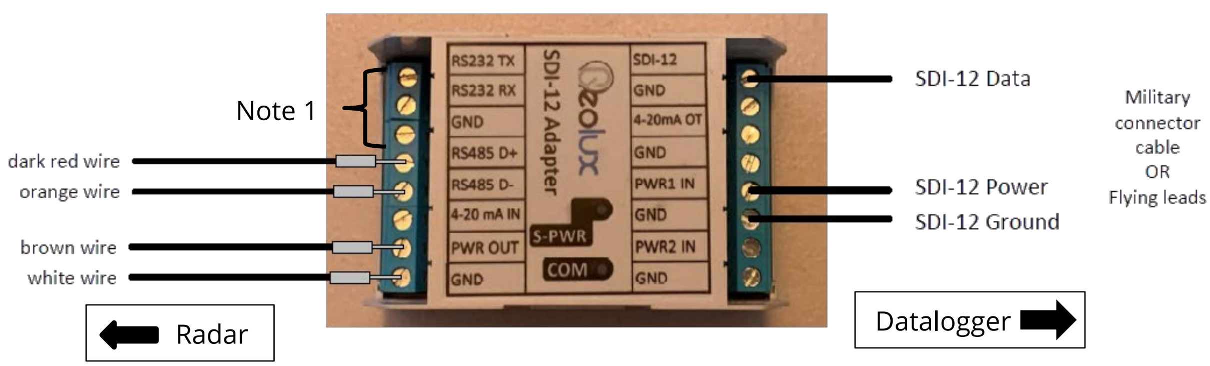
The SDI-12 Adapter is an interface device which provides SDI-12 connectivity to devices that have no SDI-12 native support. The adapter is versatile and designed to support Modbus on the sensor side. Additionally, it is equipped with DC SSR for controlling power supply for sensors that do not support low power mode. Details of SDI-12 Commands can be found in Chapter 4, section 4.2.5.

A.1 ELECTRICAL CHARACTERISTICS

Parameter	MIN	TYP	MAX	Unit
Power supply voltage	9.0	12.0	27.0	V
Power Operational mode Sleep mode		 950 85		 mW mW
Power output maximal current			2.0	A
Analog output maximal voltage			30	VDC
Analog input maximal current			22	mA
Operational temperature range	-40 -40		+85 +185	°C °F
Ingress Protection Rating	IP54			
Mechanical		75x45x50 3 x 1.8 x 2		mm in

A.2 CONNECTING TO THE SDI-RADAR-300W

Wire the radar and data logger to the SDI-12 Adapter in accordance with Figure A-1. See Table A-1 for relevant pin descriptions.



Note 1: RS232 connections only used when configuring the Geolux SDI Converter (contact FTS for details).

Figure A-1: SDI-12 Adapter wiring diagram

Table A-1: Pin Description

Pin No.	Pin Name	Pin Description	Connect To	
Left 4	RS485 – D+	RS-485 to radar	Dark red wire (D+) on radar cable	
Left 5	RS485 – D-	RS-485 to radar	Orange wire (D-) on radar cable	
Left 7	Power Output	Power output to radar	Brown wire (+Vin) on radar cable	
Left 8	GND	Power ground to radar	White wire (GND) on radar cable	
Right 1	SDI-12	SDI-12 data to data logger	SDI-12 datalogger data line	
Right 5	PWR1 IN	Power supply input 9 VDC to 27 VDC	Main power supply V+	
Right 6	GND	Power ground	Main power supply GND	

Figure A-2: SDI-12 Adapter to radar wiring

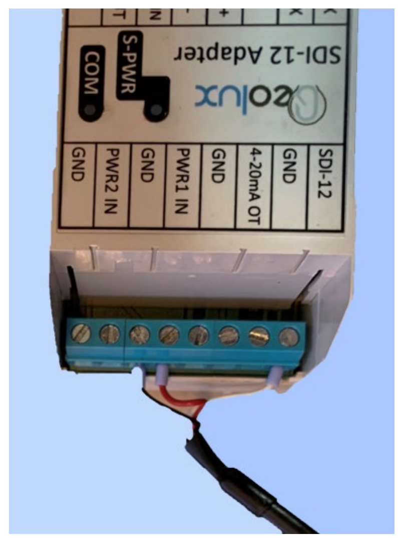


Figure A-3: SDI-12 Adapter to data logger wiring

After all wires are connected and power supply is connected to input, the SDI12 adapter is in initial mode. Its status is indicated by the COM LED.

COM LED	MEANING
Constantly ON	The adapter is communicating with (or attempting to communicate with) a device on the RS-232 input
OFF	After 10 seconds of initial mode, the LED turns off and the adapter reverts to constant operational mode.

A.3 TROUBLESHOOTING SDI-12 ADAPTER ERRORS

In the event that communication is lost between the SDI-12 Adapter and the radar, the SDI-12 datalogger will still be able to communicate with the SDI-12 adapter, but the adapter will not be able to retrieve the data from the radar. This section describes the behavior of the SDI-12 adapter when communication with the radar is lost.

A.3.1 Verification command errors

On initial adapter power-up, the adapter will try to communicate with the radar. If the radar is reachable from the adapter, the adapter will internally store the radar status to **OK;** otherwise the internal radar status will be stored as **ERROR**. This status is not reported, unless the user issues a verify command (aV!).

The second result returned by aD0! Issued after aV! Command will return the last known radar status.

The following command sequence can be used to verify the last known radar status:

1. If the radar status is OK:

   Command : 1V!

   Response : 10002<CR><LF>

   Command : 1D0!

   Response : 1+1+1<CR><LF> (1 = radar error)

2. If the radar status is in ERROR:

   Command : 1V!

   Response : 10002<CR><LF>

   Command : 1D0!

   Response : 1+1+0<CR><LF> (0 = radar error)

Note that the SDI-12 adapter checks the radar status on the initial power-up. If the radar is not connected during the adapter power-up, and then subsequently connected, issuing the Verify command will return the last known radar status, which is ERROR, even though the radar instrument is actually connected and operational. In this case, in order to get the correct status, a measurement command (aM!) followed by a Verify command (aV!) must be issued.

A.3.2 Measurement command errors

When a measurement (aM!) command is issued, the SDI-12 adapter will try to communicate with the radar instrument, regardless of the last saved radar status. If, for example, the radar was not connected initially during the power up, the SDI-12 adapter will internally store the radar status as ERROR; but when the measurement (aM!) command is issued, the SDI-12 adapter will try to power up and communicate with the radar sensor.

After the measurement command is executed, the SDI-12 adapter will update its internal radar status. If the measurement command has been successfully executed, the internal radar status will be updated to OK. If the last measurement command has failed, the SDI-12 adapter will update the radar status to ERROR.

If a subsequent verify (aV!) command is issued, the adapter will return the last known (updated) radar status.

Additionally, if the SDI-12 adapter fails to communicate with the radar instrument after issuing a measurement (aM!) command, the response to Read data command (aD0!) will be empty, even though the measure command has informed the datalogger that 4 values will be ready.

The following command sequence illustrates getting measurements from the radar instrument when the instrument is operational, and when the radar instrument is not properly connected to the SDI-12 adapter:

1. If the radar instrument is fully operational:

   Command : 1M!

   Response : 10154<CR><LF>

   ...

   Command : 1D0!

   Response : 1+1.7+1.64+12+45<CR><LF>

2. If the SDI-12 adapter cannot communicate with the radar instrument:

   Command: 1M!

   Response: 10154<CR><LF>

   Command: 1D0!

   Response : 1<CR><LF>

DOCUMENT REVISION HISTORY

Revision	Date	Description
1	08 Oct 2021	Original
2	30 May 2022	Updated information on SDI-12 Adapter and SDI-12 commands in accordance with Jan 2022 reference manual). Added configurator information (v 2.1.3).