EXTREME ENVIRONMENTS. EXTREMELY RELIABLE.

SDI-RADAR-300WL

Non-Contact Flow Meter

Operating Manual

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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-300WL flow meter, referred to as the 300WL in this manual, uses radar technology to provide precise contactless measurement of surface flow velocity and precise distance (level) measurement from the sensor to the water surface. Contactless radar technology enables quick and simple sensor installation above the water surface and requires minimum maintenance.

Radar level measurement is achieved by transmitting modulated radar wave in 77 to 81 GHz frequency range (W-band) and observing returns. Due to the modulation and detection process in the sensor very precise measurements can be achieved and the sensor is not dependent on the air temperature, humidity or other parameters of the environment.

Surface velocity measurement 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 surface velocity radar 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 2.6). 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]. Distance can be measured in range from 0.2 m to 15 m with resolution of 0.1mm and accuracy of ±2 mm[2]. The integrated tilt sensor measures the inclination angle of the sensors and the flow velocity measurement is automatically cosine-corrected according to the measured mounting tilt angle.

Calculation of the flow (discharge) is done internally by combining surface velocity measurement and level measurement information with the configured cross section of the river or channel. Configuration of the measurement parameters like profile cross section, material of the edges, location of the sensor above the water can be easily set with the configuration application (refer to Chapters 5 and 6). When parameters are set properly the sensor will calculate flow with accuracy around ±1% compared to ADCP measurement for the same location. Measurements of surface velocity and water level will also be available in parallel to the flow readings on sensor digital communication interfaces.

[1] 0.04 mph to 33.55 mph with a precision of 0.02 mph
[2] 7.87 in to 49 ft 2.2 in with a resolution of 0.004 in and accuracy of ±0.08 in

2.2 MEASUREMENT QUALITY INDICATOR

The 300WL constantly calculates signal parameters in the signal processing algorithms and will report measurement quality (signal quality) with the measurement data report. The quality indicator value can be used to better interpret data in the analysis software.
The Measurement Quality Indicator (signal quality) values are:

3->unacceptable,
2 ->low,
1->good,
0->excellent

It is up to every user to interpret the quality indicator value for their application based on their knowledge of the site. The 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.

> **For example:** A radar is mounted on a railway bridge (a common application). Measurements will be of high quality most of the time except when a train is passing due to the extensive vibrations. The radar will still report measurements, but the values could be skewed. However, the measurement quality indicator value for measurements during that time frame will be higher, indicating the data should be questioned.

2.3 RAIN AND WIND

The 300WL 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. However, for sites that has water flow in both directions, the radar sensor should be configured to report both incoming and outgoing flow by selecting the “both direction” setting in the radar sensor.

Additional rain suppression can be implemented by mounting the radar below a structure so that the first 1 to 2 meters in front of the radar are free of rain. As the energy of the radar beam drops exponentially with distance, the radar is most sensitive to the rain directly in front of the radar. If the radar instrument is being mounted on a bridge, if possible, it should be mounted below the bridge instead of on the side of the bridge, so that the bridge provides cover from the rain directly in front of the instrument.

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.

2.4 INTERFERENCE AND MULTIPLE RADARS

The 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 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.

The distance measurement radar operates in the W-band from 77 GHz to 81 GHz with continuous linear frequency modulation within the frequency range. Interference between two or more sensors will require precise coordination of the central frequencies with a timing synchronization in a range of 25 ns between each other. Such synchronization is very complex to achieve so the interference probability between several radars on the same location is very small.

Similarly, is very unlikely that other radiation sources in K band or W band in the vicinity will affect the 300WL 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.

2.5 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 measurement on both sensors, with greater inaccuracies seen on the surface velocity measurements.

The best solution for the surface velocity sensor 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.

The best solution for the distance measurement is to increase the average period to get a better average distance value. As evaporation is a naturally very turbulent event with a significant difference in atmospheric water density over the surface area over time, averaging of the distance measurement spectrum solves the accuracy problem.

2.6 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 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.

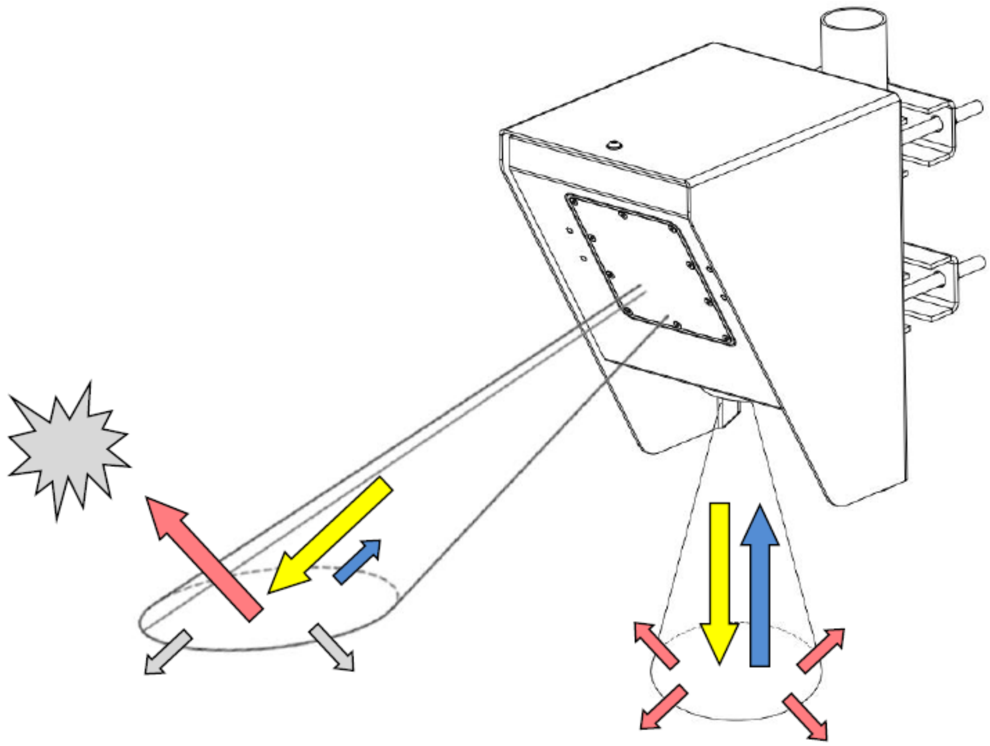


Figure 2-1: Reflected power

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

The situation for the surface velocity radar is little more complex as the angle between the transmitted radar beam (yellow arrow) and water is around 45°. In calmer conditions, most of the power is reflected in the opposite direction from the radar (red arrow) at around a 45°. 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 surface velocity 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.

When selecting the location for the 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 the water channel as this can cause additional inbound reflection to 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.

2.7 SIGNAL STRENGTH

Good signal-to-noise ratio (SNR) is the most important parameter of the radar signal that provides accurate and stable surface velocity measurements. When more radar energy is reflected back from the water surface to the radar sensor, the overall signal strength is higher. When less energy is reflected back, as it is when the water surface roughness is lower, the signal strength is lower. If the amount of noise present in the signal remains the same, when the surface roughness is lower, SNR will drop. To improve SNR internally, the radar uses low-noise programmable gain amplifier (PGA). If the strength of reflected signal is ow, the radar will increase gain level on PGA. If the strength of reflected signal is higher, gain level will be automatically reduced.

The best indication of good signal strength is the PGA value in the radar status report messages. This value is automatically changed with the AGC (automatic gain control) algorithm in the radar. Minimal possible gain is 1 and maximal possible gain is 200. The best measurement results are obtained when the PGA gain level is between 5 and 100; a PGA gain lower than 5 means that the reflected signal is very strong and it can oversaturate the receiver, which could result in reduced accuracy. Gain 200 should be avoided as it is usually an indication of very low reflections from the water surface.

2.8 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 Beam-width (3dB) – Azimuth Beam-width (3dB) – Elevation Measurement range Resolution Accuracy Installation height above H2O	 24.075 - -108 - - 0.02 (0.065) 0.01 (0.032) - - -	 24.125 - -110 12 24 - - - - 1 - -	 24.175 20 -112 - - 15.0 (49.21) - - - 15 (49.2)	 GHz dBm dBm º º m (ft) m/s (ft/s) % m (ft)
Radar Level Sensor Frequency Beamwidth (3dB) – Azimuth Beamwidth (3dB) – Elevation Resolution Accuracy Distance	 77 - - 1 (0.04) - - 0.2 (0.656)	 - 12 12 - - 2 (0.08) -	 81 - - - - - - 15 (49.2)	 Ghz - - mm (in) mm (in) m (ft)
Power supply voltage	9.0	12.0	27.0	V
Power Operational Mode Sleep Mode	 - -	 1650 350	 - -	 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)
Angle compensation	0	30	75	deg
Installation height above water	0.2 (0.656)	- -	20 (65.6)	m (ft)
Sample Rate Discharge Velocity	 - -	 1 10	 - -	 sps sps
Ingress protection rating	IP68	-	-	-
Mechanical	- -	150x200x250 (5.9x7.87x9.84)	- -	mm (in)

2.9 CABLE PIN-OUT AND WIRING

The sensor is supplied with an open-end cable consisting of 12 wires coded as shown in Table 2-2. 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.

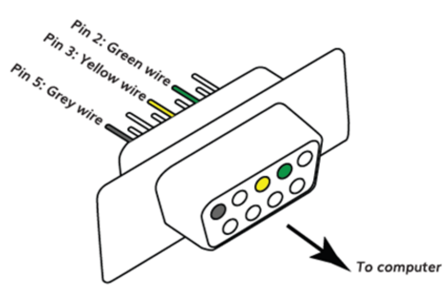
Table 2-1: Cable wiring codes

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.
4	Yellow	RS232 – RxD	RS-232 data receive signal.
5	Grey	GND	Signal ground.
6	Pink	CAN – H	CAN2.0B high signal (optional)
7	Blue	CAN – L	CAN2.0B low signal (optional)
8	Red	SDI-12 Data	SDI-12 Data line
9	Orange	RS485 – D-	RS-485 data transmitter/receiver low signal.
10	Dark Red	RS485 – D+	RS-485 data transmitter/receiver high signal.
11	Black	Alarm1 SW or 4-20mA secondary (optional)	Alarm 1 – open collector switch signal max. 60mA
12	Purple	4-20 mA	Sink for 4-10 mA analog interface. Connect sensing device as pull-up to sink the current

2.10 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.

When the RS-232 interface is connected to a standard DB-9 PC connector, the TxD line (green wire) is connected to pin 2 and the RxD (yellow wire) is connected to pin 3. In order for the serial interface to operate properly, an additional connection of the signal GND (grey wire) is needed on pin 5 of the DB-9 connector.



2.11 SERIAL RS-485 INTERFACE

Serial RS-485 interface is implemented as standard industrial half-duplex communication interface. Communication interface is internally protected against short-circuit and overvoltage. 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, consult the receiver specification.

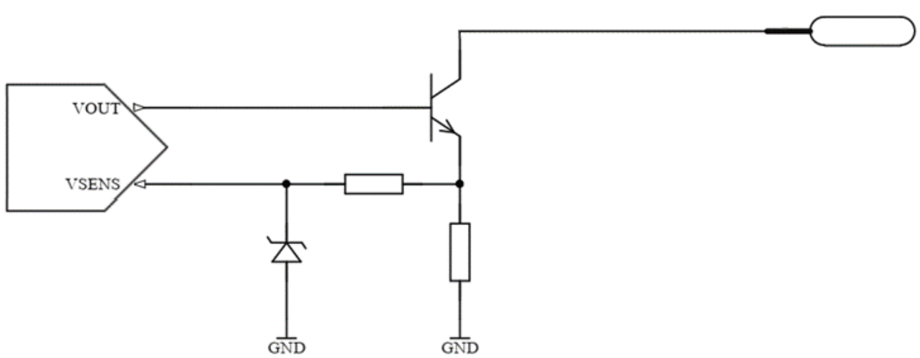
Most common communication protocol used with RS-485 interface is Modbus-RTU but other protocols are also available. Details of communication protocols are described later in this manual.

2.12 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 the setup application so the sensor will be able to signal the best suitable value range with the available current range.

The sensor’s current step has a limiting resolution of 0.3 µA. Ensure the minimal and maximal values representing 4 mA and 20 mA have sufficient resolution for system requirements.



Chapter 3 INSTALLATION

3.1 SITE SELECTION AND FEATURES

When determining where to mount the 300WL a direct, unobstructed line to the water surface is available for both the surface velocity sensor and the level sensor. Any close object in the vicinity of the sensor can reduce accuracy and introduce offsets in measurements. The best practice is to have a 1m zone around both sensors clear of obstructions.

The height of the instrument above the water surface and the inclination determine the area on the surface that is covered by the radar beam (see Section 3.2). This measurement area should be clear of any obstacles. There should be no vegetation between the radar and the measurement area because it could affect measurement accuracy.

Additionally, for the level meter, the water surface directly below the unit should be calm, clean of vegetation, rocks, sand deposition or other obstacles that could affect measurement. The surface velocity radar should be pointed upstream (water flowing towards the radar).

The structure holding the instrument (pole, bridge fence, etc.) must be solid and without vibrations. Vibrations of the mounting structure can affect the sensor's ability to eliminate detected obstacles resulting in inaccurate measurements. Vibrations should be avoided or reduced by any applicable means. If mounting at a site that has periodic vibrations (i.e. train bridge) be aware of the measurement quality indicator during a vibration period in order to determine the reliability of the data. Details can be found in Section 2.1.

Installations where pedestrians, cars or other objects are moving in front of the flow sensor closer than 75 m should be avoided to prevent reflected power from those objects being received by the radar and significantly affecting measurement accuracy (refer to in Section 2.6 and Figure 2-1 for a detailed explanation).

3.2 DETERMINING RADAR FOOTPRINT

The radars' paths and footprints are calculated based on 3 dB signal drop (half signal power) due to the antenna pattern. Most of the return energy is reflected from the inside of the calculated footprints (ellipse for the surface velocity sensor and circle for the level sensor – see Figure 3-1), but some energy could be also received from objects outside of the footprint. Although the sensors have an internal signal processing algorithm to filter such reflections, large objects close to the footprint perimeter can cause some measurement inaccuracies. Therefore, it is recommended to keep the zone around the target shape of the radars as clear as possible for the best measurement accuracy.

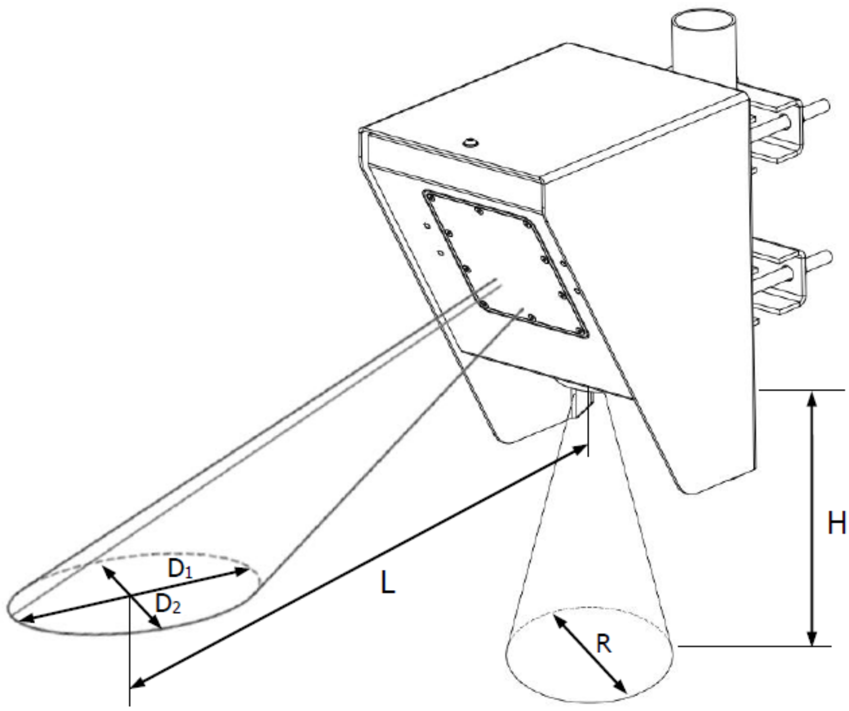


Figure 3-1: Radars' paths and footprints

Table 3-1: Calculation of Sensor Footprints

METRIC					IMPERIAL				
Height[H]	L [m]	D_1 [m]	D_2 [m]	R [m]	Height[H]	L [ft]	D_1 [ft]	D_2 [ft]	R [ft]
0.3 m	0.3	0.3	0.2	0.06	0.98 ft	0.98	0.98	0.66	0.20
0.5 m	0.5	0.5	0.3	0.11	1.64 ft	1.64	1.64	0.98	0.36
1 m	1.0	0.9	0.3	0.21	3.28 ft	3.28	2.95	0.98	0.69
2 m	2.0	1.8	0.6	0.42	6.56 ft	6.56	5.9	1.97	1.38
3 m	3.0	2.7	0.9	0.63	9.84 ft	9.84	8.86	2.95	2.07
4 m	4.0	3.6	1.2	0.84	13.12 ft	13.12	11.81	3.94	2.76
5 m	5.0	4.5	1.5	1.05	16.4 ft	16.4	14.76	4.92	3.45
6 m	6.0	5.3	1.8	1.26	19.69 ft	19.69	17.39	5.90	4.13
7 m	7.0	6.2	2.1	1.47	22.97 ft	22.97	20.34	6.89	4.82
8 m	8.0	7.1	2.4	1.68	26.25 ft	26.25	23.29	7.87	5.51
9 m	9.0	8.0	2.7	1.89	29.53 ft	29.53	26.25	8.86	6.20
10 m	10.0	8.9	3.0	2.10	32.81 ft	32.81	29.20	9.84	6.89
11 m	11.0	9.8	3.3	2.31	36.01 ft	36.01	32.15	10.83	7.58
12 m	12.0	10.7	3.6	2.52	39.37 ft	39.37	35.10	11.81	8.27
13 m	13.0	11.6	3.9	2.73	42.65 ft	42.65	38.06	12.80	8.96
14 m	14.0	12.5	4.2	2.94	45.93 ft	45.93	41.01	13.78	9.65
15 m	15.0	13.4	4.5	3.15	49.21 ft	49.21	43.96	14.76	10.34

3.3 INSTALLATION POSITION

Ensure the selected site and radar paths meets the criteria as described in Sections 3.1 and 3.2.

The minimum mounting height above the water's surface is 0.2 m; however, it is recommended to mount the sensor from 0.5 m – 15 m above the water's surface. Sensor should be mounted on a vertical pole with inclination tolerance of ±5° to the vertical plane reference.

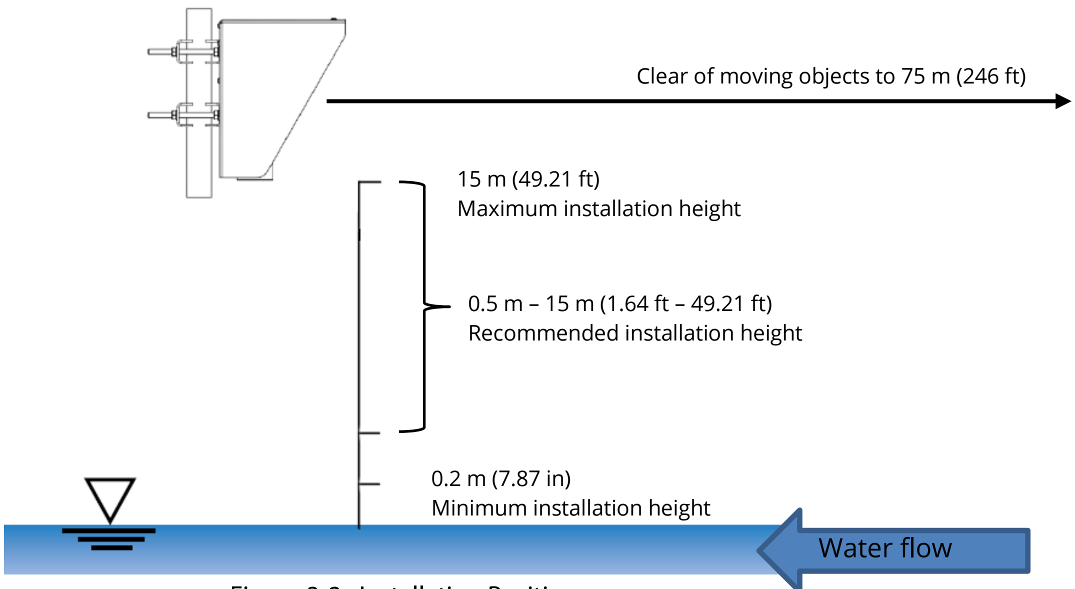


Figure 3-2: Installation Position

For optimal operation and results, the velocity sensor should be pointed directly upstream, so that the water flows towards the instrument and with the radar beam parallel with the water flow (see Figure 3-3). Any deviation from the parallel water flow direction will introduce an offset to the measurement value and the measured value will be lower than the actual surface velocity of the water.

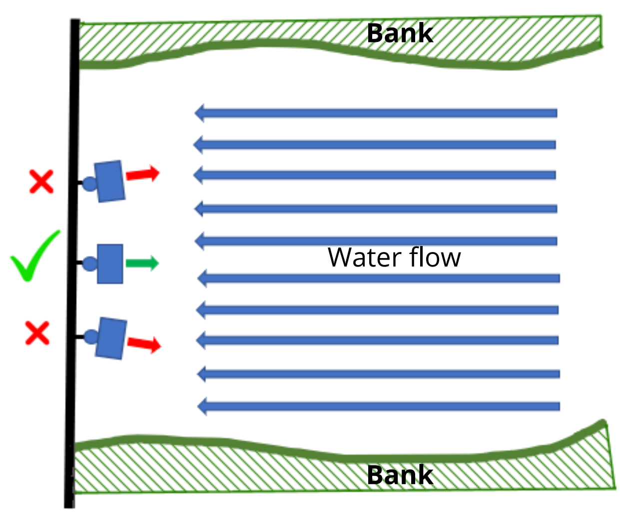


Figure 3-3: 300WL mounting position relative to water flow – aerial view

Additionally, moderate waviness of the water surface will improve the velocity measurements. 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 the monitoring site, then the filter length of the radar should be configured to 120 or more.

Chapter 4 DATA INTERFACES AND PROTOCOLS

4.1 SERIAL INTERFACES

The 300 WL 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 unit with a computer. The serial interface is used both for retrieving measurements and for configuring the device using the PC application (see Chapter 5).

Default communication parameters are:

Bitrate: 9600 bps
Data bits: 8
Stop bits: 1
Parity: None

An NMEA-like communication protocol is used to deliver flow measurements over the RS-232 interface. Detailed description of the protocol is given in the Section 4.2.

4.1.2 SERIAL RS-485 INTERFACE

The serial RS-485 interface is used for connecting multiple flow meters 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: 9600 bps
Data bits: 8
Stop bits: 1
Parity: None

4.2 DATA PROTOCOLS

The 300 WL supports the following data protocols

1) NMEA protocol on RS-232 interface that constantly outputs the detected speed, reflected signal power, and 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 RTU protocol on RS-485 interface which is supported by a variety of third-party data loggers
5) SDI-12 protocol on the SDI-12 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 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[3] is reported as speed*10 for m/s, km/h, mph, fps, fpm and as speed*1 for mm/s).
L1:	The detected level of the signal reflection from the water surface.
CSUM:	The check sum of the characters in the report from $ to * excluding these characters.

Average flow measurement report: $RDAVG,S1*CSUM<CR><LF>

$RDAVG:	The keyword sent 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 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.

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

Signal SNR 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

Water level report: $LVL,L1,L2,T1,L3,L4,S*CSUM<CR><LF>

$LVL:	The keyword sent on the beginning of each level report.
L1:	Current distance from sensor to water, in defined units, 0 being sensor reference plane. If reporting -4 then there is no detected level.
L2:	Average distance from sensor to water, in defined units, 0 being sensor reference plane. If reporting -4 then there is no detected level.
T1:	Electronic temperature (in °C).
L3:	Current relative detected level, in defined units, 0 being sensor reference plane.
L4:	Average relative detected level, in defined units, 0 being sensor reference plane.
S:	Measurement SNR (in dBm).
CSUM:	The check sum of the characters in the report from $ to * excluding these characters.

Discharge report: $DIS,D*CSUM<CR><LF>

$DIS:	The keyword sent on the beginning of each discharge report.
D:	The measured discharge, in defined units.
CSUM:	The check sum of the characters in the report from $ to * excluding these characters.

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.

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 Configurator utility is described in Chapter 5.

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 SNR threshold: 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.

#set_thld_snr=<0-5120>

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=19200
#set_baud_rate=38400
#set_baud_rate=57600
#set_baud_rate=115200

Change RS485 protocol: Changes the parameter that specifies the protocol on RS-485.

#set_485_proto=modbus_rtu
#set_485_proto=hs
#set_485_proto=geolux

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

#set_filter_len=<1-1000>

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

#set_can_id=<0-99>

Set output type for 4-20mA: Configure the 4-20mA output type.

#set_420_type=none
#set_420_type=velocity
#set_420_type=level
#set_420_type=discharge

Set output value for 4-20mA: 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_420_min=<value>

#set_420_max=<value>

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

#set_dead_time=<3-100>

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

#set_power_save=1 (go to power save)

#set_power_save=0 (left power save)

Set SDI-12 sleep mode: Configure if device is in sleep mode after retrieving data from SDI12 data line.

#set_sdi12_sleep=0

#set_sdi12_sleep=1

Change discharge units type: Sets the units type in which the discharge is reported.

#set_discharge_units=liters
#set_discharge_units=m3s
#set_discharge_units=ft3s

Change level units type: Sets the units type in which the level is reported.

#set_lvl_units=mm
#set_lvl_units=cm
#set_lvl_units=m
#set_lvl_units=in
#set_lvl_units=ft

Set level dead zone settings: Changes the dead zone of the sensor. Objects under dead zone min and over dead zone max will not be registered. Setting is set in level units and value number is accepted as float.

#set_lvl_deadzone_min=<0-level range> #set_lvl_deadzone_max=<0- level range>

Set output value for level 4-20mA: Configure the 4-20mA output minimum value for 4mA and maximum value for 20mA. Setting is set in level units and value number is accepted as float.

#set_lvl_420_min=<value>
#set_lvl_420_max=<value>

Set level filter type: Changes the level filter type: 0 – none, 1 – IIR, 2 – window

#set_lvl_filter_type=<0-2>

Set level filter length: Changes the level window length (in samples) for moving average filter. Accepts integer values

#set_lvl_filter_len=<0->

Set level sensor height: Two options: relative to bottom of riverbed or relative to staff gauge

1) Set sensor height relative to the bottom of the riverbed. The sensor will output relative measurement of the actual water level based on its height above the riverbed. Setting is set in level units and value number is accepted as float.

#set_lvl_sensor_height=<0->

2) Set sensor height relative to the measurement using staff gauge. The sensor will output relative measurement of the actual water level based on its height above the riverbed. Setting is set in level units and value number is accepted as float.

#set_lvl_staff_gauge=<0->

Retrieve current device status: Requests the current device status.

#get_info

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
sdi12_sleep:0
discharge_units:liters
lvl_units:mm
lvl_filter_type:2
lvl_filter_len:32
lvl_deadzone_min:200.000
lvl_deadzone_max:15000.000
lvl_420_min:0.000
lvl_420_max:15000.000
lvl_sensor_height:0.000

4.2.3 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 Configurator Utility. Refer to Chapter 5 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 with the current averaged flow velocity measurement.

4.2.3.1 *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>.

LEVEL: The level readout in meters, formatted as real (float) number with exactly three digits after the decimal dot separator.

For example, if the current averaged level is 5.7143, it will be reported as 5.714, or in HEX values: <0x35><0x2E><0x37><0x31><0x34><0x33>.

CSUM: Checksum, calculated by adding in modulo 256 the two byte values of the ID and All byte values from the SPEED.

Second possible command is sent 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 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, device goes to power safe mode

Third possible command is sent 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 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, device goes to normal operation mode from power safe mode.

4.2.3.2 *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#LVLTEMP#ANGLE#LEVEL#DISCH$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.

LVLTEMP: Temperature on level senor device, in degrees Celsius.

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

LEVEL: The measured tilt angle, in meters.

DISCH: The measured discharge, in m3/s.

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

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 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 the 300 WL) respond. 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 4→ 19200	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→ incoming 1→ outgoing	Read flow direction
	0X0007	2 bytes	1-512	Read averaging length

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

Function	Data start Addr	Data Length	Data Range	Detail
0X03	0X0008	2 bytes	0-8	Read defined PGA gain sensitivity
	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	1	Read device type, always 1
	0X000C	2 bytes	0-3840	Read SNR threshold (dBm * 256)
	0X000D	2 bytes	621	Read firmware code 6.2.1
	0x000E	2 bytes	1,2,5,10,20,50, 100,200	Read current gain level
	0x000F	2 bytes	0-2047	Read relative signal strength
	0x0010	2 bytes	0 – 65535	Read instantaneous speed in selected unit (integer part)
	0x0011	2 bytes	0 –65535	Read instantaneous speed in selected unit (decimal part * 1000)
	0x0012	2 bytes	0-65535	Read averaged speed in selected unit (integer part)
	0x0013	2 bytes	0-65535	Read averaged speed in selected unit (decimal part * 1000)
	0x0014	2 bytes	0-10000	Read instantaneous SNR level (dBM * 256)
	0x0015	2 bytes	0-10000	Read averaged SNR level (dBM * 256)
	0x0016-0x001F	2 bytes	0	Reserved, always 0
	0x0020	2 bytes	0-65535	Read calculated water discharge, integer part in defined units
	0x0021	2 bytes	0-65535	Read calculated water discharge, decimal part in defined units
	0x0022	2 bytes	0-65535	Read distance to water surface, integer part in defined units
	0x0023	2 bytes	0-65535	Read distance to water surface, decimal part in defined units
	0x0024	2 bytes	0-65535	Read measured water level, integer part in defined units, relative to defined staff gage zero
	0x0025	2 bytes	0-65535	Read measured water level, decimal part in defined units, relative to defined staff gage zero
	0x0026	2 bytes	0-10000	Read level sensor SNR level (dBM * 256)

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

Function	Data start Addr	Data Length	Data Range	Detail
0X03	0x0027	2 bytes	0-150	Read temperature from level sensor (celsius)
	0x0028	2 bytes	0-200	Read number of frames for level window filtering
	0x0029	2 bytes	0→no filter 1→IIR filter 2→window filter	Read level filter type
	0x002A	2 bytes	0-1000	Read level IR filter constant IR_const = value / 1000
	0x002B	2 bytes	0-level range	Read level dead zone minimum in defined units
	0x002C	2 bytes	0-level range	Read level dead zone maximum in defined units
	0x002D	2 bytes	0→mm 1→cm 2→m 3→in 4→ft	Read level unit type
	0x002E	2 bytes	0→m^3/s 1→liters 2→ft^3/s	Read discharge unit type

Table 4-6: Writing Data to the Sensor

Function	Data start Addr	Data Length	Data Range	Detail
0X06	0X0000	2 bytes	1~255	Change sensor ID
	0X0001	2 bytes	0→9600 1→38400 2→57600 3→115200 4→19200	Change baud rate
	0X0002	2 bytes	0→mm/s 1→m/s 2→mph 3→km/h 4→fps 5→fpm	Change velocity unit type
	0X0007	2 bytes	1-512	Change averaging length
	0X0008	2 bytes	0-8	Change PGA gain sensitivity
	0X0009	2 bytes	0→both 1→incoming 2→outgoing	Change flow direction filter type

Table 4-6: Writing Data to the Sensor (continued)

Function	Data start Addr	Data Length	Data Range	Detail
0X06	0000A	2 bytes	0-8	Change PGA sensitivity
	0X000C	2 bytes	0-3840	Change SNR threshold (dBm * 256)
	0x0028	2 bytes	0-200	Change number of frames for level window filtering
	0x0029	2 bytes	0→no filter 1→IIR filter 2→window filter	Change level filter type
	0x002A	2 bytes	0-1000	Change level IR filter constant IR_const = value / 1000
	0x002B	2 bytes	0 - level range	Change level dead zone minimum in defined units
	0x002C	2 bytes	0 - level range	Change level dead zone maximum in defined units
	0x002D	2 bytes	0→mm 1→cm 2→m 3→in 4→ft	Change level unit type
	0x002E	2 bytes	0→m^3/s 1→liters 2→ft^3/s	Change discharge unit type

4.2.5 SDI-12PROTOCOL

The 300WL is capable of reading and writing with the standard set of SDI-12[4] commands. The following basic SDI-12 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 (!).

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"

[4] *For a detailed explanation of SDI-12 protocols and commands refer to SDI-12 Specification, Version 1.3 at* http://www.sdi-12.org

Name	Command	Response and Details
Send Identification	aI!	a13ccccccccmmmmmmvvvxxx . . . xxx 13 - the SDI-12 version number cccccccc - 8 character vendor identification mmmmmm - 6 characters specifying the sensor model number vvv - 3 characters specifying the sensor firmware version
Start Verification	aV!	One value is ready imminently. 0 indicates not ready 1 indicates ready Verification values can be retrieved by the Send Data Command
Send Data Send Additional Data	aD0! aD1!...aD9!	a+values

4.2.6 MEASUREMENT COMMANDS

This command tells the sensor to take a measurement. The sensor returns the time until one or more measurements will be ready and the number of measurements that it will make. It does not return the measurement to the data recorder after this command. The send data (D0!) command must be issued to get the measurement(s).

COMMAND(S)	RESULTS
aM! aMC! aC! aCC!	ammm9 ammm12 mmm = number of seconds before measurements will be ready 9 or 12 = number of values that will be returned (9 values for M command, 12 values for C (concurrent measurement) command)
aD0! (for M and C commands)	a±f±f+d+d+d ±f - discharge in defined units ±f - average velocity in defined units +d - average SNR in dBm +d - angle in dBm +d - signal quality (3->unacceptable, 2 ->low, 1->good, 0->excellent)
aD1! (for M and C commands)	a±f±f+d±f ±f - relative level depending on sensor height in defined units ±f - distance from sensor to water in defined units ±d - level SNR in dBm ±f - standard deviation of water level in mm
aD2! (for C commands only)	a±d+d+d ±d – internal device temperature in °C +d – measured tilt angle of device in x direction +d – measured tilt angle of device in y direction

4.2.7 X COMMANDS

In addition to the standard set of commands the SDI-RADAR-LX-80 has an extension of custom SDI commands called X commands that access specific features of the sensor.

The format of X commands follows the requirement for standard SDI commands in that the first character of every command must be a sensor address which is then followed by the X command and terminated by an exclamation mark. Likewise, the first character of a response is also the address character.

Set commands should normally be followed by a get command to verify the parameter set was successful. Set commands are highlighted in blue.

In order for X commands to be valid, the following format conditions must be met:

1) The X and other mandatory characters must be capitalized as shown in the table
2) Do not place spaces within the command
3) Replace the “a” with the sensor address

X COMMAND	DEFINITION	RESPONSE AND DETAILS
aXGWUN!	Get velocity/ discharge unit	Response: a+d In which “d’ is the measurement unit for velocity 0 – mm/s 1 – m/s 2 – mph 3 – km/h 4 – fps 5 – fpm
aXGWUN+d!	Set velocity/ discharge unit	Replace “d” with desired measurement unit code (see codes above in Get Velocity Discharge Unit details) Response: a+d
aXGWAV!	Get velocity average factor	Response: a+d In which “d’ is the averaging velocity length (range 1-512)
aXGWAV+d!	Set velocity average factor	Replace “d’ with the desired velocity length (range 1-512) Response: a+d
aXGDFT!	Get direction filter factor	Response: a+d In which “d’ is the direction filter for velocity 0 – both 1 – incoming 2 – outgoing
aXGDFT+d!	Set direction filter factor	Replace “d” with desired direction filter code (see codes above in Get Direction Filter factor details) Response: a+d
aXGSENS!	Get velocity sensitivity factor	Response: a+d In which “d’ is the sensitivity level for velocity. Range 1-100
aXGSENS+d!	Set velocity sensitivity factor	Replace “d” with desired sensitivity level factor (range 1-100) Response: a+d

X COMMAND	DEFINITION	RESPONSE AND DETAILS
aXGLUN!	Get measurement unit for level	Response: a+d In which "d' is the level measurement unit code: 0 – mm 1 – cm 2 – m 3 – in 4 – ft
aXGLUN+d!	Set measurement unit for level	Replace "d" with desired measurement unit code (see codes above in Get Measurement Unit Level details) Response: a+d
aXGDZ0!	Get minimum dead zone value	Response: a+f In which "f" =the active zone minimum value. Sensor will not report a measurement lower than this value.
aXGDZ0+f!	Set minimum dead zone value	Replace f with desired minimum dead zone value. Sensor will not report a measurement lower than this value. Response: a+f
aXGDZ1!	Get maximum dead zone value	Response: a+f In which "f" = the dead zone maximum value. Sensor will not report a measurement higher than this value.
aXGDZ1+f!	Set maximum dead zone value	Replace f with desired dead zone maximum value. Sensor will not report a measurement higher than this value. Response: a+f
aXGSHR!	Get sensor height value	Response: a+f In which f = sensor height above riverbed
aXGSHR+f!	Set sensor height value	Replace "f" with sensor height above riverbed Response: a+f
aXGSGR+f!	Set current staff gauge reading	Replace "f" with current staff gauge reading Device will calculate sensor height above riverbed as: staff gauge reading + distance from sensor to water Response: a+f
aXGLAV!	Get average time in seconds for level	Response: a+f In which "f" = averaging time in seconds
aXGLAV+f!	Set average time in seconds for level	Replace "f" with desired averaging time in seconds Response: a+f
aXGDUN!	Get measurement unit for discharge	Response: a+d In which "d' is the code for the discharge measurement unit 0 = m^3/s 1 = liters 2 = ft^3/s
aXGDUN+d!	Set measurement unit for discharge	Replace "d" with the code for the desired discharge measurement unit (see codes above in Get Velocity Discharge Unit details)

Chapter 5 RADAR CONFIGURATOR UTILITY

A user-friendly PC application for displaying current flow measurements and configuring the flow meter operating parameters is available here under SOFTWARE:

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

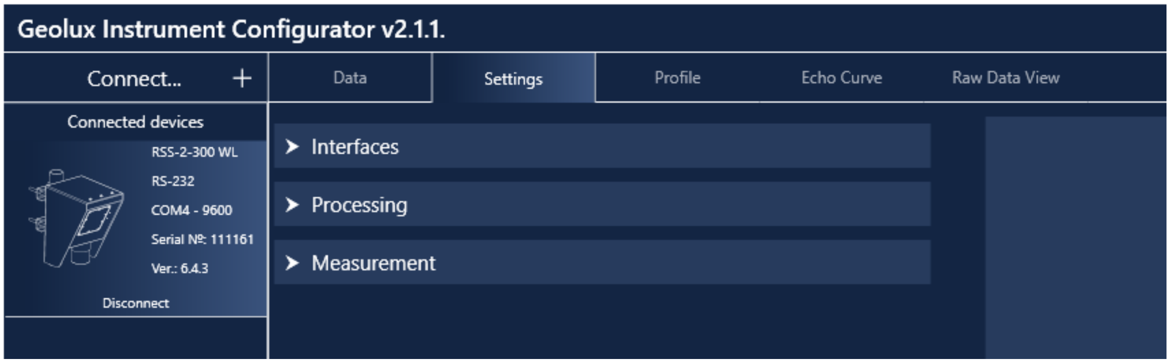
When started, the Configurator Utility displays its main window. Initially, no flow data is displayed, as the connection to the flow meter device is not established.

5.1 CONNECTING THE FLOW METER TO THE CONFIGURATOR

1) Connect your PC to the flow meter using an RS-232 serial cable connection.
2) Power cycle the sensor.
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 300WL. After the data link is established, active device parameters will be displayed, and the flow velocity measurements will be displayed:
5) The utility window is divided into several tabs: Data, Settings, Profile, Echo Curve, and Raw Data View. This section will take you through the steps to configure Settings and Profile.

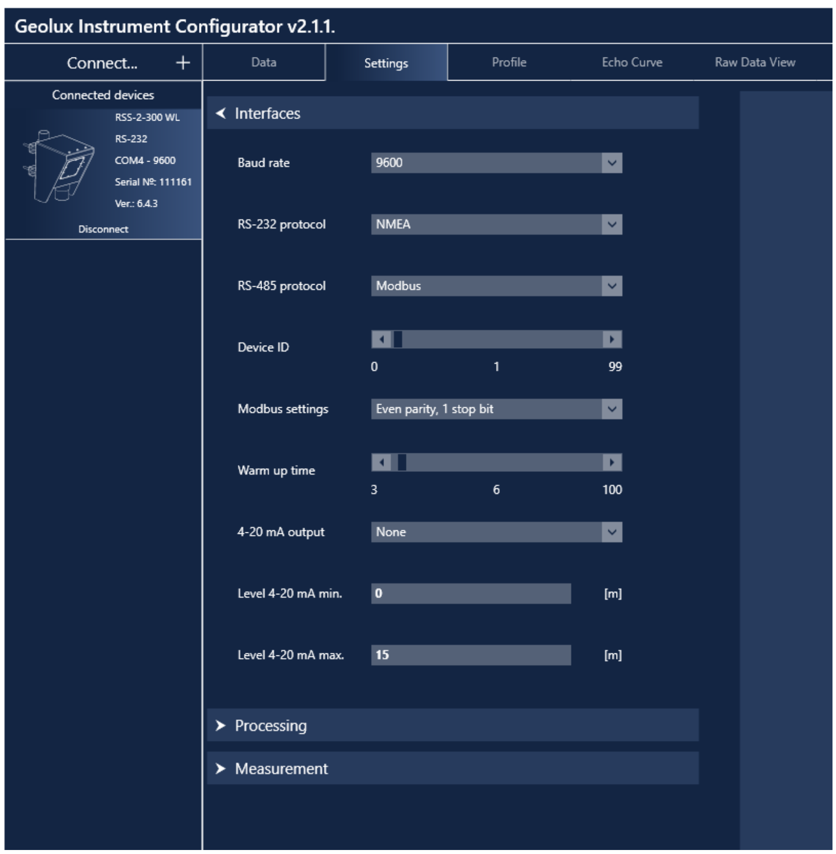
5.2 CONFIGURING SETTINGS

You can configure Interfaces, Processing and Measurement through this tab.

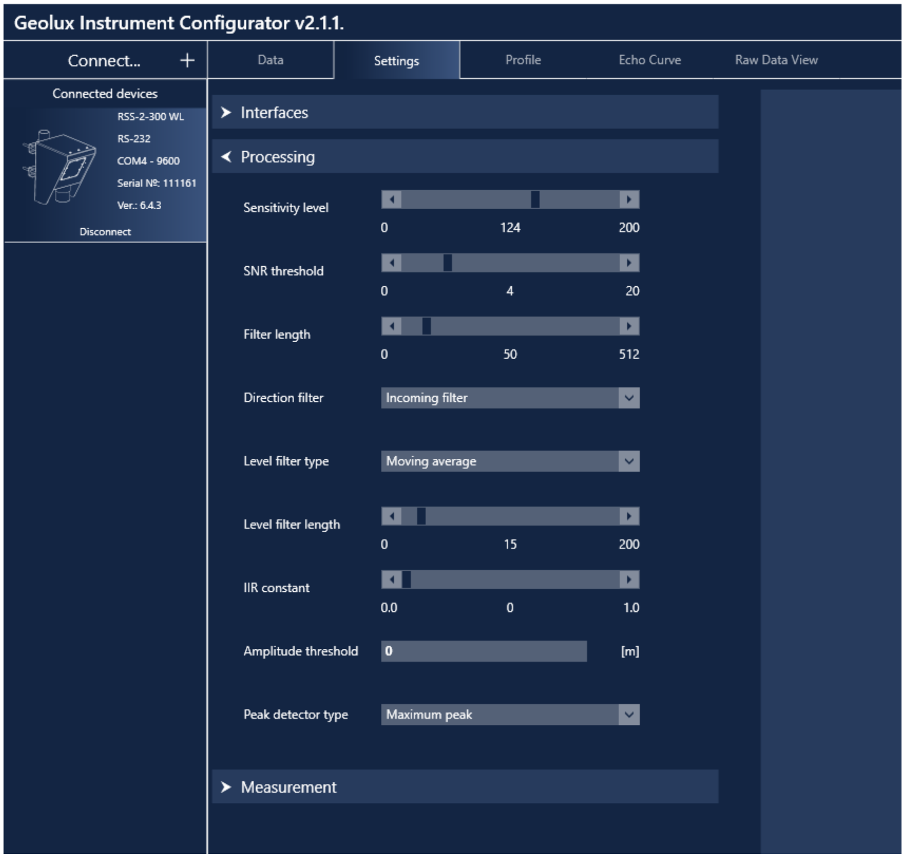


5.2.1 INTERFACES

Normally, interfaces will be set at the factory in these default settings.

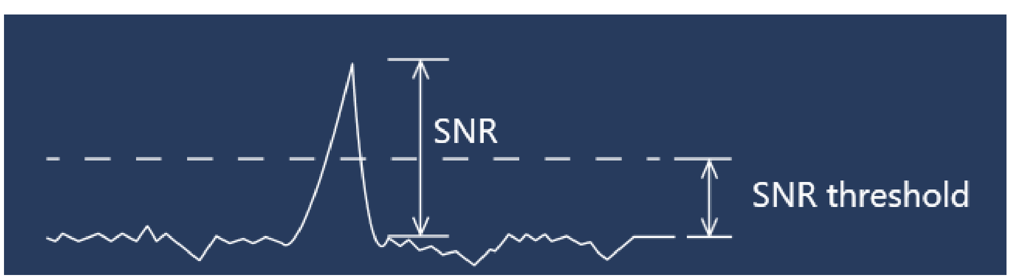


5.2.2 PROCESSING

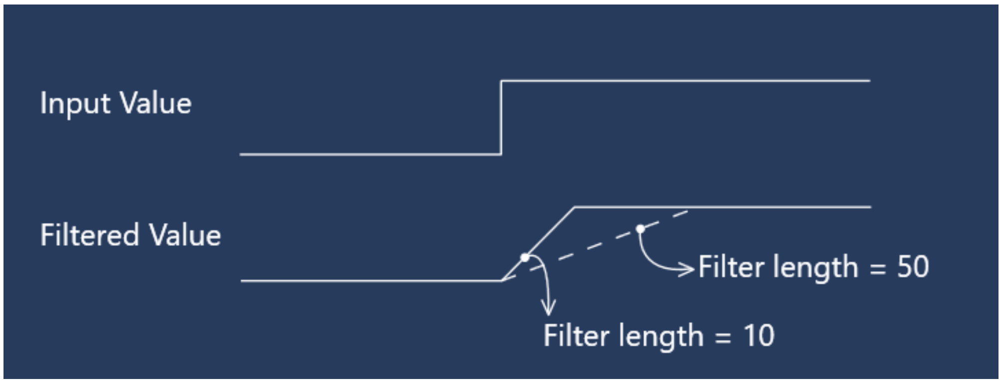


Sensitivity level: Configures the radar sensitivity level. The sensitivity level threshold is used by the radar to determine whether the reflected level is too low to detect any flow. If the instrument is incorrectly reporting flow when there is no water in the channel, it's necessary to increase the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

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



Direction Filter: The Direction Filter is used to choose whether the instrument will detect flow in both directions, or if it should detect only incoming or 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 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 one direction, it is recommended to properly configure this parameter to either incoming or outgoing, as that will improve the consistency of measurements.

Level filter type: Select the type of filter used for smoothing data. For most applications, it is recommended to use the ***moving average filter*** or the ***standard deviation filter***. A brief explanation of the filter types follows:

NO FILTER: Raw measurements are reported

IIR (Infinite-Impulse Response): When compared to moving average filter, the IIR filter reacts more quickly to initial change in the data, but it tales longer for the smoother value to reach the new measurement. The use of the IIR filter is discouraged for general applications. The IIR constant is configured separately.

MOVING AVERAGE: Calculated the average value of a number of raw measurements. The length for the moving average filter is configured separately through the "Level Filter Length".

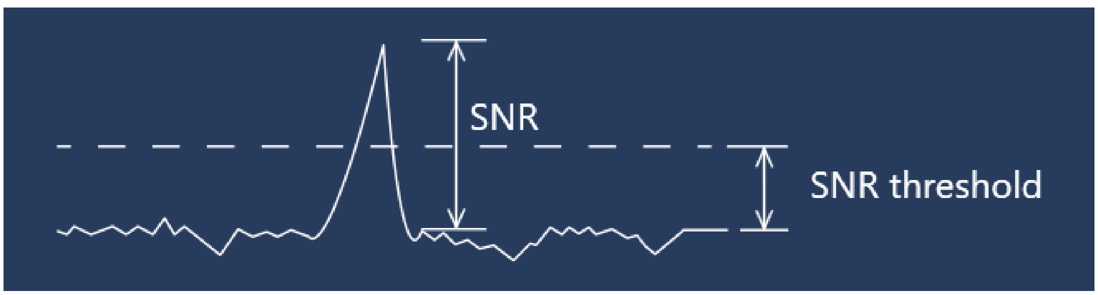
MEDIAN: Finds the median value from a number of raw measurements. The length for the median filter is configured separately through the "Level Filter Length".

STANDARD DEVIATION: Similar to the moving average filter. It takes a number of raw measurements (as defined by level filter length parameter), then removes 20% of outliers, and calculates the average of the remaining 80% of values. This type of filter gives best results.

Level filter length: The length of the averaging filter, in number of readings, to smooth the measured values. The instrument performs 1 reading per second, so a filter length value of 10 will result in a 10 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 water level changes, it will take more time for the new measurement to be reported. Typically, this parameter should be set to a value between 10 and 50. For highly turbulent water, a longer filter length is recommended.

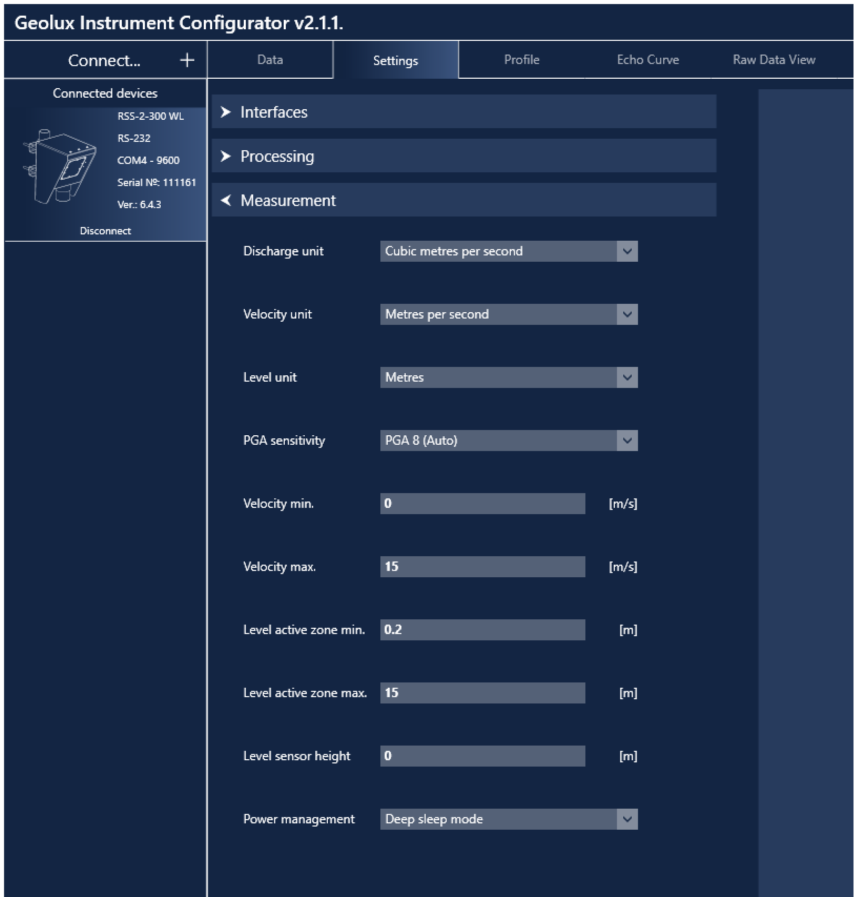
IIR constant: The constant used by the IIR filter. Accepted values are decimal numbers between 0 and 1. When the IIR constant value is closer to 0.0, the filter response will be slower. When the IIR constant value is closer to 1.0, then the filter response will be faster.

Amplitude threshold: Sets the minimum amplitude of the spectral peak in the signal analysis algorithm required to detect peak and report distance. If no peak above this value is detected, the sensor will report distance equal to 0. The threshold is used to filter noise and false readings and it is recommended to keep this value in the range 0 – 1000.



Peak detector type: Used to configure the type of algorithm used to detect the peaks in the radar echo curve. The default setting should be Maximum peak. In specific case, such as when a water level needs to be measured, but there is a lot of vegetation protruding from the water's surface, use Last Peak detector type.

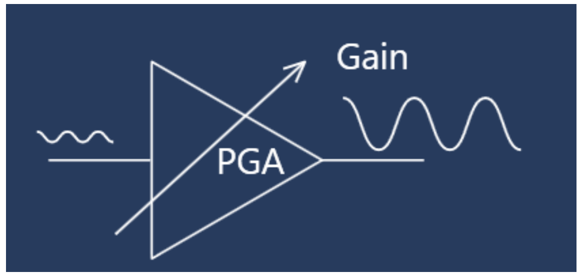
5.2.3 MEASUREMENT



Discharge unit: the measurement unit used to report the measured discharge value.

Velocity unit: the measurement unit used to report the measured velocity value. For NMEA protocol which is used the RS-232 connection, the velocity is reported as an integer value. To preserve higher precision with integer numbers, the measure 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 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 used.

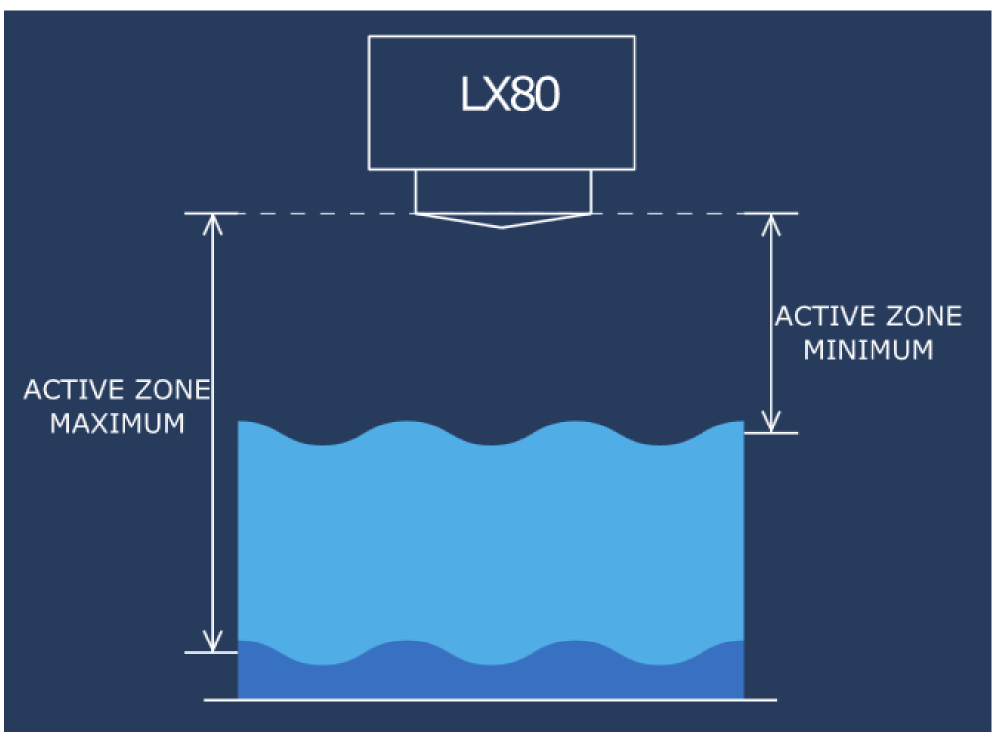
PGA Sensitivity: This parameter limits the maximum gain (amplification level) of the internal programmable gain amplifier. It is is strongly recommended to use the default value 8, which allows the internal signal amplifier to use the maximum gain when the reflected radar signal is very low. Setting this value to a lower value is used only when the instrument is mounted very close to the water surface, typically less than 1 meter. In that case this parameter should be set to a value of 4 or 5.



Velocity min.: Use to set the minimum velocity value of interest.

Velocity Max,: Use to set the maximum velocity of interest.

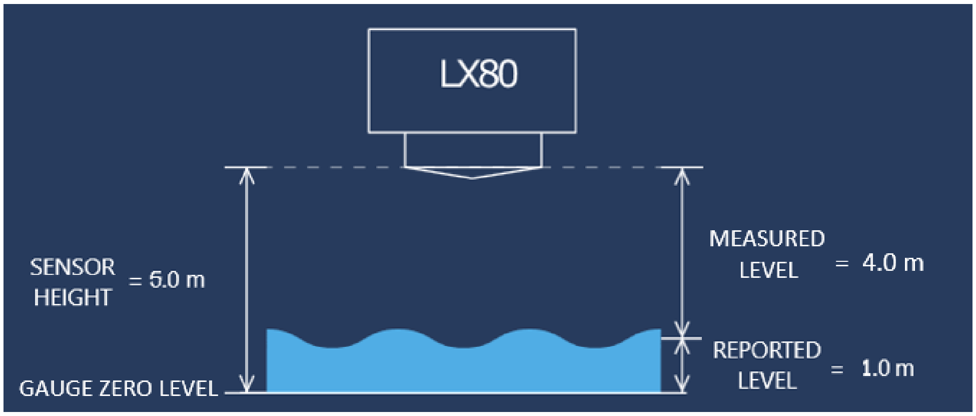
Level active zone minimum and ***Level active zone minimum:*** these parameters limit the operational range of the radar. The radar will detect the water level only within the range set by the active zone minimum and active zone maximum. This is the best way to filter unwanted radar reflections from other structures and objects that are present on the monitoring site that could cause false instrument readings. It is strongly recommended to set the **Active Zone Minimum** value to the minimum possible distance between the water and the instrument at the site and the Active Zone Maximum to the maximum possible distance between the water and the instrument at the site. Typically, the **Active Zone Maximum** is the distance between the radar and the lowest point in the channel.



Level Sensor Height: the height of the radar needs to be set above the water zero-level ("gauge zero"). The radar will output relative measurement of the actual water level based on its height above the water zero-level.

Example: the radar is mounted 5 metres above the water zero-level ("gauge zero). If the radar measures the distance between the radar and the water surface as 4 meters, it will report a water level of 1 meter.

Hint: This parameter an also be set by clicking the "Enter Staff Gauge Reading" button on the bottom of the screen and inputting the current staff gauge reading.



Power Management: Switches between the three modes. Sleep modes are set when the SDI-12 interface is used.

CONTINUOUS SCANNING MODE: in this mode the device continuously performs measurements which are transmitted over the RS-232 interface and made available over Modbus and SDI-12 interfaces.

SLEEP MODE: The device remains in sleep mode until the SDI-12 Measurement command (aM!) is received. Power consumption is only 0.08W n this mode.

DEEP SLEEP MODE: The device remains in deep sleep mode until the SDI-12 Measurement command (aM!) is received. While in deep sleep mode, the device will not be able to connect to Modbus or RS-282 interfaces. To reconfigure a device which is in deep sleep mode, it is necessary to power-cycle the device and use the Radar Configurator Utility application to connect to the device within 20 seconds after power up. If there is no attempt to connect the device over RS-232 interface within 20 seconds, the device will automatically go back to deep sleep mode. Power consumption is only 0.04W in this mode.

5.3 CONFIGURING THE UNIT FOR DISCHARGE CALCULATION

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

As described in this section, in addition to surface velocity and water level measurement, it is required to enter the channel section profile geometry into the unit, and the correction coefficient which defines the ratio between surface and average velocity. This is done through the Profile tab.

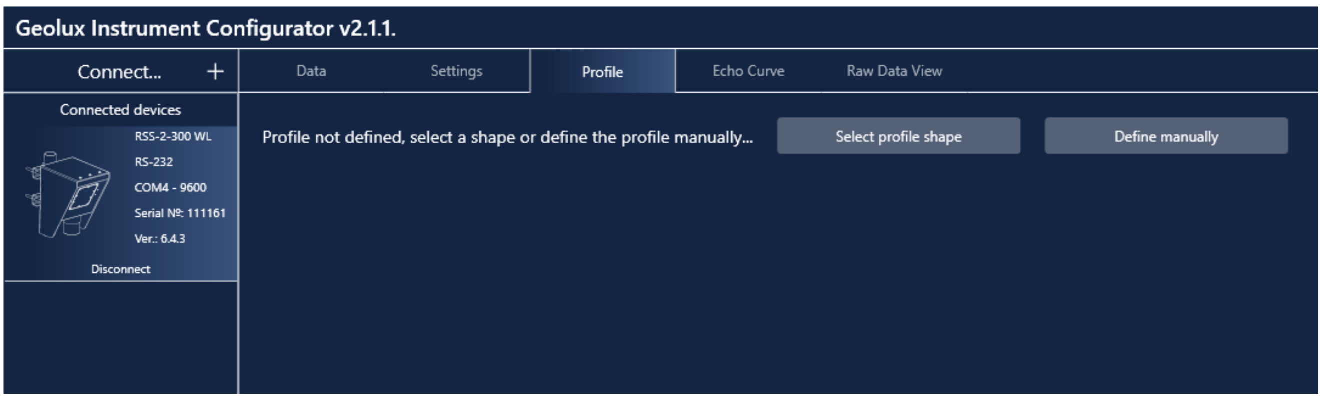


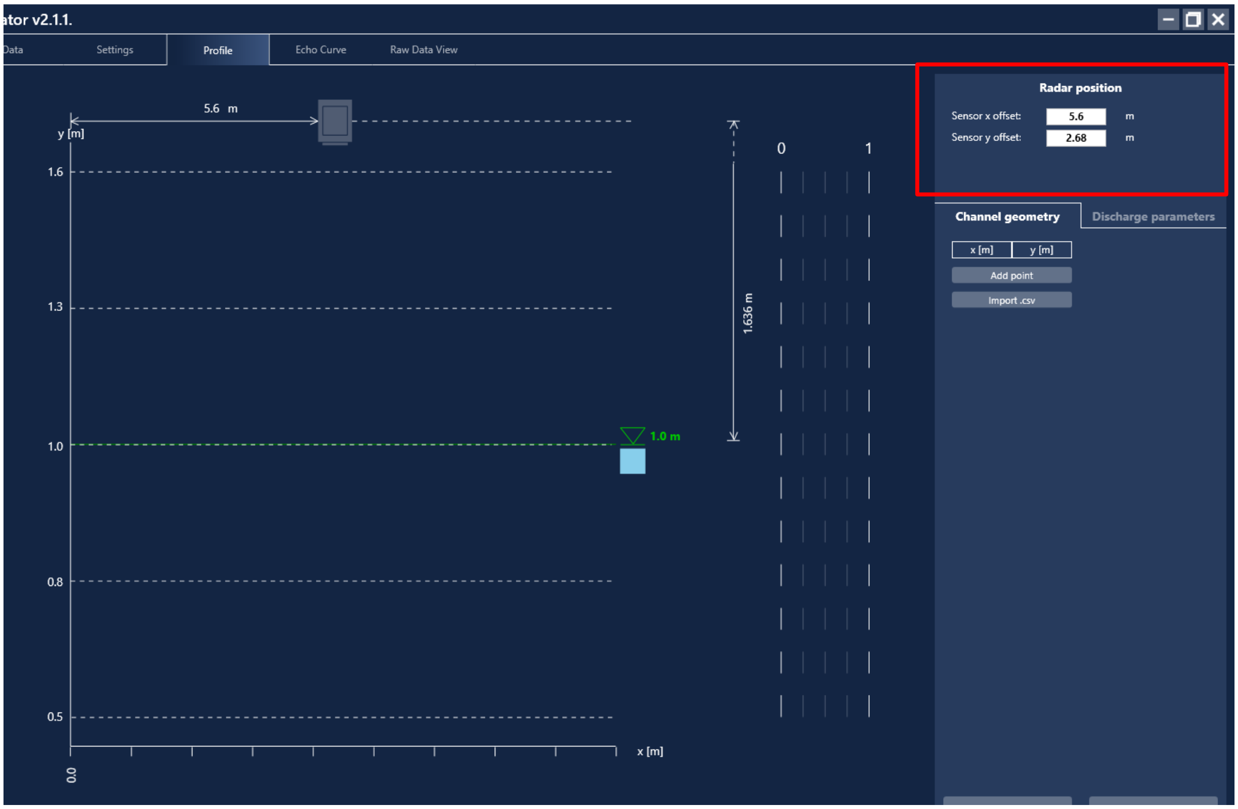
Figure 5-1: Profile Menu

You can either define the Profile by using a pre-defined profile shape or manually.

5.3.1 DEFINING PROFILE MANUALLY

Select "Define Manually". This window allows the user to define the channel section profile using the following steps:

1) Set the radar position. Ensure the correct measurements are selected. The exact measurements are not necessary. This can be re-entered at the site once the radar is placed and exact measurements determined.



2) Define Channel geometry: Channel geometry can be set by adding points or by importing a .csv file which has the channel points already defined.

   a) To add points: select "Add point" button and fill in the x and y information for the channel profile. Ensure the correct units are selected. Once all points are entered, select "Save Changes".

b) To import a .csv file: select the "Import .csv" button. The CSV file should have two columns, separated by a semi-colon (;).

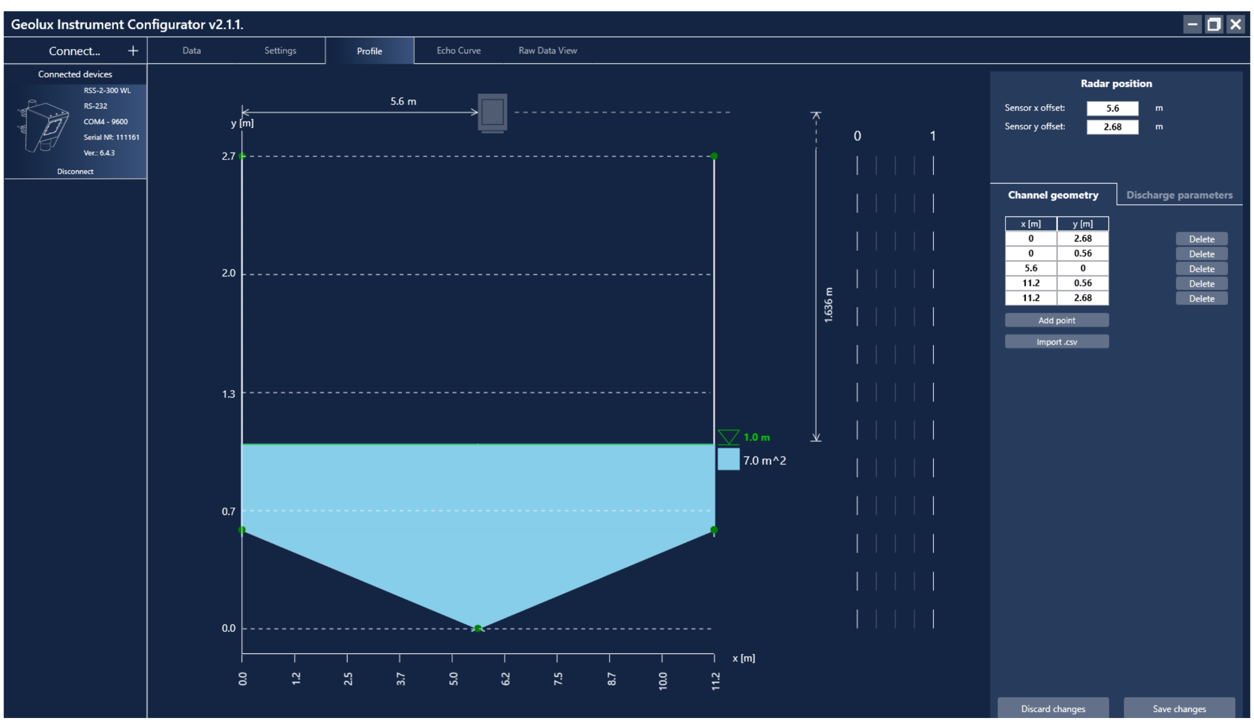
	A	B
1	0;2.68	
2	0;0.56	
3	5.6;0	
4	11.2;0.56	
5	11.2;2.68	
6		
7		

i) The first value (column) in each line is X coordinate, in the desired measurement unit, and the second value represents the Y value of the point in the profile geometry. There can be no more than 128 points defined. The points should be ordered from left to right. Any supported coordinate system can be used to define the points (mm, cm, m, in, or ft).

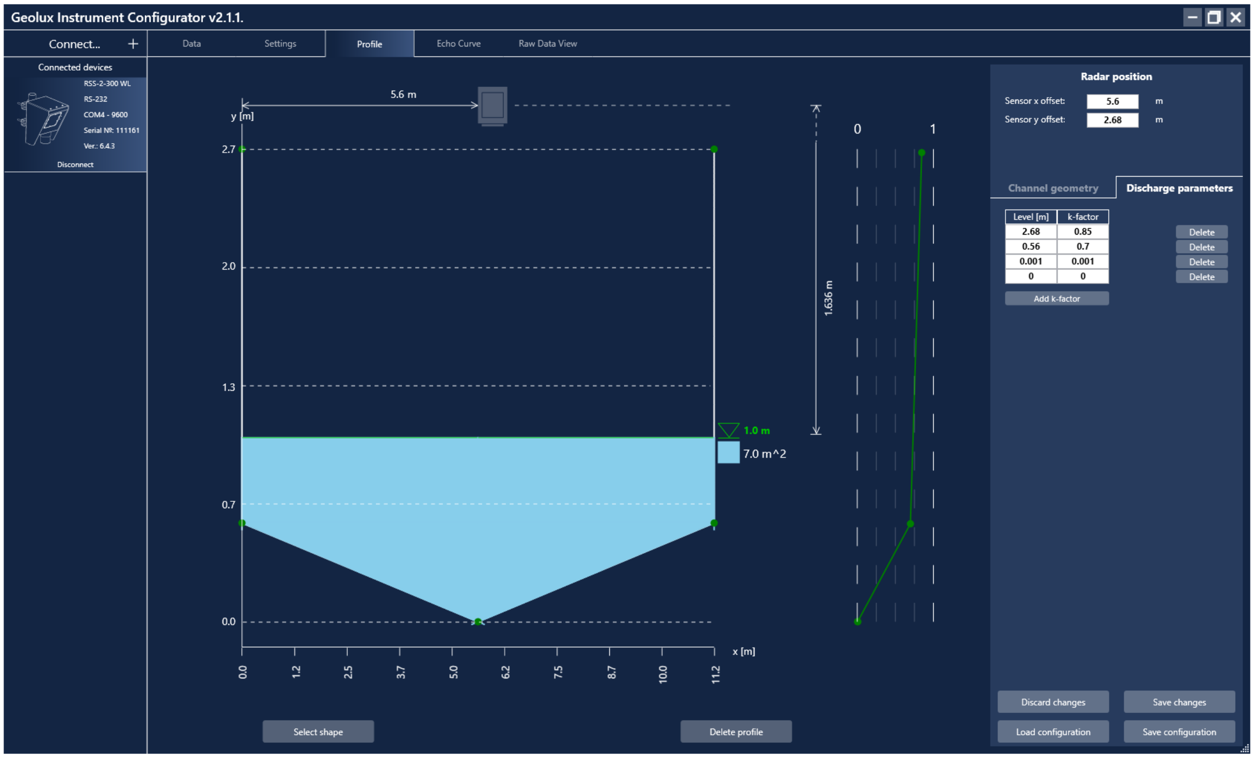
ii) It is recommended that the Y axis zero is the lowest point in the profile in order to make it easy to set the Y offset of the unit when the RSS-2-300WL is installed.

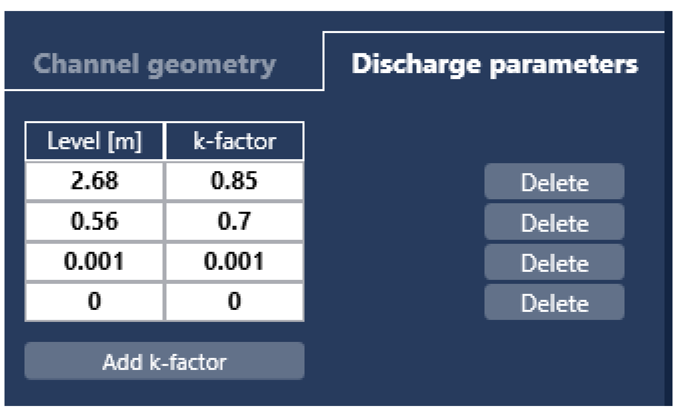
iii) Once the profile has been imported, select "Save Changes"

3) Once the channel profile is loaded it will be displayed.



4) Finally, one or more correction coefficients that define the ratio between the surface velocity and average velocity need to be defined in k-coefficients table. This is done through the "Discharge parameters". Select "Add k-factor" and insert the information. Multiple values can be defined for different water levels.





5) Once on site, mount the radar and adjust the Radar X and Y offset to accurately reflect the position on the entered profile. Then use the Staff Gauge Reading button to enter the current water level as reported on the site's staff gauge.

NOTE: This will not affect the discharge calculations and this can also be done using the SDI-12 Set Current Staff Gauge Reading X command (aXGSGR+f!).

Chapter 6 CALCULATING DISCHARGE FROM FLOW VELOCITY

The 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 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 6-1.

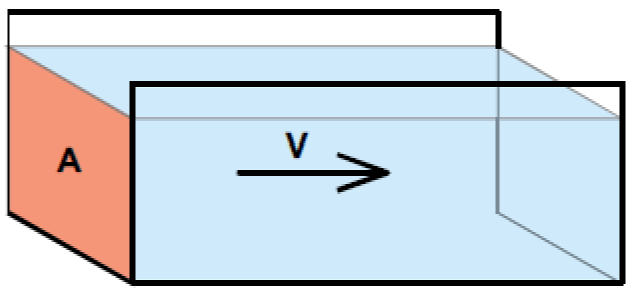


Figure 6-1: Simple Channel Diagram

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).

6.1 REAL-WORLD APPLICATION

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 6-2.

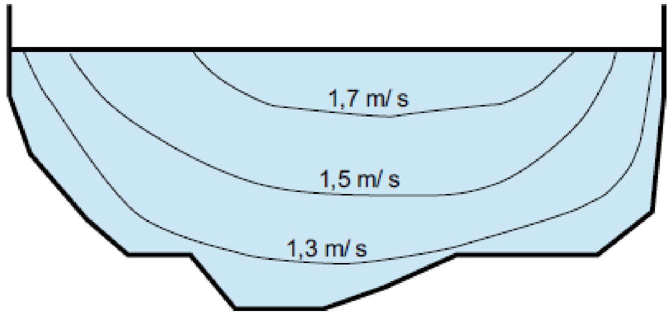


Figure 6-2: Flow Velocity in a Typical Cross-section

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 non-rectangular area of the stream cross-section, and knowing the surface flow velocity, the following formula can be used:

$$Q=k*Vs*A$$

Where:

Q is discharge
Vs is surface flow velocity
A is the cross-section area under water, and
k is the coefficient obtained by dividing the average flow velocity by surface flow velocity.

The recommended method for obtaining the k coefficient is to measure the total discharge using a different method (such as ADCP instrument) at several water levels, and then to determine the required k coefficient required to obtain the same discharge based on water level and surface velocity measurements, as measured by non-contact instruments, using the formula:

$$k = QADCP / (Vs * A)$$

Where:

k is the coefficient
QADCP is the discharge measured using ADCP equipment
Vs is the surface velocity measured by the surface velocity radar and
A is the cross section area determined by the channel geometry and water level measurement.

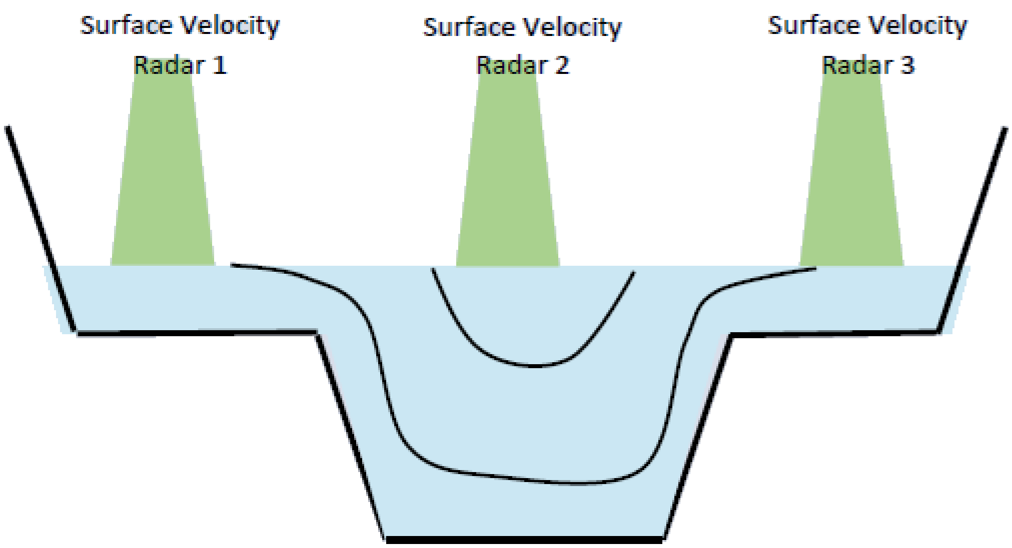
More details about water flow measurements can be found in the following technical note:

https://ftsinc.com/support/products/sensors/sdi-radar-300wl/

6.2 IMPROVING ACCURACY

Depending on the channel profile geometry at the monitoring site, it can be recommended to use multiple surface velocity sensors above the river channel. Consider the example at Figure 6-3 with the main channel and side flooding areas.

Depending on the water level, the ratio between the surface velocity at the center of the channel and the average velocity can greatly differ. For improved accuracy under such conditions, it is recommended to use single water level measurement in combination with multiple surface velocity measurements:



Please Contact FTS for discharge calculation for a single site based on multiple surface velocity radars

Chapter 7 TECHNICAL SPECIFICATIONS

7.1 TECHNICAL DATA

Characteristics and Performance Data	
Surface Velocity Radar Type	K-band 24.125 GHz Doppler radar 21 dBm EIRP
Surface Velocity Radar Beam Angle	12° Azimuth 24° Elevation
Level Radar Type	W-band 77-81 GHz FMCW radar
Level Radar Beam Angle	5°
Detection Distance	15m (49.2ft) above water
Speed Range	0.02 m/s to 15 m/s (0.066 ft/s – 49.2 ft/s)
Speed Resolution	0.001 m/s (0.0003 ft/s)
Speed Accuracy	1%
Level Resolution	0.5 mm
Level Accuracy	+/- 2 mm (+/- 0.08 in)
Sampling Frequency	1 sps
Power	
Supply Voltage	9 – 27 VDC
Power Consumption	<6.5 W (typical 5.2 W)
Maximal Current	<750mA
Communication Interface	
Serial Interface	1 x serial RS-485 half-duplex 1 x RS-232 (two wire interface)
Baud Rate	1200 bps – 115,200 bps
Serial Protocols	Modbus/RS-485 GLX-NMEA ASCII-S
SDI-12 Interface	
Analog 4-20mA Interface	
Physical	
Operating Temperature Range	-40º - +85ºC (-40º - +185ºF) (without heating or coolers)
Ingress Protection Rating	IP68
Enclosure Dimensions	150mm x 200mm x 250mm (5.9in x 7.9in x 9.8in)

DOCUMENT REVISION HISTORY

Revision	Date	Description
1	12 Oct 2021	Original
2	11 Apr 2022	Added additional information on SNR and calculating discharge. Updated to version 2.1.1 of configurator SW and screen shots. Updated to align with GLX-RSS-2-300 WL Non-Contact Flow Meter User Manual v6.4.8.