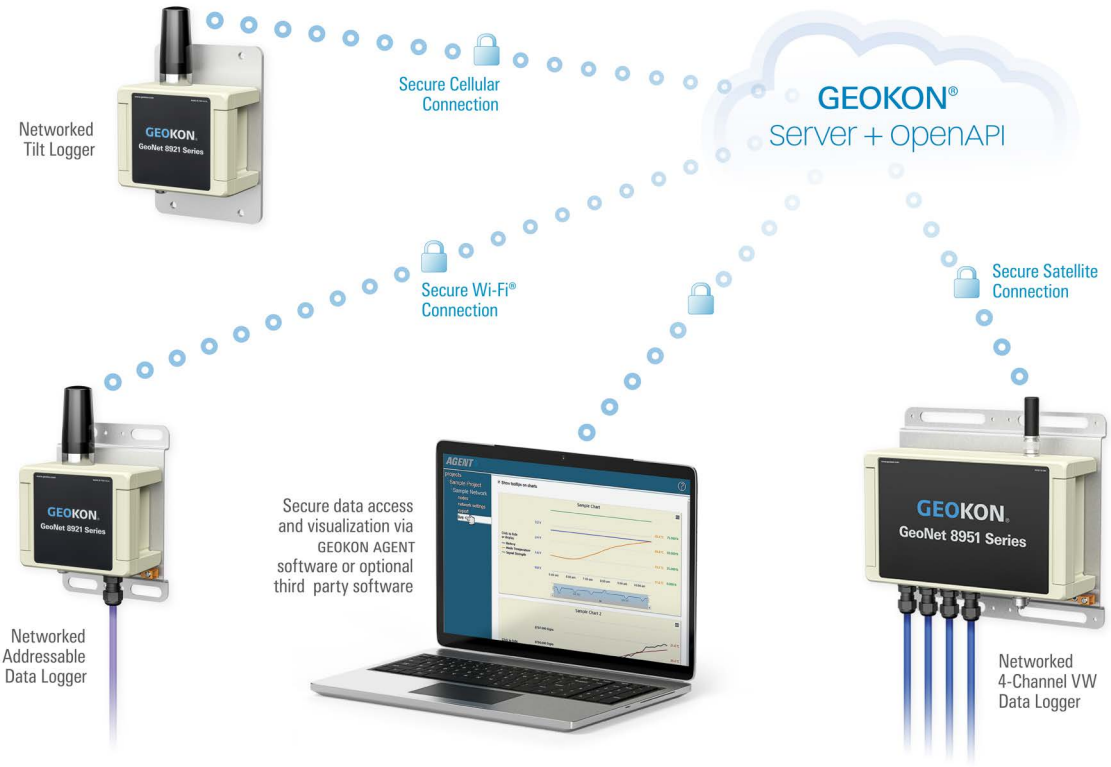
Model 8921 and 8951 Series
GeoNet Network Data Loggers & Data Acquisition System
Instruction Manual



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Note: The Model 8951 Satellite Series is not CE approved.

WARRANTY STATEMENT

GEOKON warrants its products to be free from defects in materials and workmanship for 24 months from the date of purchase, under normal use. If a product requires service, it must be returned to GEOKON—freight prepaid—for evaluation. If a manufacturing defect is confirmed, GEOKON will repair or replace the product at no charge.

This warranty is void if the product has been tampered with or damaged due to excessive corrosion, electrical overload, heat, moisture, vibration, improper specifications, misapplication, misuse, or other conditions outside GEOKON's control. Wearable components—including fuses and batteries—are not covered.

GEOKON instruments are designed for use by trained, qualified personnel. No warranties other than those stated here are provided, including any implied warranties of merchantability or fitness for a particular purpose.

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While every effort is made to ensure accuracy in our manuals and software, GEOKON assumes no responsibility for errors or omissions, nor for any impacts resulting from their use.

TABLE OF CONTENTS

1. INTRODUCTION

The Model 8921and 8951 GeoNet Network Data Loggers offer a high-value, networked data collection option. Each data logger comes from the factory ready for deployment and may commence with data acquisition in minutes.

Sensor data is collected and transferred via a cellular or satellite network to a secure cloud-based storage platform where it can be accessed through the GEOKON OpenAPI. Data visualization software, such as the free GEOKON Agent program, can be used with the OpenAPI for data viewing and reporting. Commissioning, billing and configuration are accomplished via the easy-to-use GEOKON API Portal. The portal allows users to activate data loggers, change settings, configure sensor channels, and view current data logger status. The API Portal can be found at api.geokon.com and the GEOKON Agent program can be downloaded at geokon.com/Software.

Data loggers are compatible with most manufacturers' vibrating wire, RS-485 (using MODBUS protocol), and analog instruments. Sensor cables are connected through cable glands. For multi-sensor instruments such as load cells and thermistor strings, a multichannel data logger is used.

Tilt data loggers are another available option that combines the functionality of a biaxial tiltmeter and a GeoNet Data Logger.

Model 8960 Digital Vibrating Wire Interfaces can be connected to GeoNet Multi-Channel, Addressable, and Digital High Power Data Loggers to expand the capacity of the data logger when used to connect to vibrating wire sensors (see Section 3.8).

FEATURES:

- Automated data connection to servers
- Automated calculation of engineering units via Web API integration with the GEOKON database
- Up to 8 channels
- Rugged, IP 68 rated to 1.5 m (5 feet) die-cast aluminum enclosure with pressure compensation vent to prevent condensation buildup in humid climates.
- USB-C port for firmware updates, diagnostics, and more

1.1 8921 MODEL LIST

Model Number	Data Logger Type	Cellular Network	Sensor Cable Entry
8921-01C	Single-Channel Vibrating Wire	LTE	Cable Gland
8921-08C	Eight-Channel Vibrating Wire		
8921-ADR	Addressable, RS-485		
8921-ANA	Four-Channel Analog		
8921-DHP	Digital High Power, RS-485		
8921-TLT	Tilt		Not Applicable

TABLE 1: *List of Model 8921 Data Loggers*

1.2 8951 MODEL LIST

Model Number	Data Logger Type	Network	Sensor Cable Entry
8951-01C	Single-Channel Vibrating Wire	Satellite	Cable Gland
8951-08C	Eight-Channel Vibrating Wire		
8951-ADR	Addressable, RS-485		
8951-ANA	Four-Channel Analog		
8951-DHP	Digital High Power, RS-485		
8951-TLT	Tilt		Not Applicable

TABLE 2: *List of Model 8951 Data Loggers*

1.3 INCLUDED ACCESSORIES

GeoNet Product Line	Part Number	Description	Quantity
8921 Models	ELC-824	Antenna	1
8951 Models	ELC-1026 ELC-1027 HRD-A1279	Antenna	1

TABLE 3: *List of Included Accessories by GeoNet Product Line*

1.4 ADDITIONAL ACCESSORIES (NOT INCLUDED)

Accessory Application	Part Number	Description
12 Volt Battery Conversion	8020-7-1	Solar Panel, 20-watt, regulated. For use with a 12V battery (customer supplied). Includes side-of-pole mounts, charge controller, and 4.5 m (15') interconnect cable with battery clips. Com-174 (purchased separately) is required.
	COM-174	USB cable for connection between the data logger and external battery.
Other	8900-SOL-10W-USB	10 Watt solar panel.
	KIT-GEONET-C-T20, including: COM-169 TLS-112 TLS-641	**Accessory Kit, including:** USB 2.0 A Male to C Male Cable 3/32" Flat Head Screwdriver T20 Torx Key

TABLE 4: *Additional Accessories (Not Included)*

2. MODELS

Each data logger contains internal sensors for battery, temperature, etc. External sensor cables are connected through cable glands. Data loggers are equipped with rechargeable lithium ion (or in the case of a DHP data logger, sealed lead acid) batteries. Data loggers must be connected to a solar panel or other external power supply.

Note: GeoNet Cellular data loggers are compatible with all major LTE Cat 1 networks except Verizon

2.1 VIBRATING WIRE (VW) DATA LOGGERS

2.1.1 SINGLE-CHANNEL VIBRATING WIRE DATA LOGGER

Single-channel vibrating wire data loggers will read one GEOKON vibrating wire gauge and integral thermistor.

FIGURE 1: *Single-Channel VW Data Logger, 8921 (Left) and 8951 (Right)*

2.1.2 EIGHT-CHANNEL VIBRATING WIRE DATA LOGGER

Eight-channel vibrating wire data loggers will read up to eight GEOKON vibrating wire gauges and integral thermistors.

FIGURE 2: *Eight-Channel VW Data Logger, 8921 (Left) and 8951 (Right)*

An eight-channel data logger can be configured as follows:

Maximum Number of Gauges	Maximum Number of Load Cells
Eight	One 3-gauge **and** one 4-gauge load cell Two 3-gauge **or** two 4-gauge load cells One 6-gauge load cell *Refer to Appendix E for load cell wiring tables*

TABLE 5: *Eight-Channel Data Logger Gauge/Load Limits*

2.2 DIGITAL (RS-485) DATA LOGGERS

2.2.1 ADDRESSABLE (RS-485) DATA LOGGER

Addressable data loggers are compatible with GEOKON Digital Addressable MEMS products and are capable of reading up to 64 GEOKON MEMS sensors (90 sensors, with the sensor string powered via external 12 V power supply). With custom firmware, they are also capable of reading non-GEOKON sensors that utilize RS-485 MODBUS communication protocol.

FIGURE 3: *Addressable Data Logger, 8921 (Left) and 8951 (Right)*

2.2.2 DIGITAL HIGH POWER (RS-485) DATA LOGGER

Digital High Power (DHP) data loggers are compatible with GEOKON Digital Addressable MEMS products. Data loggers are capable of reading up to 250 GEOKON MEMS sensors or 500 GEOKON 6140 Sensors. With custom firmware, they are also capable of reading non-GEOKON sensors that utilize RS-485 MODBUS communication protocol.

FIGURE 4: *Digital High Power Data Logger, 8921 (Left) and 8951 (Right)*

2.3 ANALOG FOUR CHANNEL DATA LOGGER

Analog data loggers contain a single 4-channel analog interface board, this analog interface provides measurement of up to 4 analog sensors with 16-bit resolution. Typical sensors that may be read with this interface include 0-5 V, 4-20 mA (2-Wire or 4-Wire), thermistors, and mV/V (load cells).

FIGURE 5: *Analog Four-Channel Data Logger, 8921 (Left) and 8951 (Right)*

2.4 TILT DATA LOGGER

Tilt data loggers contain an integrated tiltmeter sensor. The two axes of the tiltmeter have a range of ±90° (the calibrated range is ±30°), based on a starting position of 0° (antenna pointing up).

Tilt data loggers have two serial numbers, one for the tilt data logger and one for the internal tiltmeter.

Note: Tilt data loggers do not possess sensor-reading functionality; external sensors cannot be connected.

FIGURE 6: *Tilt Data Logger, 8921 (Left) and 8951 (Right)*

3. INSTALLATION

3.1 STATUS BUTTON & LED STATUS INDICATORS

All GeoNet devices have red and green LED indicators. When the status button is pressed on the data logger, the LEDs briefly display the network status and the data logger takes a reading and sends existing data immediately.

Table 6 shows the meaning of the various LED indications.

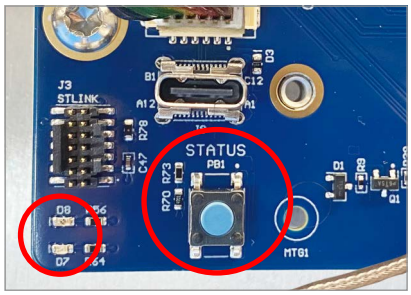

FIGURE 7: *LED Location (Left) and Status Button (Right)*

LED Indicators		Description
Green		Logging, good communications
Green	Red	Logging, no communications
	Red	Not logging, no communications

TABLE 6: *LED Indicator Meaning*

3.2 INSTALLATION OVERVIEW

A general overview of the installation is shown in the steps below. Each step is described in detail in the sections that follow.

1. Open the cover
2. Install the antenna
3. Power the data logger
4. Verify network connectivity
5. Register and configure the data logger
6. Expanding data logger capacity (optional)
7. Mount the devices
8. Connect an earth ground
9. Connect the sensors
10. Seal the data logger

3.3 OPEN THE COVER

Open the cover by wedging open the latch on the right-hand side. (If needed, use a flathead screwdriver for leverage. See Figure 8) Unscrew the two Torx screws beneath the latch with a Torx key (purchased separately). Open the cover.

Important! Ensure that no dirt, water, or other contaminants enter the enclosure.

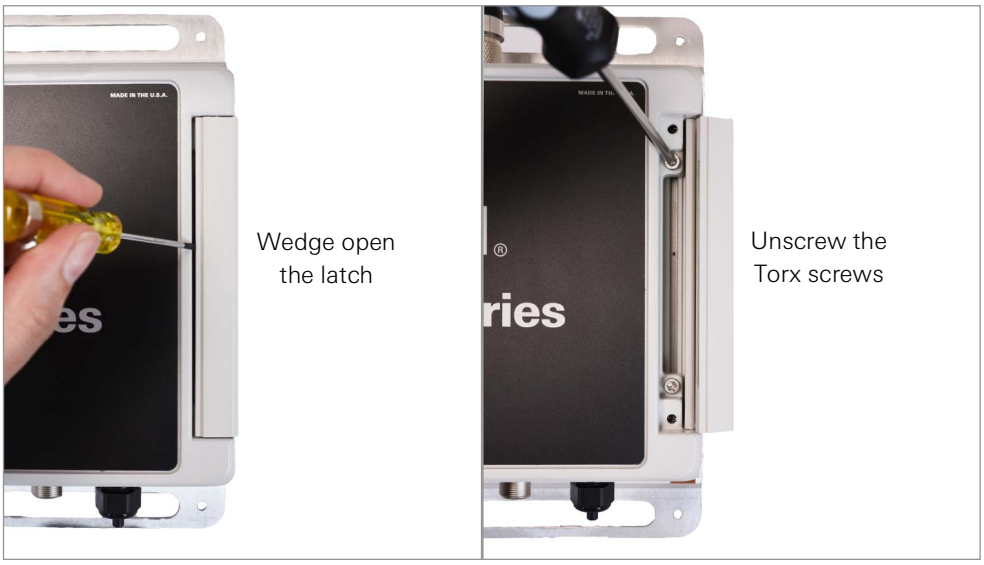

FIGURE 8: *Open the Cover*

3.4 INSTALL THE ANTENNA

Remove the rubber cap from the antenna mount. Position the antenna on the mount and then rotate the antenna in a clockwise direction until tightened.

Note: Do not cross thread the antenna. The O-ring on the bottom of the antennae must be flush with the enclosure to prevent water entry.

3.5 POWER THE DATA LOGGER

Connect the data logger to an external power source via a USB-C connector (purchased separately) (see Appendix B for a solar panel installation).

Move the battery switch (Figure 9) to the ON position. (The battery switch is located on the battery board inside the enclosure.) The green battery LED will flash twice, indicating the unit has power.

Green LED	Blue LED	Charge State
Off	Off	No Power
On	On	Bulk
Off	On	Absorption
On	Off	Float (Fully Charged)

TABLE 7: *Battery Board LED Indicator Meaning*

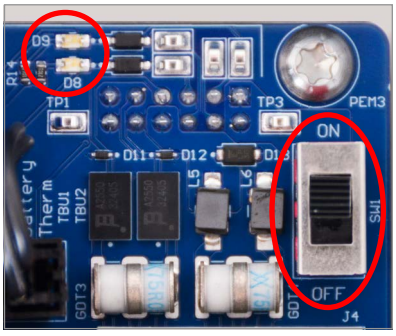

FIGURE 9: *Data Logger Battery LED Location (Left) and Switch (Right)*

3.6 VERIFY NETWORK CONNECTIVITY

Data loggers will set the network time automatically when they connect to the network.* Cellular data loggers will normally connect to the network within approximately five minutes. Satellite data loggers may take up to 20 minutes to connect.

Verify the network connection has been made by pressing the status button. The status LEDs should flash both green and red. If only the red LED flashes, wait several minutes and then check again.

Note: *GeoNet Cellular data loggers are compatible with all major LTE Cat 1 networks except Verizon.

3.7 REGISTER AND CONFIGURE THE DATA LOGGER

Register the data logger by entering the Serial Number in the GEOKON API portal: api.geokon.com. Select the option to activate network service.

Note: Data loggers may not identify correctly until the sensors are connected.

3.7.1 CONFIGURE THE DATA LOGGER VIA THE GEOKON DESKTOP APPLICATION (MANUAL CONNECTION)

Configuring the data logger is optional and only applicable to the Model 8921-ANA Analog Data Logger.

Connect the data logger to a laptop with a USB-C connector (purchased separately).

Download and launch a VCP driver, this will allow the data logger to be recognized through the USB port on a computer:

https://www.silabs.com/developers/usb-to-uart-bridge-vcp-drivers?tab=downloads

Download and launch the GEOKON Desktop application:

https://apps.microsoft.com/detail/9P05ZLF7JTHJ

Select **Settings** and select the appropriate data logger settings from the dropdown menus. Select **Apply Settings** (Figure 10). **Refer to Appendix D for configuration settings and examples.**

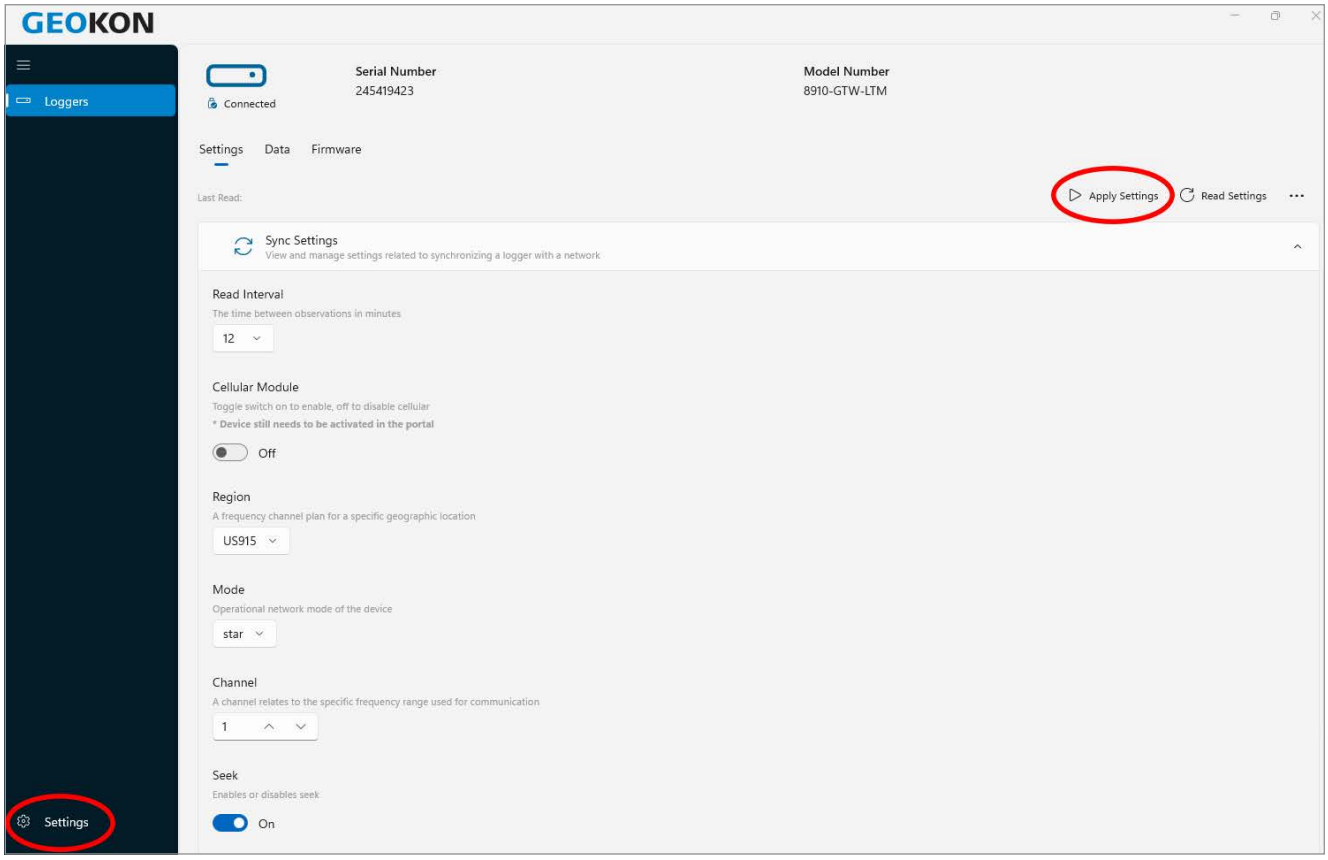

FIGURE 10: *Configuring Using the GEOKON Desktop Application*

3.8 EXPANDING DATA LOGGER CAPACITY (OPTIONAL)

Model 8960 Digital Vibrating Wire interfaces can be connected to GeoNet Multi-Channel, Addressable, and Digital High Power Data Loggers to expand the capacity of the data logger. Multiple VW interfaces can be daisy-chained together to bus the data to a single data logger. The bus limit is 32 units or 64 Channels.

Refer to the Model 8960 Instruction Manual (geokon.com/8960-Series) for information on how to connect a data logger to an interface, how to address the interfaces, and other applicable steps. To get immediate software recognition the interfaces must be connected before the data logger has been powered on.

3.9 MOUNT THE DEVICES

GeoNet mounting brackets are designed to be used with U-bolts, hose clamps, screws, etc. Mount all devices vertically, with the antenna pointing up. GEOKON recommends a mounting height of at least 2 m (6.5'). Lower than 2 m may compromise performance. As a rule, higher is usually better.

Select the mounting location with care. Certain mounting configurations can hinder or even completely block wireless signal transmission or can introduce electrical noise to the signal. (Large structures, such as walls, buildings, hills, etc. can block and/or reflect RF signals. See Section 3 for more information.)

Note: A high Received Signal Strength Indicator (RSSI) level does not guarantee trouble-free communication.

Examples of incorrect mounting configurations are shown in the following figures. Figures are for reference use only.

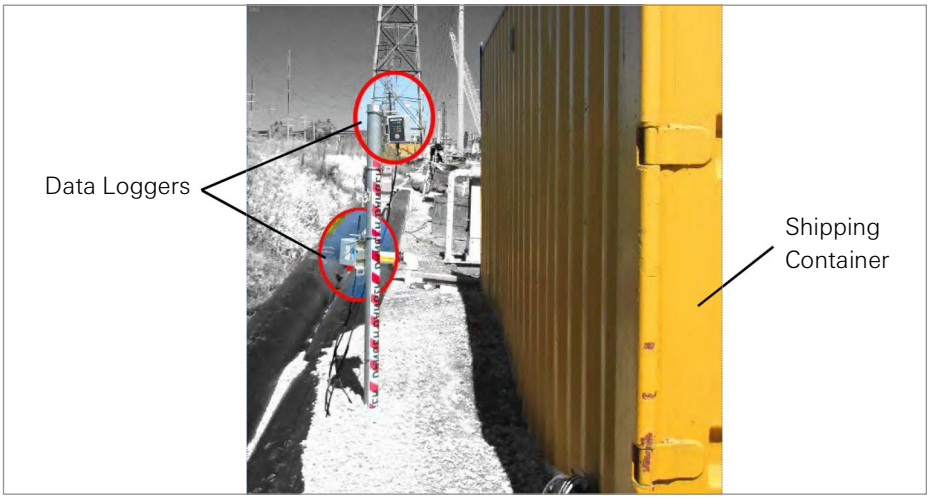

FIGURE 11: *Installing Near a Large or Metallic Object*

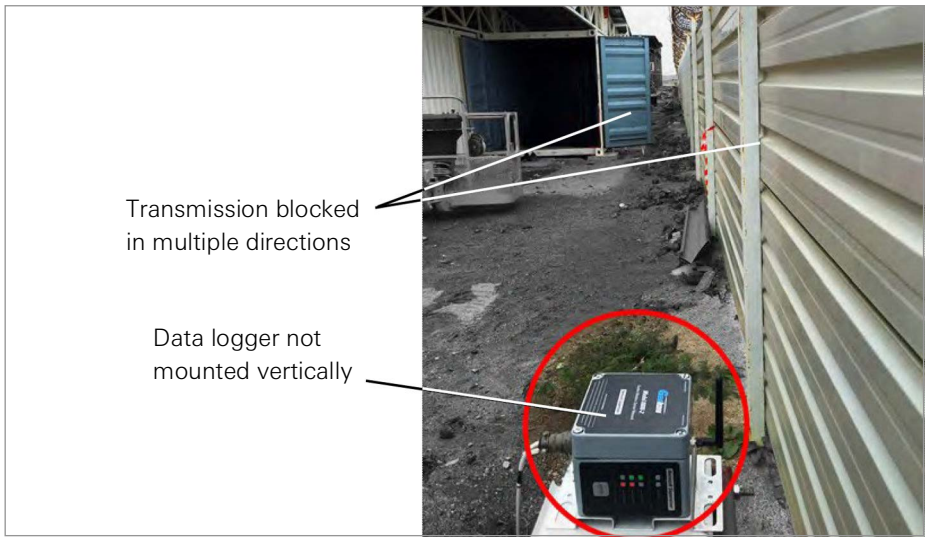

FIGURE 12: *Installing Close to Buildings or Fences/Walls, and/or Horizontally*

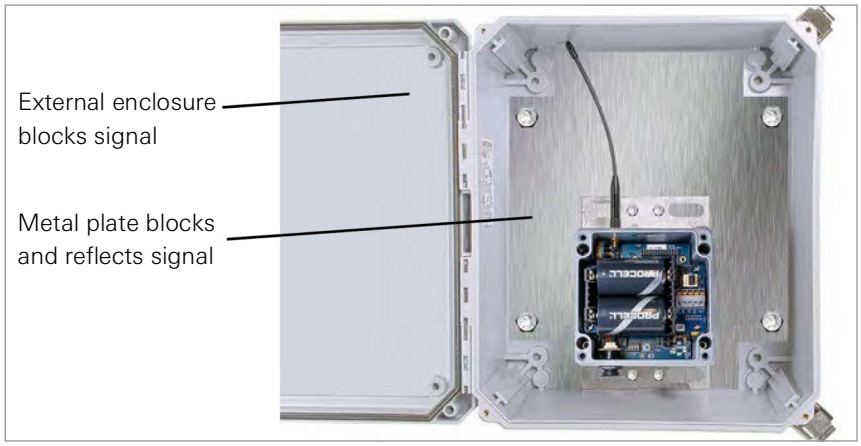

FIGURE 13: *Mounting onto a Metal Plate and/or Inside an Enclosure*

3.10 CONNECT AN EARTH GROUND

Properly grounding GeoNet devices will lessen the chance of them being damaged from nearby lightning strikes or other large transient voltages. Each vibrating wire (VW) channel is protected by a 230V gas discharge tube, followed by a high-speed surge protector and a transient voltage suppression diode. Each thermistor (TH) channel is protected by a 230V gas discharge tube, followed by an inductor (lower resistance than high-speed surge protectors) and a transient voltage suppression diode.

For these components to safely divert lightning energy to ground, a solid electrical connection to earth ground is required. All GeoNet devices can be grounded by connecting a suitable earth ground to the mounting bracket. Some GeoNet devices can also be grounded via the copper ground lug on the bottom of the enclosure.

A copper grounding rod at least six feet in length should be driven into the soil to a minimum depth of three feet, as close to the device as possible. Connect the grounding rod to the mounting bracket or the copper grounding lug on the exterior of the device with a 12 AWG or larger wire. This will provide a path from the device to earth ground in the event of a lightning strike. Alternatively, any other suitable earth ground attachment may be used.

3.11 CONNECT THE SENSORS

Note: Data Loggers will stop trying to read an empty channel after two attempts. The data logger will read all channels at the top of every hour and will resume sampling when it detects a sensor. (Reset the data logger to initiate an immediate retry.)

For ease of wiring, sensor cables should be inserted into the cable glands on multi-channel data loggers in order from left to right and wired into the VW terminal blocks in sequence, starting with channel one.

To connect a sensor:

1. Loosen the nut on the cable fitting and remove the black plastic dowel.
2. Slide the sensor cable through the cable gland nut and fitting.
3. Connect the cable leads to the terminal block by holding down an orange tab, inserting the lead, and then releasing the tab. The wiring order is shown in tables and figure below.

Important! To prevent a short circuit, do not allow the cable leads to touch each other during or after wiring.

Single/Multiple Channel Vibrating Wire Data Logger		
Position	**Color**	**Description**
VW+	RED	Vibrating Wire+
VW-	BLACK	Vibrating Wire-
TH+	WHITE	Thermistor+
TH-	GREEN	Thermistor-
SHD	BARE	Analog Ground (Shield)

TABLE 8: *Vibrating Wire Data Logger Wiring*

Addressable and DHP (RS-485) Data Logger		
Position	**Color**	**Description**
485+	WHITE	RS-485 Data+
485-	GREEN	RS-485 Data-
12V	RED	12 Volt Bus
GND	BLACK	Bus Ground
SHD	BARE	Analog Ground (Shield)

TABLE 9: *Addressable and DHP (RS-485) Data Logger Wiring*

Analog Data Logger		
Position	**Color**	**Description**
Vin+	No universal color code	Sensor Signal+
Vin-		Sensor Signal-
Exc+		Excitation Voltage+
Exc-		Excitation Voltage-
SHD	BARE	Analog Ground (Shield)

TABLE 10: *Analog Data Logger Wiring*

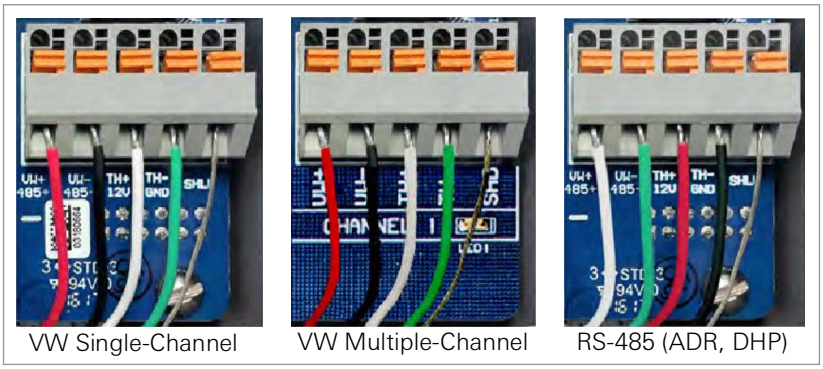

FIGURE 14: *Terminal Connections*

4. Pull gently on each conductor to ensure it is secure.
5. Tighten the cable gland nut until it firmly grips the outer jacket of the cable. The cable gland nut must be properly tightened to prevent water entry. Do not overtighten, as this might strip the plastic threads.
6. Pull gently on the gauge cable to ensure it is held in place by the cable gland.
7. Repeat these steps for each gauge cable to be connected.
8. **Analog Data Loggers Only:** Confirm the selector switch (located under the terminal block, see Figure 15) is set to the appropriate mode for the sensor being read. See Appendix D for examples on wiring and selector switch configuration.

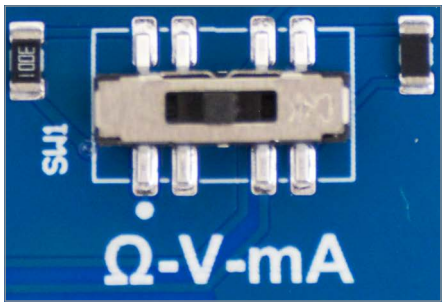

FIGURE 15: *Analog Mode Selector Switch*

3.12 SEAL THE DATA LOGGER

1. Record the serial number of the data loggers and the attached sensors. For multiple-channel data loggers, also record the channel to which each sensor has been connected. (The serial numbers are used for identification purposes in the API portal and Agent software.)
2. Make sure the cover gasket and the mating ridge on the enclosure are clean.
3. Close the cover and tighten the two Torx screws.
4. Push the latch firmly closed onto the cover.

Note: Make sure any unused openings are plugged with the provided dowel and the cable gland nut is tightened.

4. MAINTENANCE

4.1 WEATHER PROOFING

GeoNet devices are designed to be splash proof, rain proof, and are IP 68 rated to 1.5 m (5 feet). The enclosures are sealed by a gasket. The gasket will only prevent water entry if it is properly aligned inside the lid, the screws that hold the lid in place are properly tightened, and the latch is closed.

Always mount the devices so that the cable entries are on the bottom. Ensure the cable gland fittings are securely tightened and that the black plastic dowels provided are used to plug cable entries which are not in use.

Despite these precautions, the data loggers may encounter leakage along the cable if the cable is cut, or if the unit is installed in an especially humid environment.

APPENDIX A. TROUBLESHOOTING

For troubleshooting help, please visit geokon.com/Technical-Support.

APPENDIX B. SOLAR PANEL KIT

The GEOKON Solar Panel Kit enables you to power a data logger in an area that has no access to mains / domestic power.

FIGURE 16: *Solar Panel 8900-SOL-10W-USB*

Inside the kit box are the following:

- One envelope containing technical documents and instructions
- One mounting bracket
- One solar panel complete with power regulation circuitry and power cable

FIGURE 17: *Solar Panel Kit Box Contents*

Install the solar panel by following the steps listed below. Each step is described in detail in the sections that follow.

1. Select a location for the solar panel.
2. Assemble and adjust the mounting bracket to the proper angle.
3. Install the mounting bracket onto the mounting surface or pole.
4. Secure the solar panel to the mounting bracket.
5. Turn on the data logger and connect the power cable.

B.1 SELECT A LOCATION

Choose a location for the solar panel that is clear of obstructions and anything that might cast a shadow on the panel.

B.2 ASSEMBLE THE MOUNTING BRACKET

When assembling the two sections of the mounting bracket, be sure to set the sections to the desired angle before tightening the nuts. The angle of the mounting bracket will dictate the angle of the solar panel.

- Ensure the angle is at least 10 degrees, to aid in water control.
- In general, choose the best angle for the latitude of your location.
- Mounting on a horizontal surface will require a reverse configuration of the two sections compared to mounting vertically, as shown below.

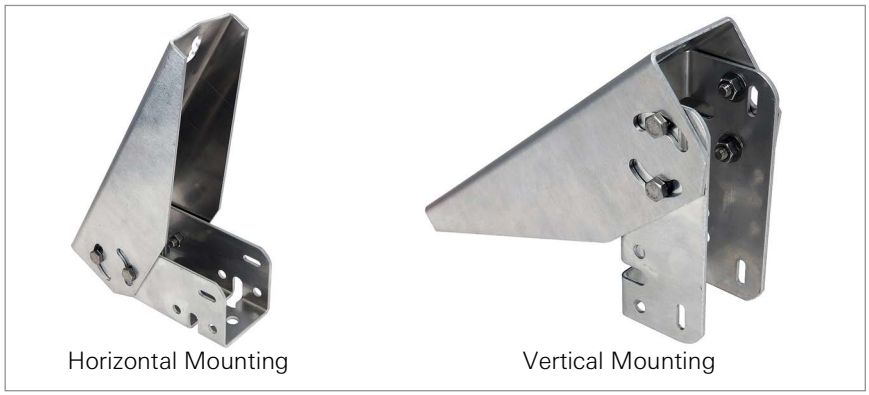

FIGURE 18: *Mounting Options*

B.3 INSTALL THE MOUNTING BRACKET

Mount the bracket on a flat surface (roof, wall, etc.) using locally supplied bolts or lag screws. If mounting to a pole, use locally supplied U-bolts and retaining clamps.

B.4 SECURE THE SOLAR PANEL TO THE MOUNTING BRACKET

Use the included nuts and screws to secure the solar panel to the mounting bracket. Use the centrally located holes provided for this purpose on the back of the solar panel.

Note: Be sure to mount the solar panel with the cable coming out the bottom of the panel, as shown below.

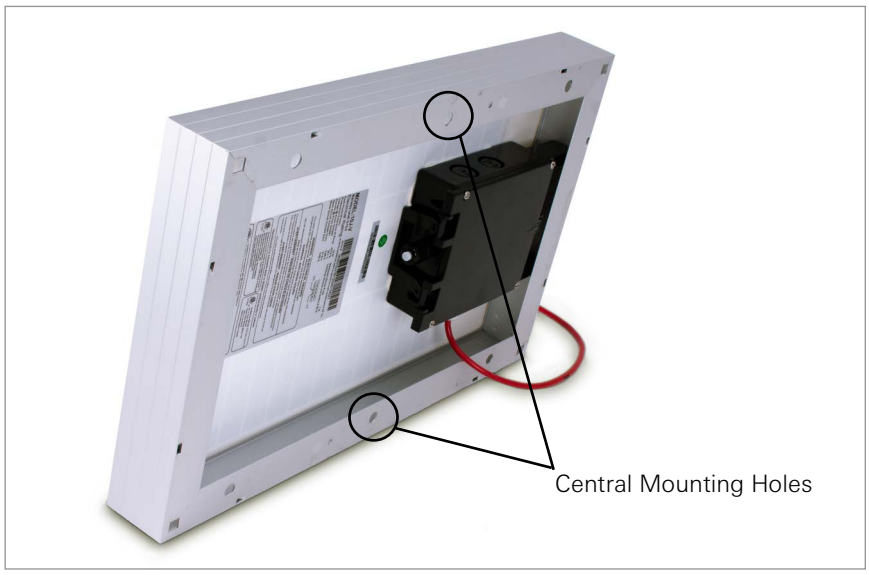

FIGURE 19: *Centrally Located Mounting Holes*

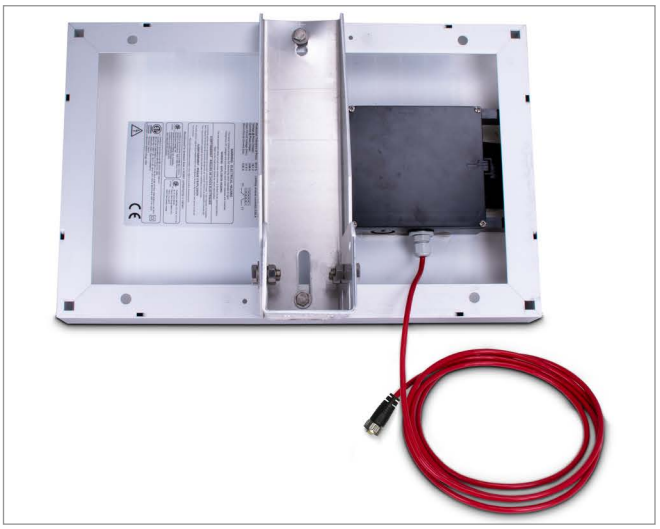

FIGURE 20: *Mounting Brackets Fastened Centrally*

B.5 CONNECT THE POWER CABLE

B.5.1 BATTERY SWITCH

Before connecting the power cable, be sure you have set the battery switch to the ON position.

B.5.2 MAKING THE CONNECTION

Remove the plastic cap from the cable connector, then attach it to the USB-C plug on the data logger.

Note: Be sure to implement a drip loop, as indicated in the previous figure, to prevent water ingress through the power connector.

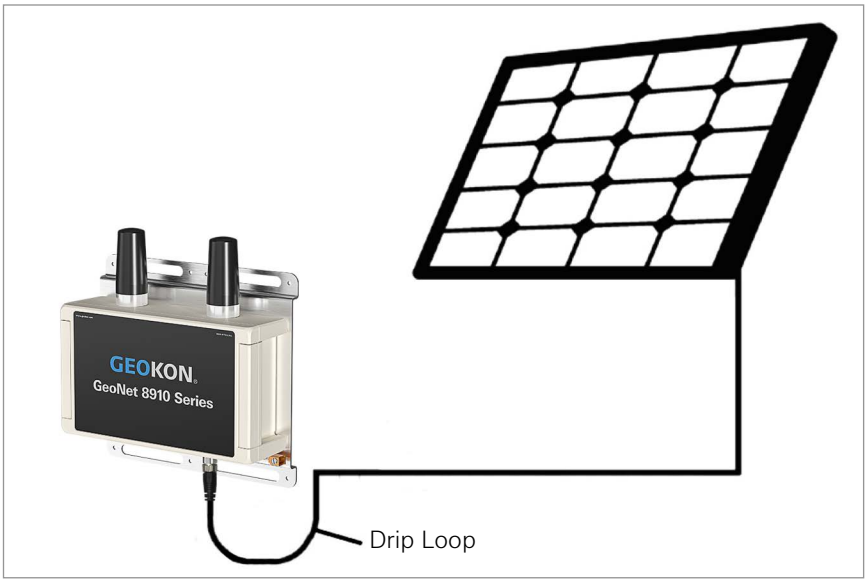

FIGURE 21: *Solar Panel with Data Logger, Image for Reference Only*

APPENDIX C. SPECIFICATIONS

C.1 GENERAL SPECIFICATIONS

Power Supply	DHP models: Internal sealed lead acid (SLA) battery pack, 4V, 10 Ah / 5-24V external All other models: Rechargeable lithium battery, / 5-24V external
Operating Temperature	-40 °C to +85 °C (range varies by power source) (TLT model max of +65 °C)
Temperature Accuracy	±0.5 °C
Direct Connection Type	USB
Enclosure Material	Die-cast aluminum, IP 68 rated to 1.5 m (5 feet)
Enclosure Dimensions	See Appendix F
Data Transmission Interval	Min: 10 minutes; Max: 1 day

TABLE 11: *General Specifications*

C.2 VIBRATING WIRE DATA LOGGER SPECIFICATIONS

Trueness	0.082 Hz
Frequency Precision	±0.146 Hz (99% CI)
Frequency Resolution	±0.002 Hz
VW Frequency Range	400-6500 Hz

TABLE 12: *Vibrating Wire Data Logger Specifications*

C.3 DIGITAL DATA LOGGER (ADDRESSABLE AND DIGITAL HIGH POWER) SPECIFICATIONS

MEMS Sensor Limits	ADR: 64 sensors (90 sensors, with the sensor string powered via external 12 V power supply) DHP: 250 sensors
Communication Protocol	RS-485 Modbus

TABLE 13: *Digital Data Logger (Addressable and Digital High Power) Specifications*

C.4 TILT DATA LOGGER SPECIFICATIONS

Range[1]	±90°
Resolution[2]	0.00025° (0.004 mm/m)
Precision[3]	±0.0075° (±0.13 mm/m)
Nonlinearity	±0.005° across ±30° range (±0.09 mm/m)
Temperature Dependent Uncertainty	±0.001° across ±5° angular range (±0.016 mm/m) ±0.0016° across ±15° angular range (±0.026 mm/m) ±0.0026° across ±30° angular range (±0.042 mm/m)
Axes	2

TABLE 14: *Tilt Data Logger Specifications*

Note:

[1] Calibrated Range: ±30°

[2] 99% confidence interval (i.e., 99 out of 100 individual readings fall within this tolerance).

[3] Includes random walk (changes between consecutive readings that have no discernible cause) and seismic noise during testing.

C.5 ANALOG DATA LOGGER SPECIFICATIONS

Channels	4
Input Type	mV, V, mA, Ω
Input Range	0 – 150 mV, 0 – 500 mV, 0 – 1 V, 0 – 5 V, 0 – 10 V, 0 – 15 V, ±150 mV, ±500 mV, ±1 V, ±5 V, ±10 V, ±15 V, ±20 mA, 0 – 20 mA, 4 – 20 mA
Voltage Mode Accuracy	±0.1% or better
Current Mode Accuracy	±0.2% or better
Resolution	16-bit
Zero Drift	±6 μV/°C
Span Drift	±25 ppm/°C (typical)
CMR @ 50/60 Hz	92 dB min.

TABLE 15: *Analog Logger Specifications*

APPENDIX D. ANALOG CONFIGURATION AND EXAMPLES

D.1 CHANNEL CONFIGURATION

Using the Geonet Desktop application, each analog input channel may be configured for the sensor being monitored:

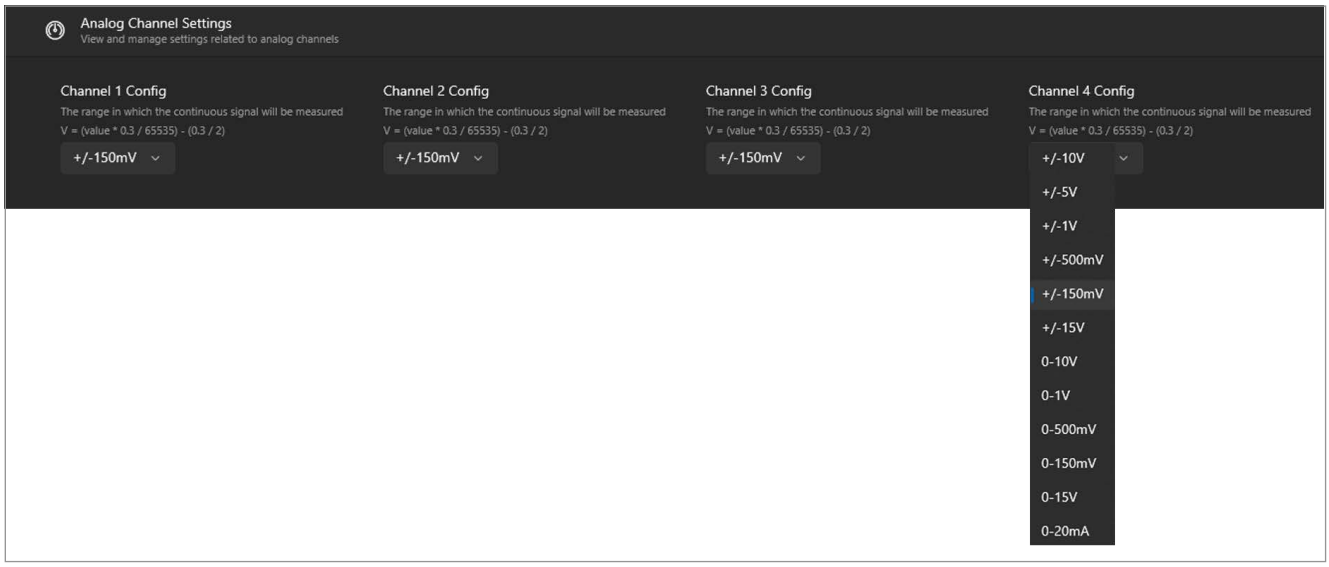

FIGURE 22: *Input Configuration Selections*

D.2 INPUT RANGE OPTIMIZATION

The 8921 Analog Data Logger contains a 16-bit Analog to Digital Converter (ADC). This ADC may be scaled using Channel Configuration so that the 16-bit range (65536 discrete values) is optimized for the attached sensor.

When configuring an input channel, for highest resolution it is best to use the input range that is closest to - but not less than - the analog sensor's output range:

Channel Input Range	Resolution
± 10 V	305 μ V
± 5 V	153 μ V
± 1 V	30.5 μ V
± 500 mV	153 μ V
± 150 mV	4.58 μ V
± 15 V	458 μ V
0 - 10 V	153 μ V
0 - 1 V	15.3 μ V
0 - 500 mV	7.63 μ V
0 - 150 mV	2.29 μ V
0 - 15 V	229 μ V
0 - 20 mA	0.305 μ A

TABLE 16: *Analog Channel and Resolution*

For example, suppose you have a sensor that has an output voltage range of 0 to 500 mV. For maximum resolution the preferred input range is 0-500 mV (Single Ended):

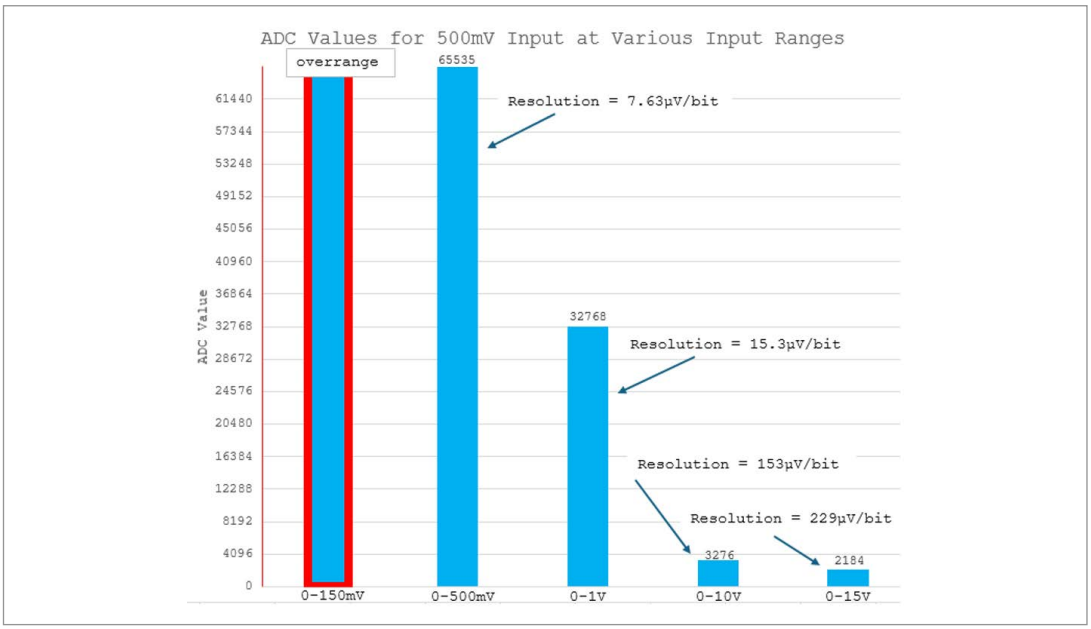

FIGURE 23: *ADC Values for 500 mV Input at Various Input Ranges*

Note that sensor output voltages exceeding 500 mV will result in an overrange of the ADC. Any voltage greater than 500 mV will read as 65535. Any voltage less than 0 V will read as 0 (underrange).

Similarly, sensors that have a differential (±) output range have the same requirements. Suppose you have a sensor that outputs ±1 V:

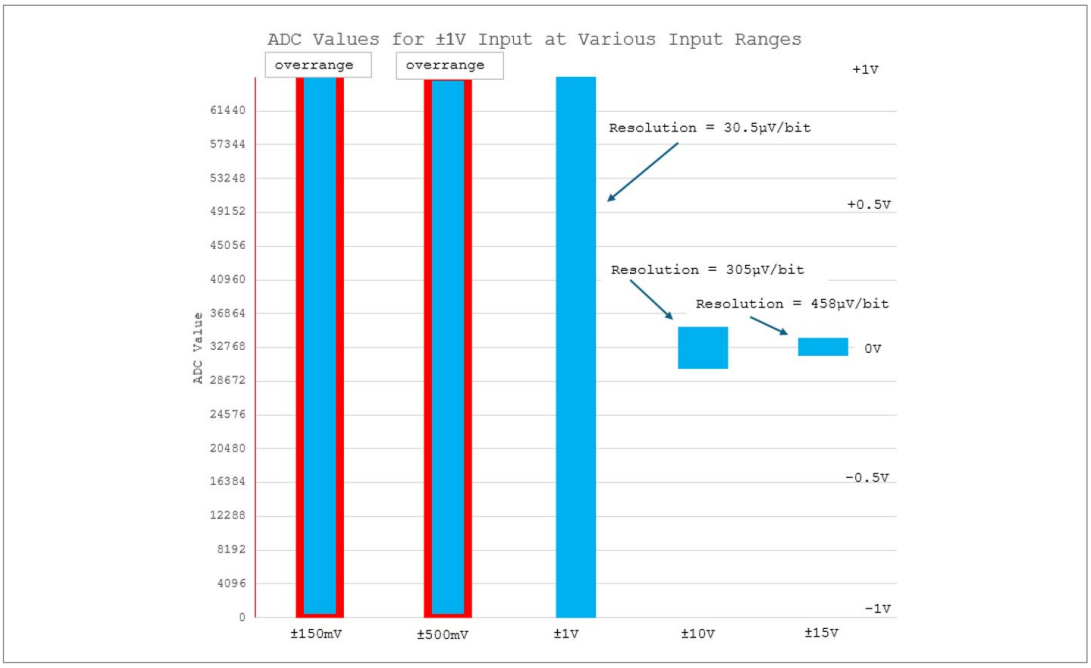

FIGURE 24: *ADC Values for ±1 V Input at Various Input Ranges*

Note that sensor output voltages exceeding ±1 V will result in an overrange/underrange of the ADC. Any voltage greater than +1 V will read as 65535, and any voltage less than -1 V will read as 0.

D.3 ADC VALUE TO VOLTAGE CONVERSION

The voltage output by the sensor is converted to a 16-bit value by the ADC. This 16-bit value can be converted back to voltage with the following formulas:

SINGLE ENDED SENSORS (0-15V, 0-10V, 0-1V, 0-500MV, 0-150MV)

Value = ADC 16-bit value

Range = ADC Input Range (V)

Resolution = 65535

$$V = Value \times \frac{Range}{Resolution}$$

EQUATION 1: *Voltage Conversion for Single Ended Sensors*

Example:

Value = 16384

Range = 0-10 V (10 V)

The conversion from the 16-bit value to voltage is:

$$V = 16384 \times \frac{10}{65535}$$

$$V = 2.500\ V$$

DIFFERENTIAL SENSORS (+/-15V, +/-10V, +/-5V, +/-1V, +/-500MV, +/-150MV)

Value = ADC 16-bit value

Range = ADC Input Range (V)

Resolution = 65535

$$V = Value \times \frac{Range}{Resolution} - \frac{Range}{2}$$

EQUATION 2: *Voltage Conversion for Differential Sensors*

Example:

Value = 8192

Range = +/-5 V (10 V)

The conversion from the 16-bit value to voltage is:

$$V = 8192 \times \frac{10}{65535} - \frac{10}{2}$$

$$V = -3.75\ V$$

D.4 POWER

Power (12V nominal) is provided to each sensor by way of EXC+/EXC- for each channel.

D.5 SENSOR WIRING AND CONFIGURATION EXAMPLES

Model 3400-2 or 3400-3 Semiconductor Piezometers (connected to channel 1):

Sensor Type	Positions and Wire Colors					Switch Setting	Channel Configuration
	Vin+	Vin-	Exc+	Exc-	SHD		
Model 3400-2 (0-5 V)	White	White's Black	Red	Red's Black	BARE	V	0-10 V
Model 3400-3 (4-20 mA)	Black	N/C	Red	N/C	BARE	mA	0-10 V

TABLE 17: *Wiring Example for Model 3400-2 or 3400-3 Semiconductor Piezometers*

Model 3400-1 Semiconductor Piezometer with thermistor (connected to channels 1 and 2):

Sensor Type	Positions and Wire Colors					CH1 Switch Setting	CH1 Channel Configuration
	CH1 Vin+	CH1 Vin-	CH1 Exc+	CH1 Exc-	CH1 or CH2 SHD		
Model 3400-1 (0-100 mV)	White	White's Black	Red	Red's Black	BARE	V	±150 mV
	CH2 Vin+	CH2 Vin-	CH2 Exc+	CH2 Exc-		CH2 Switch Setting	CH2 Channel Configuration
	Green	Green's Black	N/C	N/C		Ω	0-15 V

TABLE 18: *Wiring Example for Model 3400-1 Semiconductor Piezometer*

Model 3800-1 Thermistor Probe (connected to channel 1):

Sensor Type	Positions and Wire Colors					Switch Setting	Channel Configuration
	Vin+	Vin-	Exc+	Exc-	SHD		
Model 3800-1-1	TH+	TH-	N/C	N/C	BARE	Ω	0-15 V

TABLE 19: *Wiring Example for Model 3800-1 Thermistor Probe*

D.6 READING A 4-20 MA SENSOR (CURRENT MEASUREMENT)

Current measurements are possible by installing the 4-20 mA device (2-wire or 4-wire) between the input channel's Vin+ and Vin- terminals and setting the channel's Ω-V-mA switch to the **mA** position.

2-WIRE 4-20 MA SENSOR

Connect the sensor's power wire to the channel's EXC+ terminal.

Connect the sensor's output wire to the channel's Vin+ terminal.

Setting the Ω-V-mA switch to the mA position connects the 4-20 mA output internally across a 125 Ω precision resistor:

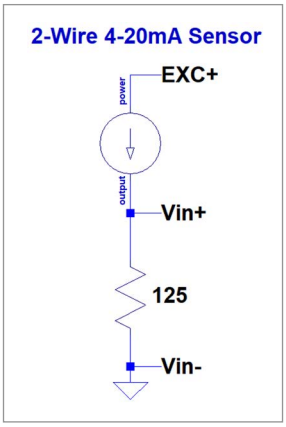

FIGURE 25: *2-Wire 4-20 mA Sensor*

Setting the Input Channel to 0-10 V, current is then calculated:

1. Measure Vin+.
2. Determine the 4-20 mA current: $I(4-20\ mA) = \frac{Vin+}{125\ \Omega}$

Example:

- A 2-Wire 4-20 mA sensor is connected between CH1 EXC+ and Vin+

- The Ω-V-mA switch for CH1 is set to the mA position
- CH1 is configured as 0-10 V
- The voltage measured at CH1 Vin is 2.5 V
- The current is calculated:

$$I(4-20\ mA) = \frac{2.5\ V}{125\ \Omega}$$

$$I(4-20\ mA) = 0.2\ A = 20\ mA$$

4-WIRE 4-20MA SENSOR

Connect the sensor's power wire to the channel's EXC+ terminal.

Connect the sensor's GND wire to the channel's EXC- terminal.

Connect the sensor's output+ wire to the channel's Vin+ terminal.

Connect the sensor's output- wire to the channel's Vin- terminal.

Setting the Ω-V-mA switch to the mA position connects the 4-20 mA output internally across a 125 Ω precision resistor:

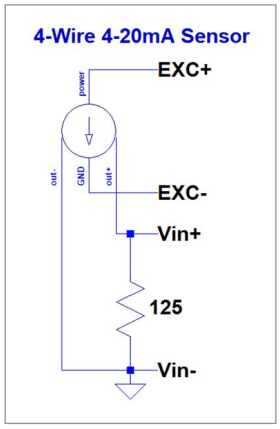

FIGURE 26: *4-Wire 4-20mA Sensor*

Setting the Input Channel to 0-10 V, current is then calculated:

1. Measure Vin+.
2. Determine the 4-20 mA current: $I(4-20\ mA) = \frac{Vin+}{125\ \Omega}$

Example:

- A 4-Wire 4-20 mA sensor is connected as above at CH1
- The Ω-V-mA switch for CH1 is set to the mA position
- CH1 is configured as 0-10 V
- The voltage measured at CH1 Vin is 0.6 V
- The current is calculated:

$$I(4-20\ mA) = \frac{0.6\ V}{125\ \Omega}$$

$$I(4-20\ mA) = 0.0048\ A = 4.8\ mA$$

D.7 READING A THERMISTOR (RESISTANCE MEASUREMENT)

Resistance measurements are possible by installing the resistance device (i.e. thermistor) between the input channel's Vin+ and Vin- terminals and setting the channel's Ω-V-mA switch to the Ω position.

Setting the Ω-V-mA switch to the Ω position connects the thermistor internally to the Excitation Voltage (12 V) via a 3 kΩ precision resistor:

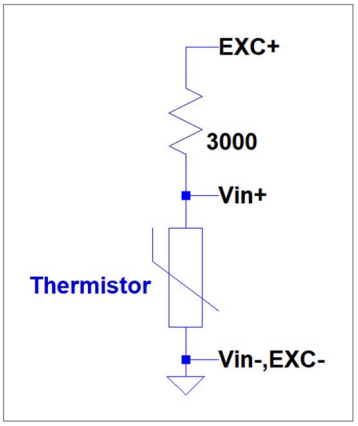

FIGURE 27: *Thermistor*

Setting the Input Channel to 0-15 V, resistance is then calculated:

1. Measure the excitation voltage EXC+.
2. Measure Vin+.
3. Determine the excitation current: $\mathrm{Iexc} = \frac{\mathrm{EXC+} - \mathrm{Vin+}}{3000}$
4. Determine the resistance: $\mathrm{R} = \frac{\mathrm{Vin+}}{\mathrm{Iexc}}$

Example:

- A thermistor is connected between CH1 Vin+ and Vin-
- The Ω-V-mA switch for CH1 is set to the Ω position
- CH1 is configured as 0-15 V
- The voltage measured at CH1 Vin is 7.2 V
- The resistance is calculated:

  $\mathrm{Iexc} = \frac{12\ \mathrm{V} - 7.2\ \mathrm{V}}{3000}$

  $\mathrm{Iexc} = 0.0016\ \mathrm{A}$

  $\mathrm{R} = \frac{7.2\ \mathrm{V}}{0.0016\ \mathrm{A}}$

  $\mathrm{R} = 4500\ \Omega$

APPENDIX E. VIBRATING WIRE LOAD CELL WIRING

E.1 WIRING SINGLE LOAD CELL

8CH Interface[1]	Function	3-Gauge Load Cell Violet Cable	4-Gauge Load Cell Violet Cable	6 Gauge Load Cell Orange Cable
Channel 1 VW+	Gauge #1	Red	Red	Red
Channel 2 VW+	Gauge #2	Red's Black	Red's Black	Red's Black
Channel 3 VW+	Gauge #3	White	White	White
Channel 4 VW+	Gauge #4	NC	White's Black	White's Black
Channel 5 VW+	Gauge #5	NC	NC	Green
Channel 6 VW+	Gauge #6	NC	NC	Green's Black
Channel 1 SHD	Shield	All Shields	All Shields	All Shields
VW- Channels[2]	Common	White's Black[3]	Green	Blue
Channel 1 TH +	Thermistor	Green[3]	Blue	Yellow
Channel 1 TH -	Thermistor	Green's Black	Blue's Black	Yellow's Black

TABLE 20: *Single Load Cell Wiring*

Note:

[1] Where second Load Cell is being included, retain relative channel position count up from channel 5.

[2] Common "VW-" between all channels associated with each VW Load Cell

[3] White's black and Green wires are switched on GEOKON three-gauge VW load cells prior to serial number 3313.

E.2 LOAD CELL CONFIGURATION SWITCH SETTINGS

POS 1	POS 2	POS 3	Configuration
OFF	OFF	OFF	Std. No Load Cell
ON	OFF	OFF	One 3-Gauge Load Cell
OFF	ON	OFF	One 4-Gauge Load Cell
ON	ON	OFF	Two 3-Gauge Load Cells, second starting at channel 5
OFF	OFF	ON	Two 4-Gauge Load Cells, second starting at channel 5
ON	OFF	ON	One 3-Gauge Load Cell & One 4-Gauge Load Cell starting at channel 5
OFF	ON	ON	One 4-Gauge Load Cell & One 3-Gauge Load Cell starting at channel 5
ON	ON	ON	One 6-Gauge Load Cell

TABLE 21: *Load Cell Configuration Switch Settings*

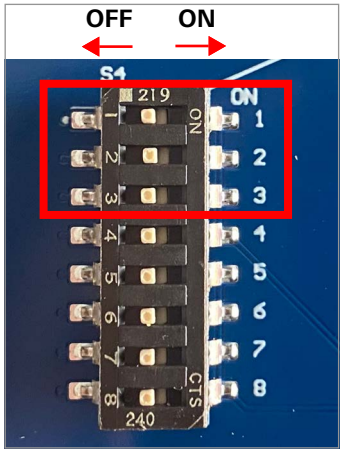

FIGURE 28: *Load Cell Configuration Switch*

APPENDIX F. UNIT DIMENSIONS

Note: Dimensions shown below are in inches.

F.1 SINGLE-CHANNEL (01C) AND ADDRESSABLE (ADR) MODELS

FIGURE 29: *Single-Channel (01C) and Addressable (ADR) Models*

F.2 EIGHT-CHANNEL (08C), ANALOG (ANA), AND DIGITAL HIGH POWER (DHP) MODELS

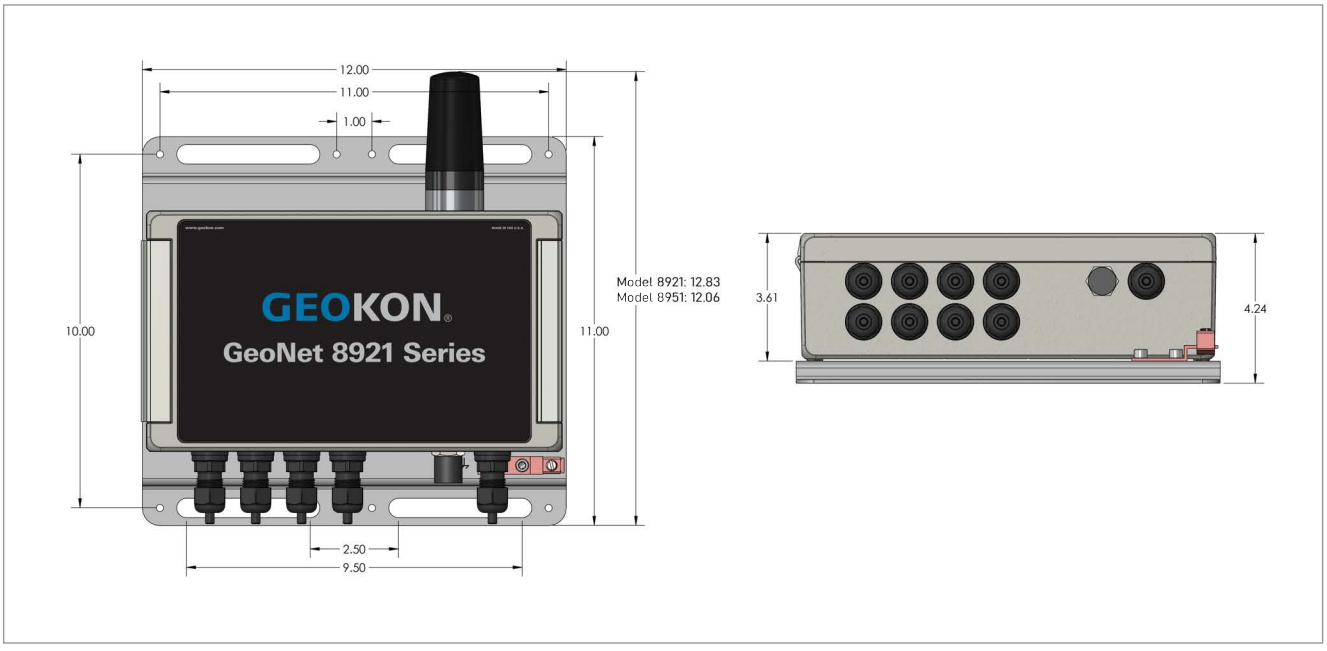

FIGURE 30: *Eight-Channel (08C), Analog (ANA), and Digital High Power (DHP) Models*

F.3 TILT (TLT) MODELS

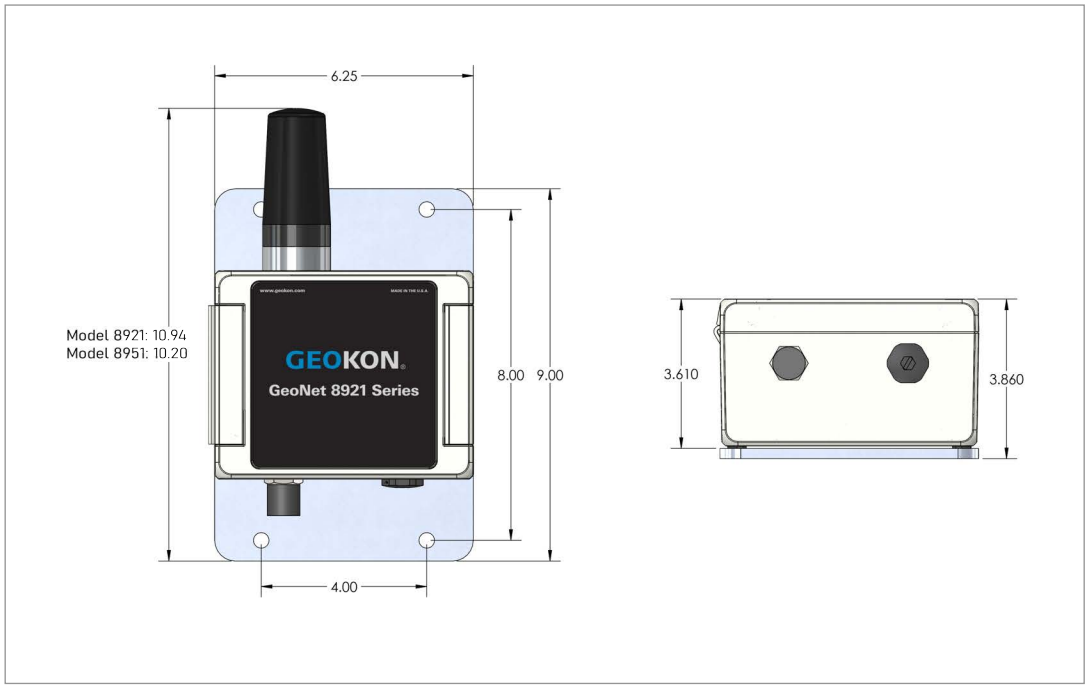

FIGURE 31: *Tilt (TLT) Models*

APPENDIX G. MOUNTING BRACKET DIMENSIONS

Note: Dimensions shown below are in inches.

G.1 EIGHT-CHANNEL (08C), ANALOG (ANA), AND DIGITAL HIGH POWER (DHP) MODELS

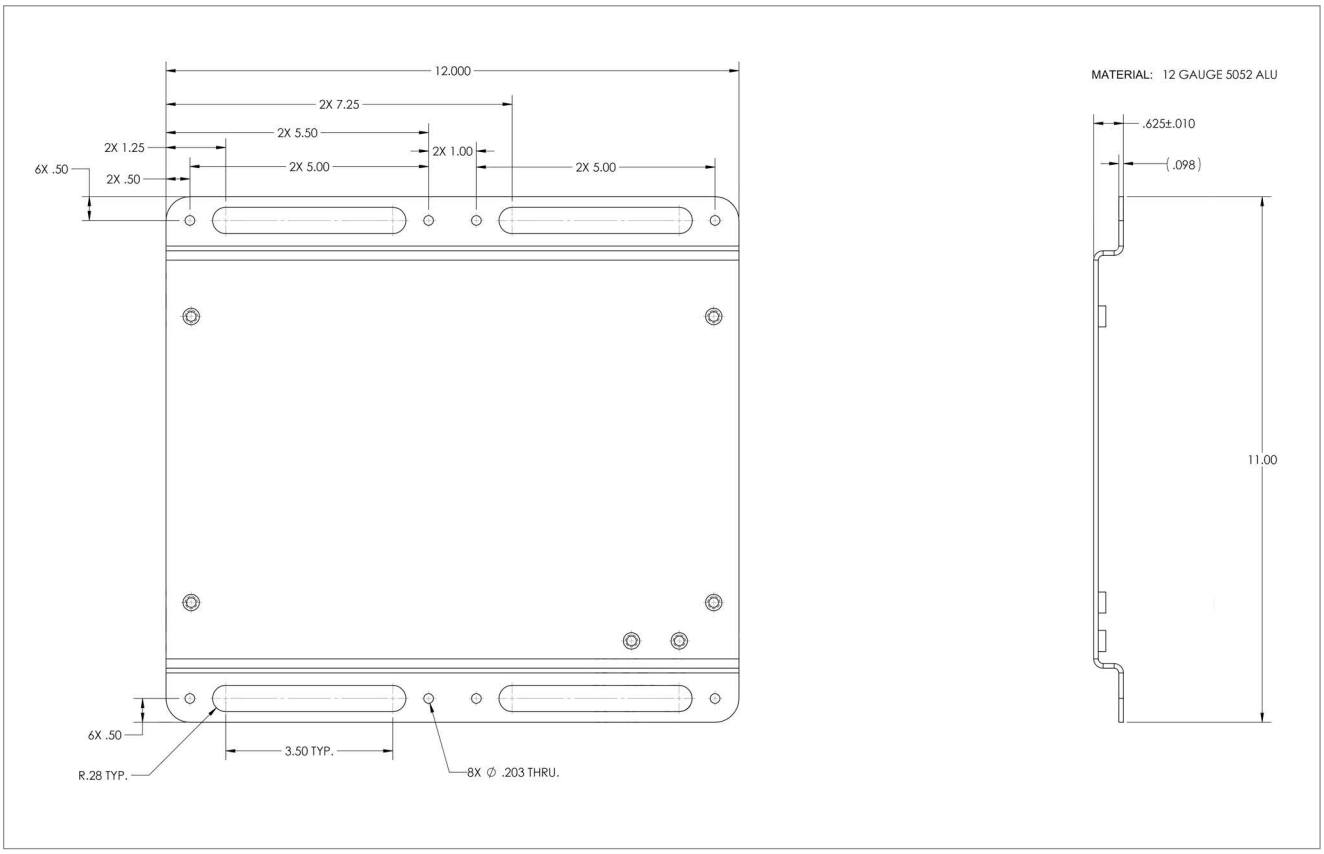

FIGURE 32: *Eight-Channel (08C), Analog (ANA), and Digital High Power (DHP) Models*

G.2 SINGLE-CHANNEL (01C) AND ADDRESSABLE (ADR) MODELS

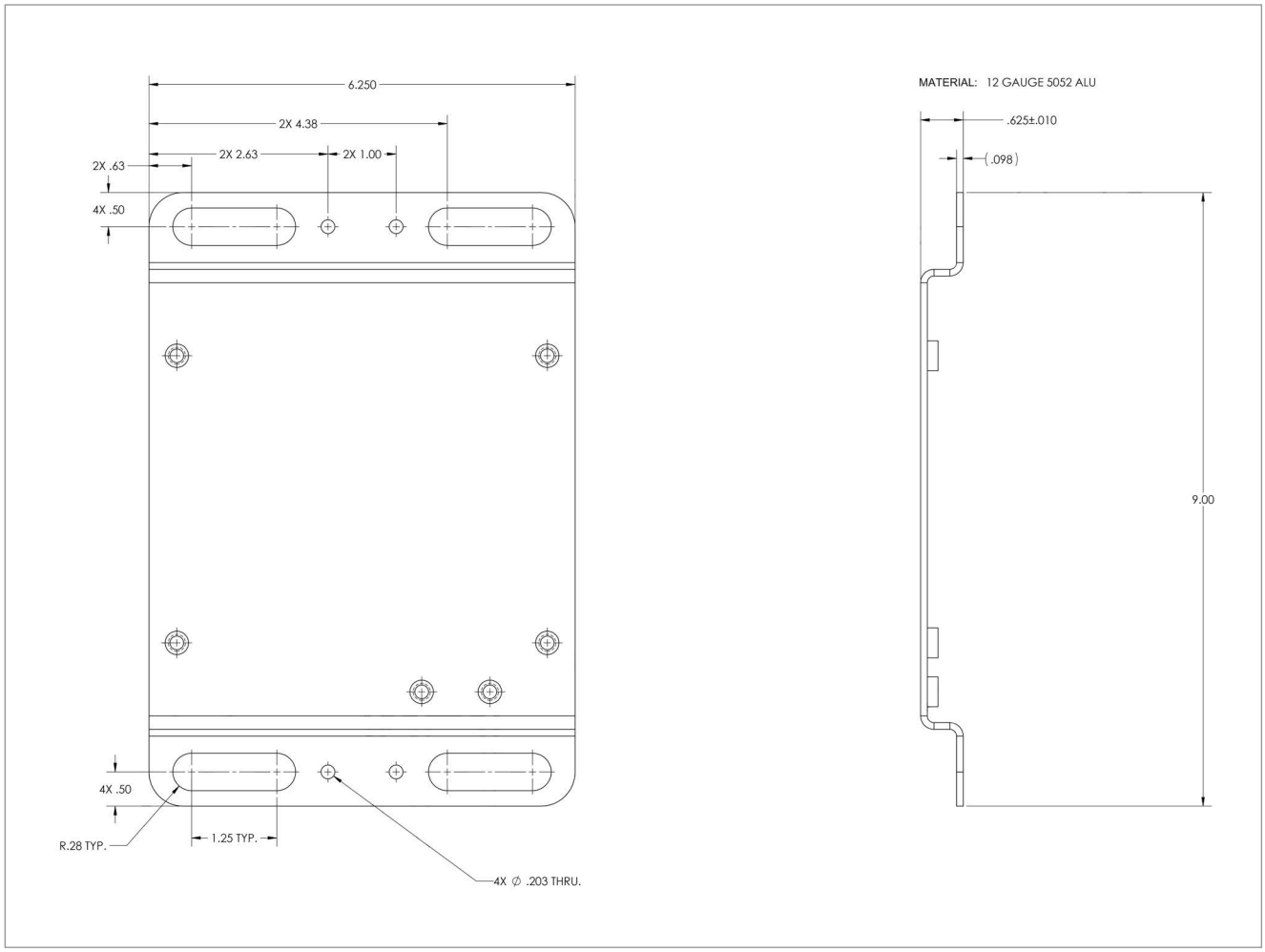

FIGURE 33: *Single-Channel (01C) and Addressable (ADR) Models*

G.3 TILT (TLT) MODELS

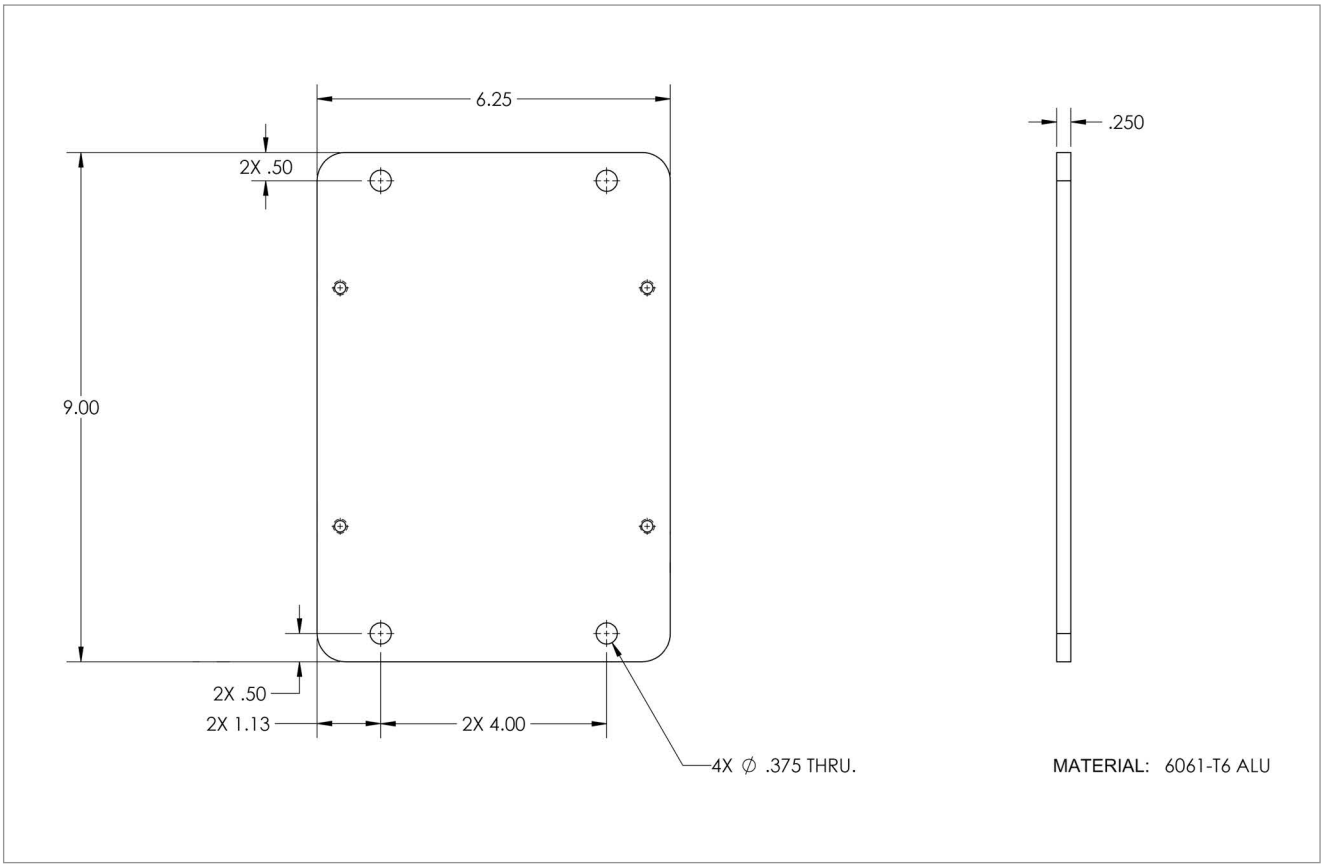

FIGURE 34: *Tilt (TLT) Models*

APPENDIX H. COMPONENTS (TYPICAL REPLACEMENT PARTS)

H.1 SINGLE-CHANNEL (01C) AND ADDRESSABLE (ADR) MODELS

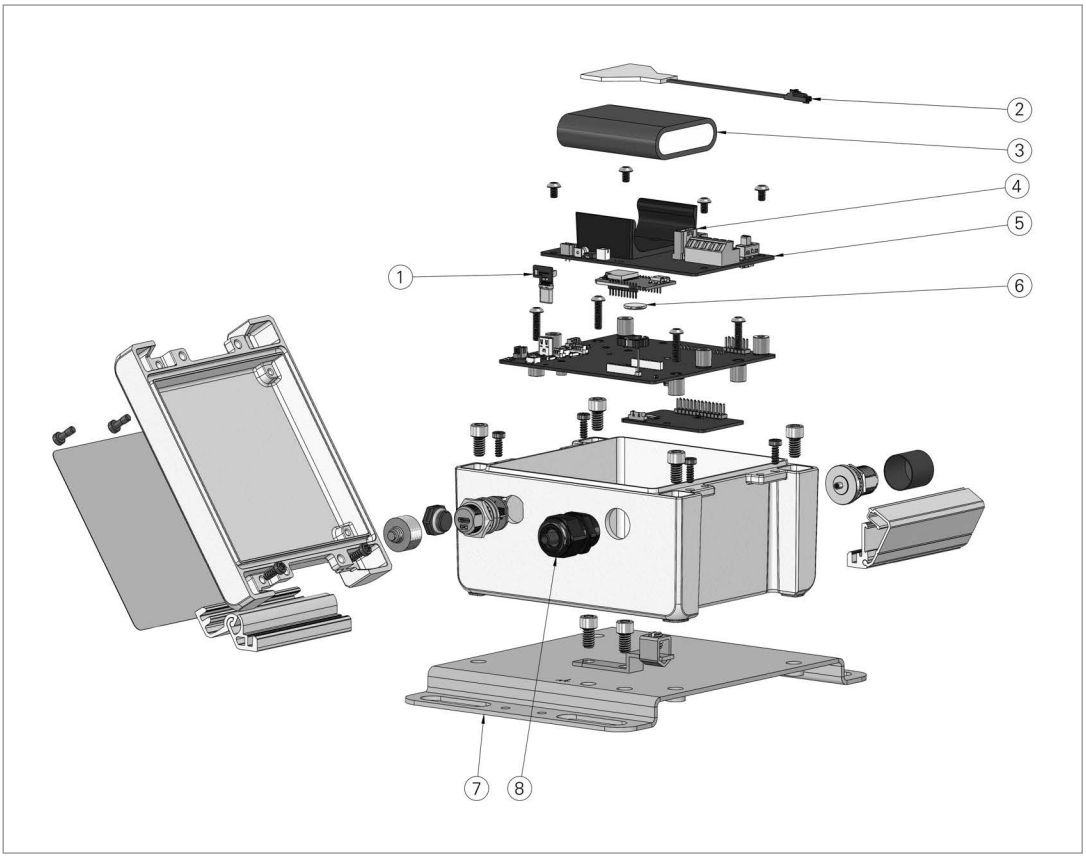

FIGURE 35: *Single-Channel (01C) and Addressable (ADR) Models*

Item No.	Part Number	Description
1	S-8910-13	PicoBlade to USB-C Plug OVP
2	ELC-1046	Thermistor Assembly
3	BAT-207	Battery Pack
4	N/A	Fuse, contact GEOKON for more information.
5	Rechargeable: S-8910-3-LI	Battery Holder PCBA
6	BAT-122	Lithium Coin Cell Battery
7	BOX-500-BRACKET	Mounting Bracket
8	**CON-A443, including:** CON-A342 CON-A331 SEAL-09	**Assembled Cable Gland, including:** Dowel Pin Cable Fitting Seal Ring
9 (Not Pictured)	8951 Models: ELC-1026 ELC-1027 HRD-A1279 All other Models: ELC-824	Antenna

TABLE 22: *Single-Channel (01C) and Addressable (ADR) Models Components Parts List*

H.2 EIGHT-CHANNEL (08C) AND ANALOG (ANA) MODELS

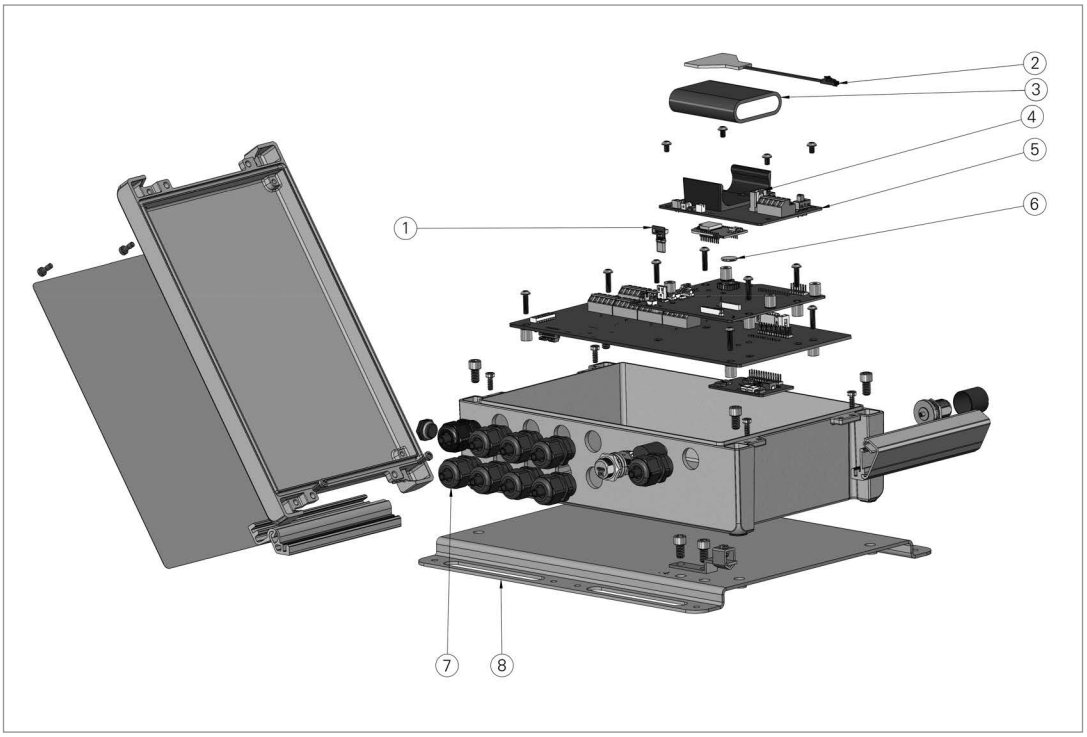

FIGURE 36: *Eight-Channel (08C) and Analog (ANA) Models*

Item No.	Part Number	Description
1	S-8910-13	PicoBlade to USB-C Plug OVP
2	ELC-1046	Thermistor Assembly
3	BAT-207	Battery Pack
4	N/A	Fuse, contact GEOKON for more information.
5	S-8910-3-LI	Battery Holder PCBA
6	BAT-122	Lithium Coin Cell Battery
7	**CON-A443, including:** CON-A342 CON-A331 SEAL-09	**Assembled Cable Gland, including:** Dowel Pin Cable Fitting Seal Ring
8	BOX-501-BRACKET	Mounting Bracket
9 (Not Pictured)	8951 Models: ELC-1026 ELC-1027 HRD-A1279 All other Models: ELC-824	Antenna

TABLE 23: *Eight-Channel (08C) and Analog (ANA) Models Components Parts List*

H.3 DIGITAL HIGH POWER (DHP) MODELS

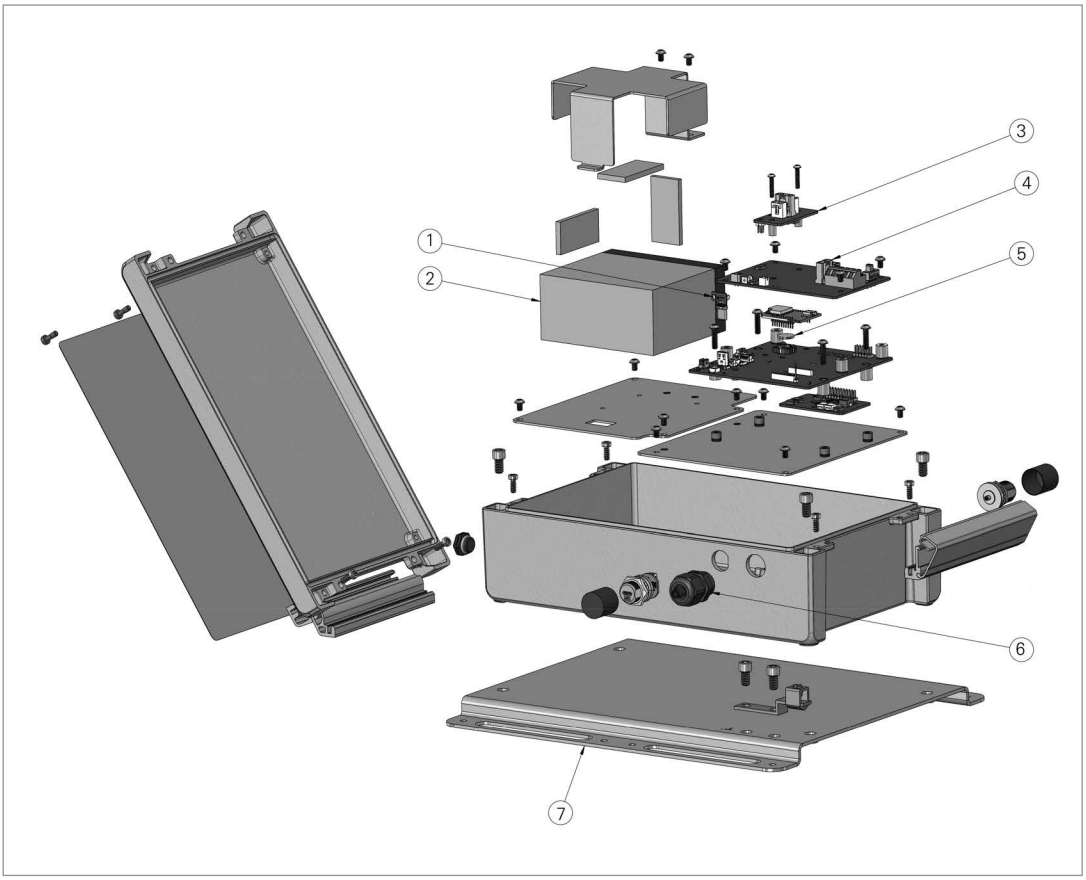

FIGURE 37: *Digital High Power (DHP) Models (Antenna Not Pictured)*

Item No.	Part Number	Description
1	S-8910-13	PicoBlade to USB-C Plug OVP
2	BAT-209	Sealed Lead Acid Battery
3	S-8910-3-1	LoRa SLA OVP
4	N/A	Fuse, contact GEOKON for more information.
5	BAT-122	Lithium Coin Cell Battery
6	**CON-A443, including:** CON-A342 CON-A331 SEAL-09	**Assembled Cable Gland, including:** Dowel Pin Cable Fitting Seal Ring
7	BOX-501-BRACKET	Mounting Bracket
8 (Not Pictured)	8951 Models: ELC-1026 ELC-1027 HRD-A1279 All other Models: ELC-824	Antenna

TABLE 24: *Digital High Power (DHP) Models Components Parts List*

H.4 TILT (TLT) MODELS

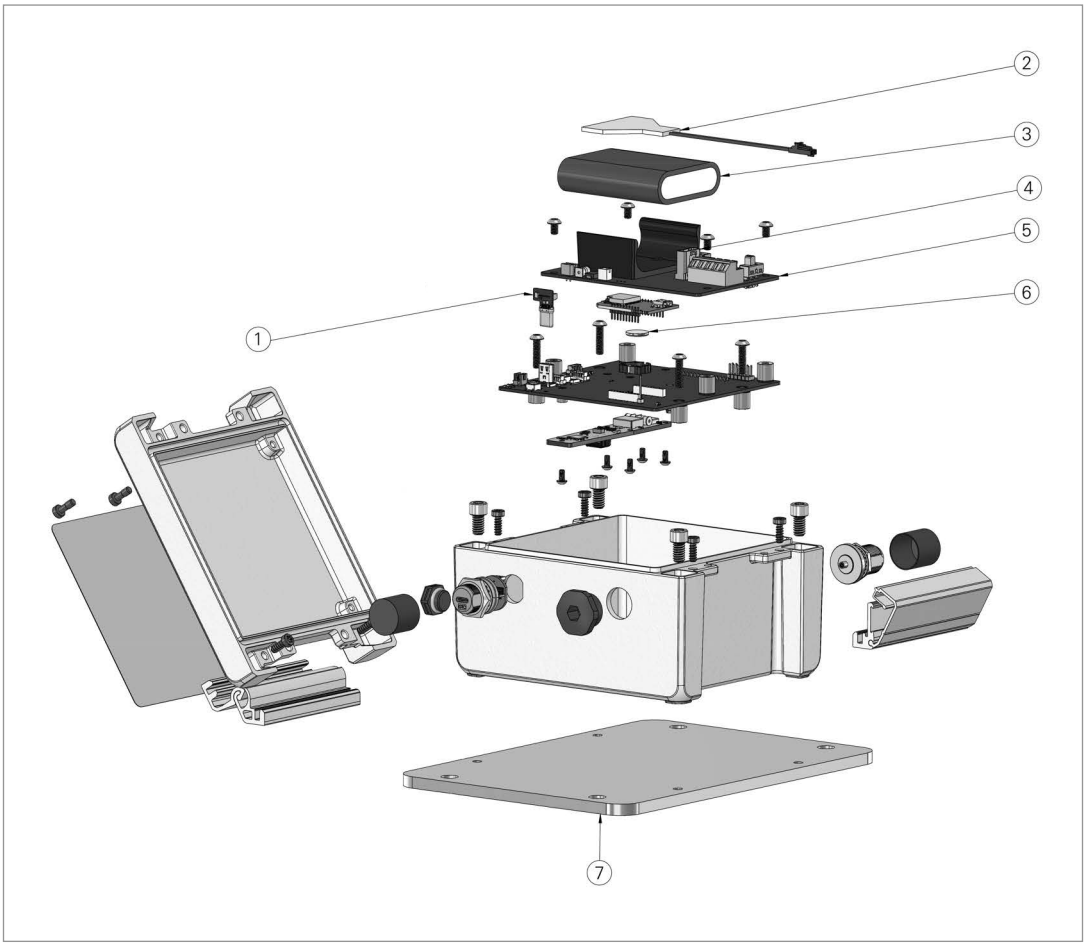

FIGURE 38: *Tilt (TLT) Models*

Item No.	Part Number	Description
1	S-8910-13	PicoBlade to USB-C Plug OVP
2	ELC-1046	Thermistor Assembly
3	BAT-207	Battery Pack
4	N/A	Fuse, contact GEOKON for more information.
5	S-8910-3-LI	Battery Holder PCBA
6	BAT-122	Lithium Coin Cell Battery
7	BOX-500-TILTBRACKET	Mounting Bracket
8 (Not pictured)	8951 Models: ELC-1026 ELC-1027 HRD-A1279 All other Models: ELC-824	Antenna

TABLE 25: *Tilt (TLT) Models Components Parts List*

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