Ultrasonic Flowmeter
Model PRGEN-MNU

SMARTREK Datasheet Ultrasonic Flowmeter

1 Overview

The PRGEN-MNU is designed for monitoring overflows in sewer networks. It is an essential task for assessing infrastructure capacity and responding to critical events. Installed in manholes, it provides continuous water level monitoring and real-time estimates of flow and discharged volume. With its robust design and wireless connectivity, it is particularly well suited for challenging underground environments. It is commonly used to monitor combined sewer overflows and parshall flume. The sonar sensor, connected to the node via a long cable, allows for flexible and optimal installation while maintaining reliable communication with a SpiderMesh repeater located near the surface.

1.1 Features

The node continuously measures water level using a wired sonar sensor. It calculates flow and total volume using Manning's equation or custom equations. When an overflow is detected, it automatically increases the sampling frequency using the AFP algorithm to better track rapid variations. The IP68-rated enclosure and high-capacity battery ensure long-term operation in underground environments. Data is transmitted wirelessly via SpiderMesh to a repeater placed near the manhole cover. Atrax integrates easily with existing systems.

1.2 Applications

- Overflow monitoring
- Parshall flume
- Weir
- Water and waste water
- Sewer
- Tank monitoring

1.3 Sensors

MNU-2424 from APG

The MNU-2424 is a rugged and reliable ultrasonic sensor designed for accurate water level measurement in wastewater applications. It provides non-contact measurement, making it well suited for harsh environments where debris, chemicals, or fluctuating conditions could affect traditional sensors. The sensor's durable PC/PBT housing and NEMA 6P-rated enclosure ensure long-term protection against water ingress, including submersion.

Equipped with a compact threaded design (1"-3" NPT), the MNU-2424 is easy to install in various mounting configurations. Its precise level detection capabilities make it ideal for monitoring sewer overflow, flow in open channels, and water levels in flumes or weirs. For more details about the probe, visit APG's website.

Contents

2 Data

2.1 Measurement Process and Data Acquisition

The PRGEN-MNU powers the MNU-2424 ultrasonic probe periodically and takes a precise water level measurement before shutting it down to conserve energy. The probe has a wide dead zone of 50 cm, meaning it cannot measure distances smaller than this range. The node includes an advanced signal processing algorithm designed to mitigate reflection issues commonly found in sewer environments. This includes a distance-locking algorithm and a median filter with a retry mechanism, ensuring reliable data capture even in areas with partial obstructions or irregular surfaces.

The node computes flow using Manning's equations, and provides configuration parameters tailored to the site's specific channel or pipe characteristics. The computed flow data is recorded in a totalizer, allowing for cumulative flow tracking over time.

The PRGEN-MNU features automatic fast polling with built-in hysteresis to ensure timely detection of overflow events. This adaptive sampling mechanism increases measurement frequency when water levels rise, capturing rapid changes while avoiding unnecessary power consumption from frequent polling in stable conditions. The result is a system that provides real-time monitoring of sewer flow, overflow events, and total discharge volume.

2.2 Configurations

The PRGEN-MNU adapts to various sewer monitoring applications by adjusting the sampling behaviour, the flow computation equations, and overflow detection settings. The node operates at a standard sampling interval under normal conditions, but when water levels rise, it can switch to a faster polling mode when the Automatic Fast Polling (AFP) feature is enabled. The AFP threshold setting defines the distance between the overflow point and the activation level for fast polling, ensuring that it captures rapid changes in flow effectively.

Accurately measuring the flow requires key parameters such as the cross-section type (rectangular, trapeze, triangular, circular, or a custom equation), hydraulic slope, and conduit geometry.

The PRGEN-MNU provides flow estimation for weir and flume using a custom flow equation of the form:

$$Q = y \times H^z$$

The node includes a configurable flow computation level which determines the reference point for flow calculation. If water levels exceed the flow error level, the system is no longer in open-channel conditions, and the computed flow value becomes unreliable. In such cases, the node flags a flow computation error condition to indicate the system is beyond its calibrated range.

The included totalizer logs cumulative flow over time and can be cleared as needed for tracking discharge volumes over specific periods.

2.3 Data and parameter list

Table 1: Configuration options available for the PRGEN-MNU

Name	Unit	Default	Description
SAMPLETIME	min	10	Time interval at which the node samples the probe
EMPTYLEVEL	m	7	Distance from the probe to the bottom
FLOWERRLEVEL	m	7	Level at which the overflow is fully submerged
FLOWCOMPUTELEVEL	m	6.7	Reference level for flow computation
MCSPARAM	m	1	Geometrical parameter M
BCSPARAM	m/m	1	Geometrical parameter B
STRICKLER	-	1	Strickler coefficient
HYDROSLOPE	m/m	0.05	Hydraulic slope
CSTYPE	-	5	Cross-section type: 0: None 1: Rectangle 2: Trapeze 3: Triangle 4: Reserved 5: Circular 6: Custom Math Exp
RESETTOTAL	-	0	Reset totalizer flag
AFPENABLE	-	1	Enable automatic fast polling
AFPSAMPLINGTIME	m	5	Fast sampling time
AFPFASTTHRESHOLD	m	0.2	Threshold for fast polling

Table 2: Values available from the PRGEN-MNU

Name	Unit	Resolution	Description
RSSI		1	RF signal strength at the node.
VOLTAGE	V	0.05	Voltage of the battery pack.
RAW	m	0.001	Distance from sensor head to water surface
FLOW	L/s	-	Computed flow value
TOTALIZER	L	1	Cumulative flow
ERRORCODE	-	1	Error Code: 0: No error 2: Co-processor communication error 4: Invalid configuration 8: Probe communication error 9: Probe CRC error 10: Distance too small (50 cm) 11: Loss of echo 12: Invalid depth 13: Device is Booting 16: Corrupt flow computation
ISAFP	-	1	Fast polling status

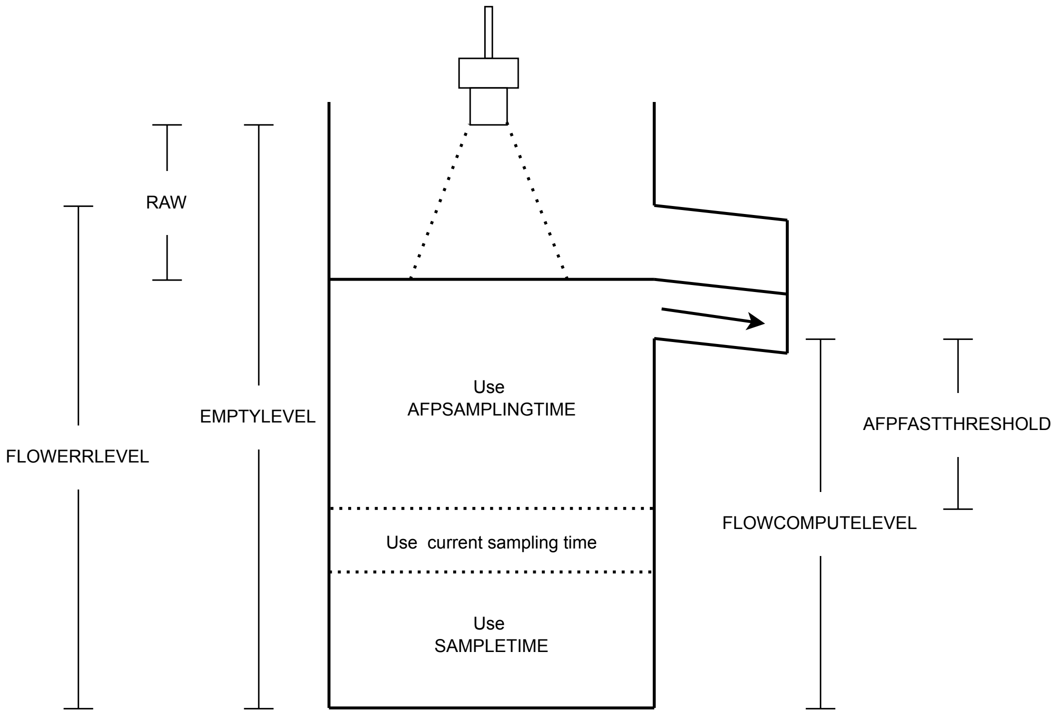


Figure 1: Reference distance diagram

2.4 Error codes

This section lists all possible error codes reported by the node. Each code corresponds to a specific fault or condition that may affect measurement reliability. Use this information for diagnostics, maintenance, and system integration.

If an error such as invalid depth, distance too small, or loss of echo is detected, it will continue to report the last valid measurement. This ensures stable output during short-term signal loss or measurement anomalies.

0 No error
: The device is operating normally. No error has been detected.

2 Co-processor communication error
: The node is unable to communicate with the co-processor responsible for sonar communication. Measurement is not possible.

4 Invalid configuration
: The configuration provided is inconsistent or invalid. Conditions checked include:

  - STRICKLER is negative with a CSTYPE using the manning equation (Rectangular, Trapeze, Triangular or Circular)
  - CSTYPE is not supported

  If CSTYPE is NONE, the configuration is considered valid regardless of other parameters.

8 Probe communication error
: The probe did not reply with the expected number of bytes before the timeout.

9 Probe CRC error
: The probe responded, but the response failed CRC validation, indicating data corruption.

11 Loss of echo
: The sonar signal did not return a valid echo. This may occur in turbulent or complex environments.

12 Invalid depth
: The measured distance exceeds the configured 'EMPTY_LEVEL' plus a 30 mm threshold, making the depth value invalid.

13 Device is Booting
: The device is booting and no valid data has yet been taken. Consider distances and flow values invalid.

16 Corrupt flow computation
: The water level is above 'FLOWERRLEVEL'. Flow cannot be computed accurately using the Manning equation under these conditions.

2.5 Modbus

When used with a Modbus gateway, the data and configuration for PRGEN-MNU are mapped to input and holding registers respectively. The Modbus register offset at which the information is mapped depends on the Gateway used. As such, refer to the manual of your SpiderMesh Gateway for more details.

Table 3: Modbus holding register list for the PRGEN-MNU

Offset	Register	Encoding	Format
SAMPLETIME	0	1 min	u16
EMPTYLEVEL	1	0.001 m	u16
FLOWERRLEVEL	2	0.001 m	u16
FLOWCOMPUTELEVEL	3	0.001 m	u16
MCSPARAM	4	0.0005 m/m	u16
BCSPARAM	5	0.0005 m/m	u16
STRICKLER	6	1	i16
HYDROSLOPE	7	m/m	float
CSTYPE	9	0 to 6	u16
RESETTOTAL	10	0 or 1	u16
AFPENABLE	11	0 or 1	u16
AFPSAMPLINGTIME	12	0 to 7 min	u16
AFPFASTTHRESHOLD	13	0.01 m	u16

Table 4: Modbus input register list for the PRGEN-MNU

Offset	Register	Encoding	Format
0	RSSI	1	i16
1	VOLTAGE	0.05 V	u16
2	mPowerCorrected	%	u16
3	RAW	0.001 m	m
4	FLOW	L/s	float
6	TOTALIZER_UPPER	1 L	u32
8	TOTALIZER_LOWER	1 L	u32
10	Reserved	-	-
11	mCorrectedDepth	m	float

2.6 Manning's Equation

Manning's equation is an empirical method used to estimate the flow rate in open channels. It relies on observed data to relate flow velocity to the channel's geometry, roughness, and slope. This equation is widely used due to its simplicity and effectiveness in various water flow calculations. The Strickler coefficient (K) is related to the Manning coefficient (n) by the formula: K = 1 / n This means the Strickler coefficient is the reciprocal of the Manning coefficient. Manning's equation, using the Strickler coefficient is:

$$Q = KAR_h^{2/3}S_0^{1/2} \tag{1}$$

Where:

Q is the flow in m^3/s

K is the Strickler coefficient

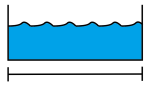
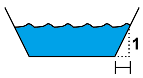
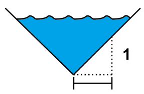
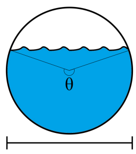
A is the wet area in m^2

R_h is the hydraulic radius. It is obtained by dividing the Area by the wetted perimeter $R_h = A/P_{wet}$

S_0 is the hydraulic slope in m/m

For a detailed list of roughness coefficients (n) for various surface types and channel conditions, please refer to one of the many tables available in the literature.

Table 5: Cross section type equation used in the PRGEN-MNU

CSTYPE	MCSPARAM	BCSPARAM	R_h	Wet area*
None	-	-	-	-
Rectangle	-		$\frac{bh}{b+2h}$	bh
Trapeze			$\frac{(b+mh)h}{b+2h\sqrt{1+m^2}}$	$(b+mh)h$
Triangle		-	$\frac{mh}{2\sqrt{1+m^2}}$	mh^2
Circular	-		$\frac{1}{4}(1-\frac{\sin\theta}{\theta})$	$\frac{1}{8}(\theta-\sin\theta)b^2$

*h stands for height: the distance from the bottom of the conduit to the water level

2.7 Local Storage

The PRGEN-MNU only stores a few recent data points in volatile memory for filtering purposes, and provides the latest filtered measurement when polled. All measurement data is lost upon reboot, except for the totalizer value, which remains stored to maintain cumulative flow tracking. The gateway manages data storage, retaining historical records for further analysis and integration with external systems.

2.8 Data poll timing

The PRGEN-MNU operates with asynchronous data measurement based on the configured sampling time. This setting determines how frequently the node retrieves new measurements from the probe. When the node is polled, it transmits the most recent data read. The minimum DYN is set to 500 milliseconds, defining the shortest interval between successive data transmissions. This period is configurable to optimize network usage and power consumption. Refer to the documentation of your SpiderMesh Gateway for more details on how to set the DYN of your network.

3 SpiderMesh

SpiderMesh is a Low Power Wide Area Network (LPWAN) protocol, from concept to reality, it is a Machine-to-Machine (M2M) wireless technology built from the ground up.

The first truly cooperative mesh technology, featuring bit synchronized communication, we make it possible to counter the well known effect of packet collision as the network increases in size. A true differentiation between SpiderMesh and other mesh protocols.

While standard protocols re-transmit data in a nondeterministic fashion in the event of a packet collision, SpiderMesh makes it possible to avoid these collisions. Thus, unrivaled and unmatched performance in terms of power consumption, network size and reliability in maintaining M2M communication.

Table 6: General network specifications

Specifications	Performance
Frequency Band	North America: 902-928MHz Europe, Australia/NZ: 860MHz Japan: 925MHz
Wireless Technology	SpiderMesh
Encryption	AES-128
Range	Up to 10km/7Miles (LOS*) 500m average (NOLS**) 300m (deciduous forest)
Max hop count	30 (total range is 30x node-to-node range)
Max number of A-Link on network	Unlimited

*LOS: line of sight **NLOS: near line of sight

3.1 Portia

The PRGEN-MNU as well as all the other Atrax products are powered by the SpiderMesh Portia module. Portia radio transceivers provide an extremely high wireless network range. To achieve this, radios use the proprietary SpiderMesh technology, a cooperative mesh wireless protocol developed by Smartrek Technologies. This protocol provides synchronous communication between the links to mitigate network contention issues. This strategy allows Portia radios to offer a connectivity solution for the most challenging applications.

The nodes act as repeaters within the linked networks. Data transfer is bidirectional, and thus, nodes allow for controlling, reading, or both, of either digital or analog external modules, therefore connecting them to the mesh network. Activating a link in the field only requires the node to be on the same radio frequency channel as the network during deployment. This considerably reduces installation complexity, as there is no technical knowledge required for its use.

For more details about the Portia radio module, refer to the Portia module datasheet.

3.2 Node Register Configuration

The Portia radio module provides hardware registers that can be tuned to change its configuration. The SpiderMesh network allows remote reading and writing of these registers and as such, the Portia within the PRGEN-MNU can be configured through its registers to better suit the system to your application. Registers can be used to configure the RF channels and other mesh parameters, access internal memory and much more. Available public registers are documented within the Portia module datasheet.

3.3 Gateway Requirement

In order to fetch the data from the node, the node must be connected to one of the compatible Smartrek gateways. The PRGEN-MNU is compatible with the following Smartrek Gateway:

- Smartrek Modbus Gateway
- Smartrek Smart Gateway V1
- Smartrek SG+

4 Power

A battery pack with nine D-cell alkaline batteries powers the PRGEN-MNU. Figure 2 illustrates the expected battery life based on the mesh configuration. However, this graph is for guidance purposes only, as battery life can vary significantly depending on external factors such as the installation environment and the quantity of overflow events, which may reduce the battery life. The graph aims to represent what a standard installation would look like under typical conditions.

Each Atrax node comes with high-quality batteries, but using replacements with lower capacity may result in reduced operational time. To maximize battery life, ensure proper configuration and adhere to the recommended installation guidelines, particularly regarding settings that influence sampling frequency.

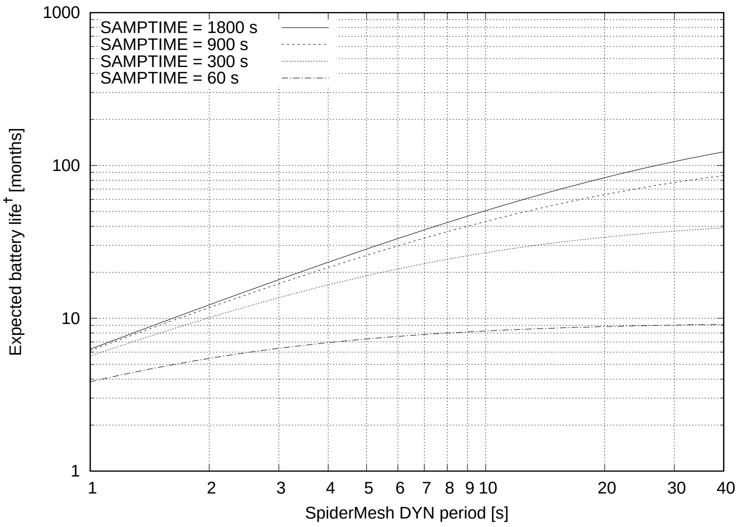


Figure 2: Battery Life Expectancy
† Battery life depends on the network configuration as well as other parameters, such as loss of connectivity and others.

The power consumption of the PRGEN-MNU is closely tied to its sampling configuration. The sample time setting determines how frequently the probe activates, directly impacting energy use. Longer intervals between samples reduce power consumption by limiting the number of activations, while shorter intervals provide more frequent data updates at the cost of increased energy usage. Selecting an appropriate sample time is crucial for balancing battery life with monitoring needs.

Installation conditions also play a significant role in power consumption. Ultrasonic reflections can interfere with measurements in challenging environments, such as manholes with ladders, walls, or other obstructions. The node employs advanced signal processing to counteract this, including a distance-locking algorithm and a median filtering system with retries. These additional processing steps help ensure accurate readings but require extra power when reflections cause measurement instability. The complexity of the environment increases the energy needed to maintain reliable data.

Overflow detection introduces another layer of variability in power consumption. The node samples at a steady rate during normal operation, but when water levels approach overflow conditions, the Automatic Fast Polling (AFP) mechanism activates, **significantly increasing the sampling frequency**. This ensures real-time capture of critical water-level changes, but results in higher power draws. Properly configuring AFP settings helps optimize energy use, ensuring that increased sampling only occurs when necessary while preserving battery life in standard conditions.

5 Technical Specifications

5.1 Performance

Table 7: Specifications of the PRGEN-MNU

Specifications	unit	Performance
Enclosure protection	-	IP68
Nb of input channel	-	1
Probe supply voltage	V	12
Probe communication protocol	-	Modbus RTU
Physical interface	-	RS-485
AFP hysteresis	m	0.25
Number of D-cell	-	9
Battery pack configuration	-	3s3p
Dimension	mm	280 x 229 x 145
Weight	kg	3.5

5.2 Pinout

Pin number	Name	Purpose
1	PWR+	Positive power supply rail
2	PWR-	Negative power supply rail
3	RS-485 A	Non-inverting transceiver Input/Output (A)
4	RS-485 B	Inverting transceiver Input/Output (B)

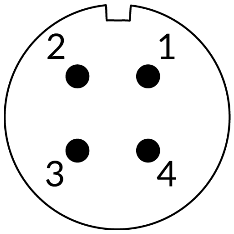
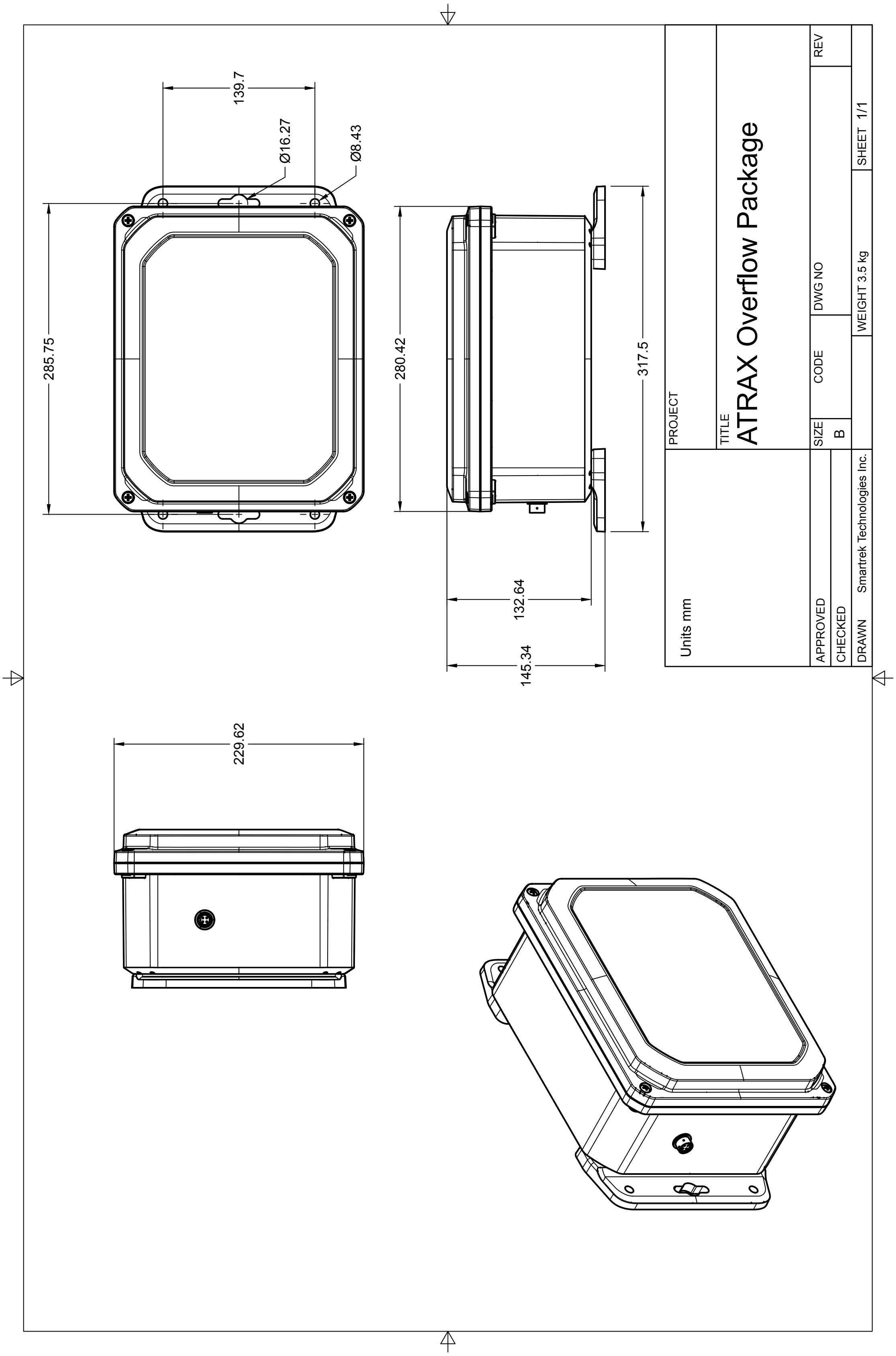


Figure 3: Mating connector pin numbering

5.3 Technical Drawing



6 Installation and Configuration

This guide will walk you through the necessary steps to install properly and configure your PRGEN-MNU to ensure optimal performance. It is important to follow these instructions carefully to avoid any potential issues or damage to the device. If you have any questions or encounter any problems during the installation process, please refer to the troubleshooting section of this guide or contact Smartrek Technologies support for further assistance.

6.1 Probe Installation

1. **Choose Probe Location:**
   Ensure the probe has a clear beam path, with no obstructions within its 10-degree beam angle. Place the probe as far away as possible from obstacles like walls, ladders, ropes, or other objects that could interfere with the ultrasound signal. The ultrasound pathway must be unobstructed to ensure accurate measurements. Position the probe 50 cm above the highest expected water level. If necessary, hang the probe to achieve the best possible installation location. Ladders often interfere with ultrasonic measurements, causing unreliable readings due to echoes and obstructions. One effective solution is to install the sensor as far from the ladder as possible. This may involve suspending the probe by its cable from the end of a bracket. Figure 4 below illustrates a recommended installation that minimizes ladder interference by positioning the sensor head away from the obstruction.

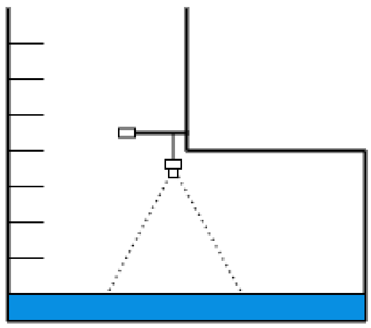


Figure 4: Recommended installation to stay as far as possible from ladders.

2. **Install the Bracket at the Selected Location:**
   Once the optimal location is determined, install the bracket at the chosen spot. For concrete surfaces, use Tapcon screws. Pre-drill the holes and then drill with an impact drill to securely fix the bracket.

3. **Fix the Node to the Bracket:**
   Attach the node to the bracket, ensuring that it either hangs freely or is properly secured. The sensor head must remain unobstructed to maintain data integrity, as any obstruction can compromise the accuracy of measurements.

4. **Measure Important Distances:**
   Ensure the following distances are accurately measured:
   - Probe bottom to empty level
   - Probe bottom to overflow bottom
   - Probe bottom to overflow top

5. **Measure Overflow Geometry Parameters:**
   Measure the geometry parameters based on the selected cross-section type. Detailed information about cross-section types and geometry is provided in section 2.6. Using a digital level, measure the hydraulic slope inside the overflow. Note the material used in the overflow in order to select the right strickler coefficiant.

6.2 Repeater Installation

It is essential to install a repeater, another node, or a gateway within 70 meters of the manhole for reliable communication. In cases where redundancy becomes necessary, consider adding an additional repeater. Connectivity can be challenging in metallic manholes due to signal interference, so ensuring proper placement of network devices is crucial for stable operation. Follow your repeater installation guidelines, and place the repeater as close to the manhole as possible. Install the main unit at the top of the manhole for better conectivity. The sonar is equipped with a 20 ft cable to allow optimal placement of both the probe and the communication unit.

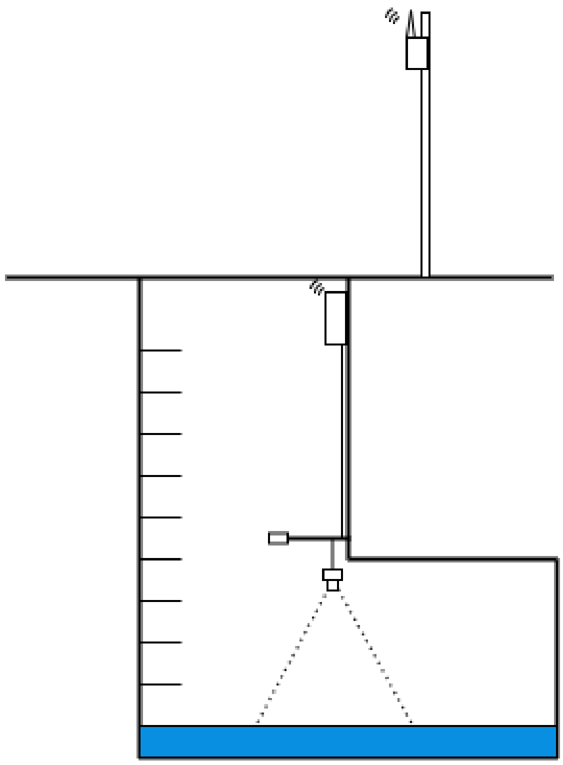


Figure 5: Typical installation nearby a manhole

6.3 Node Configuration

Use the measurements taken during installation along with the cross section parameter described in table 5 to determine the appropriate configuration settings to input through your gateway. This step is typically completed using the Smartrek Web Application or via Modbus registers. Refer to your gateway's manual to learn how to configure a node. Parameter descriptions are presented in table 1 and figure 1. Every application needs to configure at least the following parameter:

- SAMPLETIME
- EMPTYLEVEL
- CSTYPE

If your application requires flow computation you must configure those parameter as well.

- FLOWCOMPUTELEVEL
- FLOWERRLEVEL
- MCSPARAM and/or BCSPARAM refer to table 5 for more details
- STRICKLER
- HYDROSLOPE

If you want to use the AFP feature your must configure the following parameter:

- AFPENABLE
- AFPSAMPLINGTIME
- AFPFASTHRESHOLD

If you need to configure a custom flow equation, please contact Smartrek Technologies to obtain the appropriate parameters.

6.4 Connect the node to a network

To establish a connection with a Smartrek gateway, the following conditions must be met:

- The node must be on the same channel as the gateway.
- The node must have the same encryption as the gateway.
- The node must be within range of the gateway or any other node that is connected to it.

Once the node begins searching for a network, the channel LED will blink three times every 8 seconds, indicating the search process.

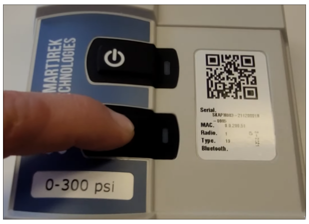
With the correct configuration, the node will automatically sync to the network upon powering on, eliminating the need for manual intervention.

However, after a successful connection, please ensure that the node is manually added to the node list of the gateway. Otherwise, the gateway will not recognize the device as connected.

For configuring the channel and encryption settings, refer to the user guide of your gateway.

6.5 Change SpiderMesh channel

A video guide is available for this step



First, make sure the sensor is powered off. If it is still on, hold down the power button for at least ten seconds until it turns off. Once the sensor is off, locate the channel button. While **keeping the channel button held down**, proceed to the next steps.

While keeping the channel button held down. **Press the power button** once.

Once you have pressed the power button while holding down the channel button, the power LED on the sensor will start blinking to indicate that it is booting up. You must wait until the power LED stops blinking **and** the **channel LED stays lit up solid** before **releasing the channel button**. This indicates that the channel change process is starting.

Slowly press the channel button a number of times that correspond to the desired channel.
To clarify, “slowly” means that you should wait for a brief moment between each press. This will ensure that the sensor can register each press correctly and prevent any accidental multiple presses from being registered as a single press. The number of times you need to press the button corresponds to the desired channel number, so if you want to set the sensor to channel 5, you would press the channel button slowly five times. Each time you press the button, the channel LED on the sensor will light up to indicate that it has registered the press.

Once you have finished pressing the channel button the desired number of times, **hold down the channel button** one last time while waiting for the channel LED to turn off. This indicates that the sensor has successfully completed the channel change process. Once the channel LED turns off, release the channel button. The channel LED will then flash the number of times corresponding to the new channel to confirm the successful channel change.

Power cycles the node (turn it off and on again) and the node will connect to the newly selected channel.

7 Maintenance and Troubleshooting

7.1 Troubleshooting

Issue	Data occasionally shows spikes and/or glitches.
Causes	1. Low battery power. 2. Obstacle in the beam path. 3. Nearby obstacles, such as ladders, create reflections and cause signal integrity issues.
Actions	1. Verify battery power. If the power pack is below 10%, replacing the batteries may resolve the issue. 2. Inspect the installation and remove any obstacles in the probe's beam path, such as ropes, debris, or other obstructions. 3. Move the probe further away from any obstacles, such as ladders. Do not hesitate to hang the probe to position it in an area free from potential interference. The wire harness is designed to support flexible placement.

Issue	The connection with the node is intermittent.
Cause	1. Communication between the node in the manhole and the repeater is not strong enough
Actions	1. Install another repeater at the location nearest to the manhole. This will provide redundancy and a stronger connection. 2. If possible, install the node in the higher end of the manhole

Issue	The node is not connecting to the gateway
Causes	1. The Node is turned off. 2. The Node does not have the same encryption as the gateway. 3. The Node is not on the same channel as the gateway.
Actions	1. Hold the power button down for at least 5 seconds to power off the node. 2. Press the power button once 0.5 seconds to power on the node.

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Issue	The node is not connecting to the gateway
	3. Count the number of times the bottom LED will pulse at boot; it corresponds to your channel number. **Beware, at boot the top led blink always 3 times to indicate the start up of the radio module.** **Beware, while in network seek mode, the bottom led will blink 3 times once every 8 seconds.** 4. Make sure that the node is on the same channel as the gateway.

8 Ordering Information

Table 11: Product number of the PRGEN-MNU

Part number	Description	Country
PRGEN-MNU-1	Atrax node	North America

Table 12: Product number for the accessories of PRGEN-MNU

Part number	Description
MNU-2424-C20	MNU-2424 sonar probe
PRGEN-OVERFLOW-MNU-KIT	The overflow kit contains: - PRGEN-MNU-1 - IP68 enclosure - MNU-2424-C20 - Mechanical support for MNU-2424-C20