Model 8960 Series

Digital Vibrating Wire Interfaces

Instruction Manual



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1. INTRODUCTION

GEOKON Model 8960 Series Addressable Vibrating Wire Interfaces incorporate state-of-the-art signal conditioning and digital addressing to enable Modbus RTU clients to read GEOKON vibrating wire sensors.

Interfaces are now manufactured with a pressure compensation vent to prevent condensation buildup in humid climates.

The 8960 interfaces allow reading both the vibrating wire and the thermistor built into the sensor.

Interfaces are queried using industry standard Modbus Remote Terminal Unit (RTU) protocol over a simple half-duplex RS-485 connection. The sensor is excited and measured by the interface, and the digitized measurement is then read.

1.1 8960 MODEL LIST

1.1.1 CABLE STYLE (CAB/12P)

Model Number	Description
8960-01C-CAB-SL	Addressable VW Interface for single sensor (non-bussed), 3 m cable length, bare leads
8960-01C-CAB-VL	Addressable VW Interface for single sensor (non-bussed), customer specified cable length, bare leads
8960-01C-12P-SL	Addressable Interface for single sensor (non-bussed), 3 m cable length, sensemetrics 12-pin connector
8960-01C-12P-VL	Addressable Interface for single sensor (non-bussed), customer specified cable length, sensemetrics 12-pin connector

TABLE 1: *Cable Style Model List*

1.1.2 ENCLOSURE STYLE (CBL)

Model Number	Description
8960-01C-CBL	Single-Channel Addressable VW Interface in enclosure
8960-04C-CBL	Four-Channel Addressable VW Interface in enclosure
8960-08C-CBL	Eight-Channel Addressable VW Interface in enclosure

TABLE 2: *Enclosure Style Model List*

1.2 INCLUDED ACCESSORIES

GeoNet Product Line	Part Number	Description	Quantity
Cable Style (CAB/12P) Interface	CON-959	2-Position Connector Housing	1
	CON-960	3-Position Connector Housing	1
Enclosure Style (CBL) Interface	N/A	N/A	N/A

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

1.3 ADDITIONAL ACCESSORIES (NOT INCLUDED)

Part Number	Description
8020-38	Addressable Bus Converter
8960-EXTENSION or -EXTENSION-V	Extension Cable with bare leads, 3 m (10') length. Varied cable lengths are available (-EXTENSION-V model).

TABLE 4: *Additional Accessories (Not Included)*

2. MODELS

2.1 ADDRESSABLE VIBRATING WIRE CABLE INTERFACE

The cable connector option will connect to one GEOKON vibrating wire gauge. Sensor cables are connected through a cable gland.



FIGURE 1: *Cable Style (CAB/12P) Addressable VW Interface (Bare Leads shown)*

2.2 ADDRESSABLE VIBRATING WIRE ENCLOSURE INTERFACE

The enclosure option reads the quantity of gauges outlined below. Sensor cables are connected through cable glands.

2.2.1 SINGLE-CHANNEL ENCLOSURE INTERFACE

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



FIGURE 2: *Single-Channel Enclosure (CBL)*

2.2.2 FOUR-CHANNEL ENCLOSURE INTERFACE

Four-channel interfaces will read up to four GEOKON vibrating wire gauges and integral thermistors.



FIGURE 3: *Four-Channel Enclosure (CBL)*

A four-channel interface can be configured as follows:

Maximum Number of Gauges	Maximum Number of Load Cells
Four	One 3-gauge **or** one 4-gauge load cell *Refer to Appendix J for load cell wiring tables*

TABLE 5: *Four-Channel Interface Gauge/Load Limits*

2.2.3 EIGHT-CHANNEL ENCLOSURE INTERFACE

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



FIGURE 4: *Eight-Channel Enclosure (CBL)*

An eight-channel interface 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 J for load cell wiring tables*

TABLE 6: *Eight-Channel Interface Gauge/Load Limits*

3. INSTALLATION

Installation is different depending on the model number. Refer to the applicable procedure below.

3.1 INSTALLATION FOR 8960-01C-#-# (CAB/12P) CABLE INTERFACE

For added convenience, the Model 8960-01C Addressable Vibrating Wire (VW) Interface is assembled with the readout cable already attached.

HARDWARE REQUIREMENTS

Communications: RS-485, half-duplex

Data Rate: 115,200 baud

Power: 5V to 15V DC, 57mA (peak)

3.1.1 CONNECT THE SENSORS

To connect your sensor to the 8960 interface, attach the sensor cable using the following steps:

1. From one end of the sensor cable, trim off 2" to 3" of the jacket, exposing the five individual wires.
2. Trim all of the insulation off the shield wire, if applicable.
3. Cut the four remaining wires 6 mm (0.24") shorter than the shield wire.
4. Trim 6 mm (0.24") of insulation off each of these four wires. This short length reduces the possibility of a short circuit.

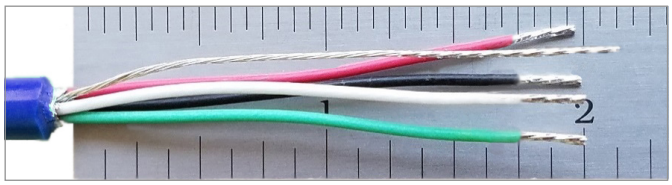


FIGURE 5: *Wires Trimmed to Two Inches*

5. The ends of the wires should be as neat as possible (e.g., twisted, tinned, or ferruled), to ease insertion into the connectors of the interface.
6. Loosen the cable nut on the open end of the 8960 interface. See below.



FIGURE 6: *Cable Nut*

7. Unscrew the instrument housing into two halves.
8. Remove and save the white plastic dowel. If you plan to eventually disconnect and store the 8960 interface, you should replace the dowel to ensure the housing remains water-tight.

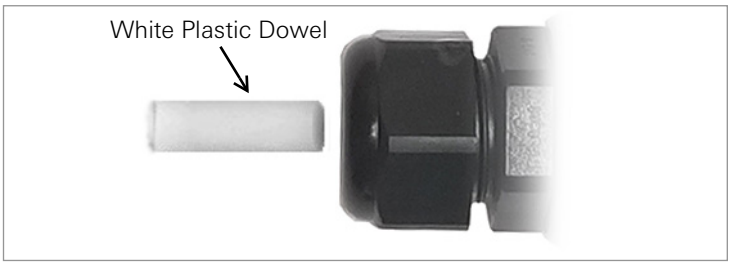


FIGURE 7: *Plastic Dowel*

9. Slide the sensor cable through the cable nut and the cable gland.
10. For ease of wiring, the male half of the connector can be removed from the female half, which is mounted to the circuit board. To separate the two halves, pull with steady pressure on the male half until it comes free. Refer to the figure below.

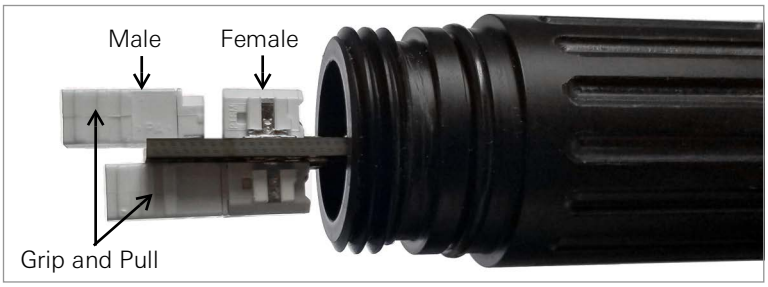


FIGURE 8: *Detaching PCB Connectors*

11. Insert the shield wire into the **center** hole of the male three-wire connector. If the shield wire is not stiff enough to penetrate the center hole, double the thickness of the wire by bending the last 6 mm (0.24") of the shield wire over onto itself and try again. Refer to the figure below.



FIGURE 9: *Doubled Shield Wire*

Caution! The shield wire must be inserted into the **center** hole of the three-hole connector; inserting the shield wire into any other position will cause a short and may damage the sensor and/or the interface.

12. Insert the two thermistor wires (white and green conductors are standard for GEOKON sensors) into the holes on either side of the shield wire **(hole choice does not matter)**.
13. Insert the remaining wires (red and black conductors are standard for GEOKON sensors) into the two-wire connector **(hole choice does not matter)**.
14. If the male halves of the connectors were removed from female halves, reinsert them to their counterparts on the circuit board. Refer to the figure below.

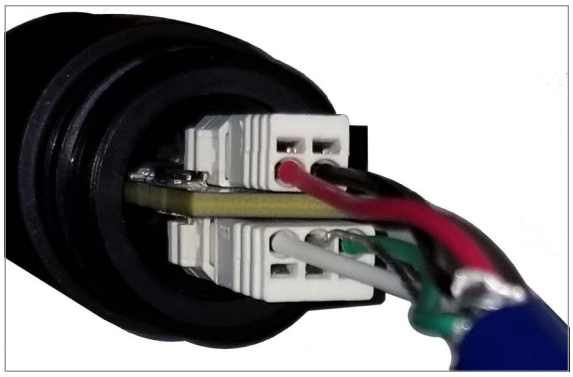


FIGURE 10: *Connector Assembly*

15. Gently pull on each conductor of the cable to make sure the connections are secure.
16. Screw together the two halves of the housing.
17. Tighten the cable gland nut until it firmly grips the outer jacket of the cable. Doing this ensures that water does not enter the housing. **(Do not over tighten the nut; doing so may damage the plastic threads.)**
18. Connect the wires at the open end of the readout cable to the unit intended for reading the instrument. The wiring functions are displayed below:

8960-01C Conductor Color	Description
WHITE	Communication RS-485+
GREEN	Communication RS-485-
RED	12-volt power to the string
BLACK	Ground
SHIELD	Analog ground

TABLE 7: *8960-01C Wiring Functions*

RELEASING CONDUCTORS FROM THE INTERFACE CONNECTORS

To release a conductor wire from the connector after it has been inserted, use the supplied screwdriver to push and hold in the small tab located just above the tinned end of the wire, as shown in the figure below. Then pull on the wire below the screwdriver.

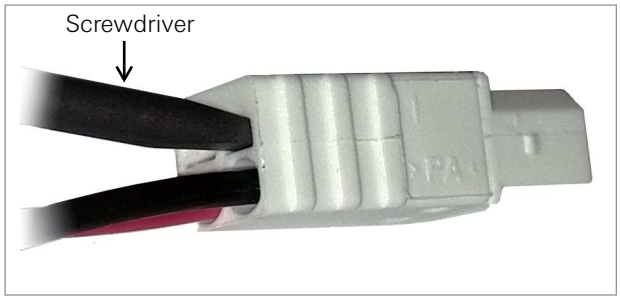


FIGURE 11: *Releasing a Conductor*

3.2 INSTALLATION PROCEDURE FOR 8960-#-CBL ENCLOSURE INTERFACE

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

1. Mount the interface
2. Connect an earth ground
3. Connect the sensors
4. Bus additional interfaces together
5. Connect a GeoNet Data Logger
6. Address the interface
7. Seal the interface

3.2.1 MOUNT THE INTERFACE

Mount all interfaces vertically, with the cable entries pointing down.

3.2.2 CONNECT AN EARTH GROUND

Properly grounding the interfaces 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. Interfaces can be grounded by connecting a suitable earth ground to the mounting bracket, or 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. Alternatively, any other suitable earth ground attachment may be used. 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 interface to earth ground in the event of a lightning strike.

3.2.3 CONNECT THE SENSORS

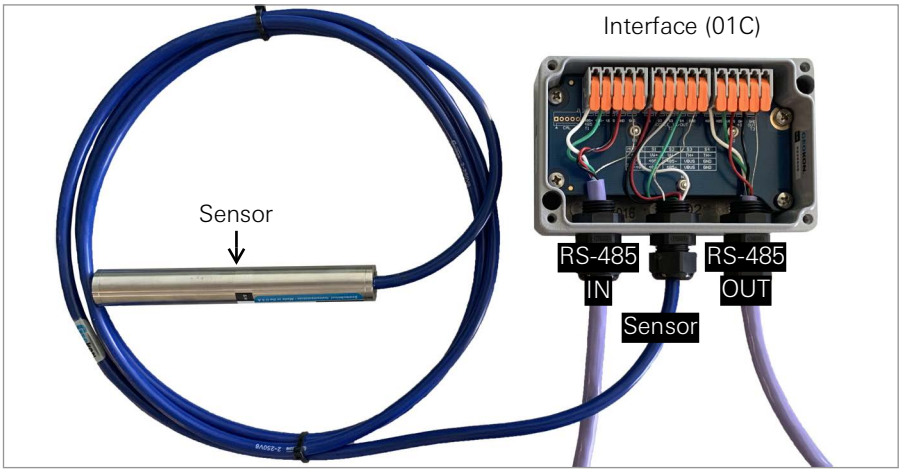


FIGURE 12: *Sensor to Interface Connection*

For ease of wiring, sensor cables should be inserted into the cable glands on Multi-channel interfaces in order from left to right (See Appendix I for labeled ports) and wired into the VW terminal blocks in sequence, starting with channel one. To connect a sensor using a cable gland connection:

1. Loosen the nut on the cable fitting and remove the white plastic dowel.
2. Slide the sensor cable through the cable gland nut and fitting.
3. Wire each conductor into the terminal block by pulling up (or pushing down) on an orange tab. Insert the bare end of the conductor into the terminal block, and then press the tab down (or release the tab). Refer to the wiring table below.

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

Sensor to Interface Wiring		
Position	**Conductor Color**	**Description**
VW+	RED	Vibrating Wire+
VW-	BLACK	Vibrating Wire-
TH+	WHITE	Thermistor+
TH-	GREEN	Thermistor-
SHD	BARE	Analog Ground (Shield)

TABLE 8: *Sensor to Interface Wiring*

4. Pull gently on each conductor to make sure 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 over-tighten, because this might strip the plastic threads.
6. Pull gently on the cable to make sure it is held in place by the cable gland.

3.2.4 BUS ADDITIONAL INTERFACES TOGETHER

Skip to Section 3.2.5 if not bussing additional interfaces.

Multiple interfaces can be bussed together using the RS-485 ports. The bus limit is 32 units or 64 channels. The maximum total bus length between the data logger and the last interface is 1,200 m.

1. Wire one end of an RS-485 cable into the RS-485 OUT of the first interface in the bus and the other end into the RS-485 IN of the next interface. Refer to the wiring chart below. (RS-485 cables are connected in the same manner as sensor cables. See Section 3.2.3 for details.)

Interface RS-485 Port Wiring		
Position	**Conductor Color**	**Description**
485+	WHITE	RS-485 Data+
485-	GREEN	RS-485 Data-
12V	RED	12 V Bus
GND	BLACK	Bus Ground
SHD	BARE	Analog Ground (Shield)

TABLE 9: *Interface RS-485 Port Wiring*

2. Repeat the previous step until all interfaces in the bus are connected.
3. Set the termination switch for the **last** interface in the bus to the ON position.

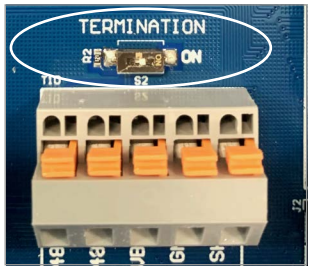


FIGURE 13: *Termination Switch*

Model 8960-01C-CBL single channel interface only: When using the RS-485 OUT port to connect to another interface in a bus, remove the termination resistor/jumper as shown below.

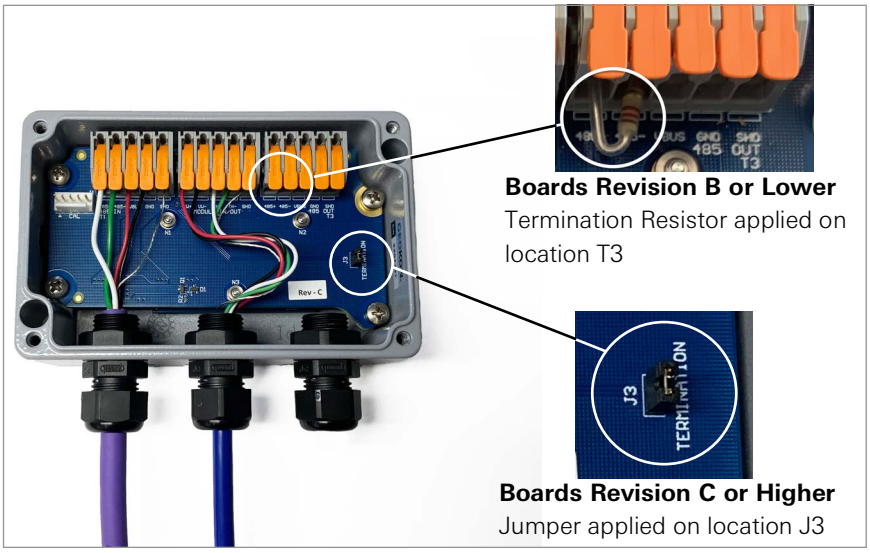


FIGURE 14: *Terminator Resistor / Jumper Location for 8960-01C-CBL*

3.2.5 CONNECT A GEONET DATA LOGGER

Connections can be made to GEOKON GeoNet Data Loggers using the RS-485 ports.

1. It is best practice to connect to a GeoNet data logger *before* the data logger is powered on. If the connection is made after the data logger is powered on, the additional channels will not be registered until the top of the next hour. Perform the procedure below to expedite the connection.
   a. Remove the batteries and move the power switch to the OFF position.
   b. Press and hold the reset button for 10 seconds.
   c. Press reset at least 5 additional times.
2. Wire one end of an RS-485 cable into the RS-485 IN of the first interface in the bus and the other end into the RS-485 connector of the data logger (located just below the power switch). Refer to the wiring chart below. (RS-485 cables are connected in the same manner as sensor cables. See Section 3.2.3 for details.)

Note: Earlier multi-channels had a "485_OUT" connector. Please disregard this connector.

Interface RS-485 Port Wiring		
Position	**Conductor Color**	**Description**
485+	WHITE	RS-485 Data+
485-	GREEN	RS-485 Data-
12V	RED	12 V Bus
GND	BLACK	Bus Ground
SHD	BARE	Analog Ground (Shield)

TABLE 10: *Interface RS-485 Port Wiring*

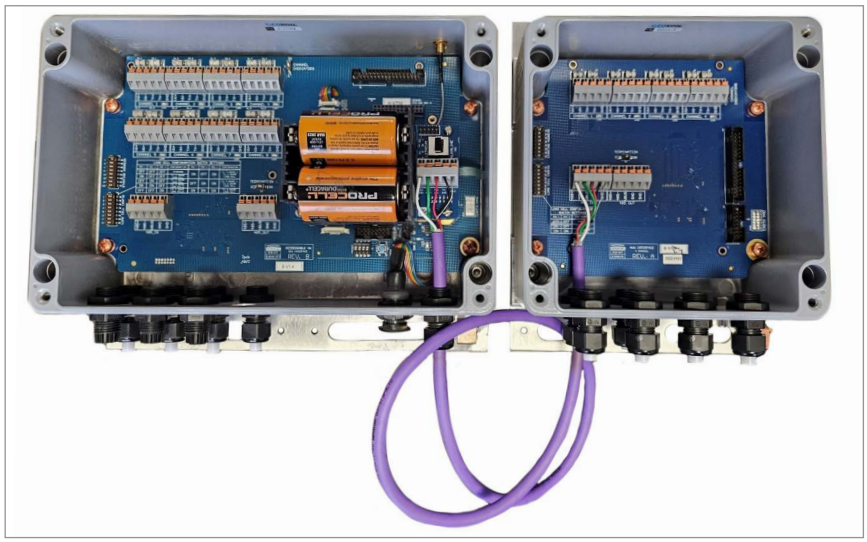


FIGURE 15: *Model 8940 Data Logger (Left) Connected to Model 8960 Interface (Right)*

3. On multi-channel data loggers set the termination switch to the OFF position (to the left).

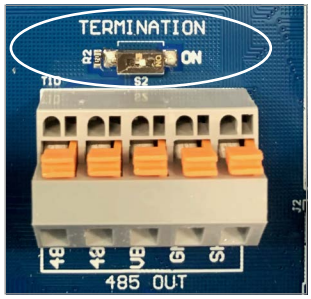


FIGURE 16: *Termination Switch*

4. Channel Indicators can be used to verify which channels are read, and when. Turning off the indicators when they are not needed will conserve battery power.



FIGURE 17: *Channel Indicators*

3.2.6 ADDRESS THE INTERFACE

DETERMINING THE ADDRESS

When using an interface to expand the capacity of a GeoNet Data Logger, the interface address must be set so that the channels (sensor inputs) of the interface are assigned correctly. The dip switches on the PCB are used to set the starting address (first channel) of the interface. The GeoNet Data Loggers will always be set to channel 1, as the first channel on the bus.

For example, a 4-channel data logger reads channels 1-4; therefore, the starting address of a bussed interface would be set to the next available channel, which is channel 5. Refer to Table 11 for more examples.

GeoNet Data Logger Capacity	Set the First Interface to:
1 Channel	Channel 2
4 Channels	Channel 5
8 Channels	Channel 9

TABLE 11: *Interface RS-485 Port Wiring*

When multiple interfaces are bussed together, the starting address is determined by the total number of channels that precede it. For example, an interface proceeded by an eight-channel data logger and two four-channel interfaces would have 16 channels preceding it (8+4+4=16); therefore, the next interface starting address would be set to channel 17.

SETTING THE DIP SWITCHES

Once the starting address for each interface has been determined, the DIP switches must be set accordingly. Each switch is assigned with a value (see Figure 18). Turn on the DIP switches which, when values are added together, will equal the starting address.

For example, if setting the starting address to 17, turn on switch numbers 1 and 5 (corresponding values 1+16=17).

For a complete list of addresses and switch combinations, see Appendix D.

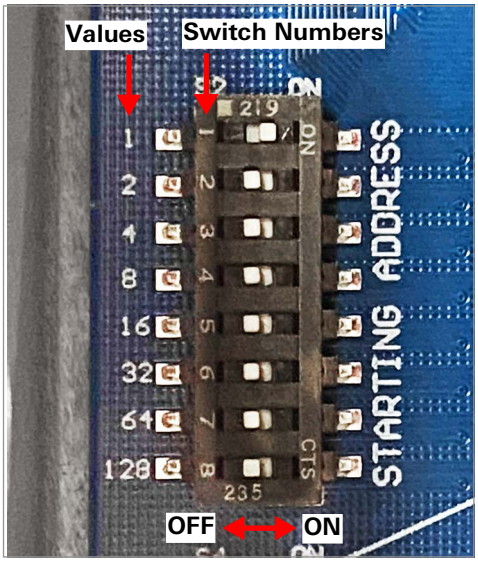


FIGURE 18: *Dip Switches*

ADDITIONAL INFORMATION AND CONSIDERATIONS

The following rules and guidelines apply when setting a value:

- An address range can only be used once. The numbers within that range cannot be within the address range of another data logger/interface on the same bus.
- Gaps between multiple address ranges are OK.
- The address ranges of the data logger/interface(s) in the bus DO NOT need to be sequential when physically connected.
- The maximum channel value that can be set or included at the end of an address range is 250.

3.2.7 SEAL THE INTERFACE

1. Record the serial number of the interfaces and the attached sensors. For multiple-channel interfaces, also record the channel to which each sensor has been connected.
2. Make sure the cover gasket and the mating ridge on the enclosure are clean and that the gasket is properly seated inside the groove on the cover. Place the cover on the unit.
3. Tighten the cover screws slowly. If using an electric screwdriver, **do not fully tighten the screws.** Perform the final tightening by hand. Work in a diagonal pattern.

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

4. MODBUS RTU PROTOCOL

4.1 INTRODUCTION TO MODBUS

The Model 8960 Interface use the industry standard Modbus Remote Terminal Unit (RTU) protocol to communicate with the chosen readout method. As the name suggests, Modbus was designed to work on what is known as a **bus network**, meaning that every device receives every message that passes across the network. Model 8960 Interfaces use the RS-485 electrical interface because of its prevalence, simplicity, and success as a robust, industrial physical layer.

More information about Modbus can be found at the following website:

http://www.modbus.org/specs.php

4.2 MODBUS RTU OVERVIEW

The Modbus RTU protocol uses packets (messages made up of multiple sections) to communicate and transfer data between devices on the network. The general format of these packets is as follows:

1. Modbus Address (one byte) – The address of the specific device on the bus.
2. Function Code (one byte) – The action to be carried out by the server device.
3. Data (multi-byte) – The payload of the function code being sent.
4. Cyclic Redundancy Check or CRC (two bytes): A 16-bit data integrity check calculated over the other bytes in the packet.

4.3 MODBUS TABLES

Modbus tables (maps) define the memory locations within each 8960 interface and what information they contain. For example, the most recent sensor reading is stored in a table. This reading is presented in different formats in different sections of the table. The register location and size of these variables is detailed in the table below.

Variable	Type	Modbus Register	Decimal	Description
Frequency	float32	0x0100	256	Measured frequency in Hz
Resistance	float32	0x0102	258	Measured thermistor-reasistance
Trigger	unit16	0x0118	280	Writing to this register initiates a sample

TABLE 12: *RAM Storage*

4.4 READING SENSORS WITH THE 8960-01C INTERFACES

While Modbus RTU supports roughly 20 different function codes, the simple functionality of a bused VW sensor eliminates the need for all but two of them. Specifically, the **Preset Single Register** (0x06) and the **Read Holding Registers** (0x03). The **Preset Single Register** function code is used to issue a 'trigger' command to the interface. This initiates a pluck and read sequence. The **Read Holding Registers** function code is used to read the values stored in 16-bit registers in the 8960. In this case, the measurement result occupies two 16-bit registers. The readings can be retrieved as frequency (Hz). An example of this trigger and subsequent query is shown in Table 13 and 14.

TX->01 06 0118 00 01 C9 F1	Trigger address #1
RX<-01 06 0118 00 01 C9 F1	Sensor acknowledges the single write
TX->01 03 0100 00 02 C5 F7	Get contents of 2 registers @ 0x0100 (gauge frequency)
RX<-01 03 71 58 45 4B 12 7B	Registers = 0x454B7158, 3255.08 Hz
TX->01 03 01 02 00 02 64 37	Get contents of 2 registers @ 0x0102 (thermistor resistance)
RX<-01 03 5D 3A 45 51 3A FE	Registers = 0x45515D3A, 3349.83 Ω

	Device Address	Function Code	Data Address	Data to Write	*CRC
HEX_{16}	01	06	0118	0001	C9F1
DEC_{10}	1	6	280	1	51697

TABLE 13: *Example Trigger Command - Sensor #1*

The following table shows the IEEE-754 floating point response as two parts, each one composed of two bytes. Because of how this information is stored in the memory, the two parts are received in reverse order. The complete floating point number in HEX is 0x454B7158 (3255.08).

	Device Address	Function Code	Byte Count	Lower 16 bits	Upper 16 bits	*CRC
HEX_{16}	01	03	04	7158	454B	127B
DEC_{10}	1	3	4	3255.08		4731

TABLE 14: *Example Response - Sensor #1, Floating Point Frequency Reading*

```
14:20:01.750 [TX] - 01 03 01 00 00 02 C5 F7
14:20:01.860 [RX] - 01 03 71 D1 45 4B C3 91
```

FIGURE 19: *PC Terminal Program Screen Capture*

Note: The Modbus CRC is sent the least-significant byte (LSB) first. When calculating the CRC for the write of address 0118 in Table 5, the Modbus CRC algorithm will return 0xF1C9 (61897D). Our examples show the decimal value after the LSB and most-significant byte (MSB) are swapped.

4.5 EXCITATION SWEEPS

The Model 8960 Interface is designed to excite and measure all GEOKON VW transducers. It will automatically detect any resonant frequency between 400 and 5,000 Hz. There are no settings for sensor type.

The maximum time between sending a trigger and data availability is **370** milliseconds.

5. MODBUS AND CAMPBELL SCIENTIFIC DATA LOGGERS

5.1 DESCRIPTION

CRBasic is the programming language used with all Campbell Scientific CRBasic data loggers. Campbell Scientific's LoggerNet software is typically used when programming in CRBasic.

Campbell Scientific's CR6 data logger can directly communicate with the Model 8960 Interface, using the RS-485 protocol.

If your data logger has built-in RS-485 communications, connect the interface using a cable and the wiring diagram below. (The data logger must have the appropriate port available.)

Data Logger Connection	Conductor Color	8960 Connection (RS-485 IN)
12 V (OUT)	RED	12 V
485+	WHITE	485+
485-	GREEN	485-
GND	BLACK	GND
SHIELD	BARE	SHD

TABLE 15: *Data Logger with built-in RS-485 Conversion to Model 8960 Wiring Table*

5.2 MODEL 8020-38 ADDRESSABLE BUS CONVERTER

Campbell Scientific's CR1000 and CR800 data loggers do not support the RS-485 protocol. To accommodate this, GEOKON provides the Model 8020-38 RS-485 to TTL/USB converter.

The Model 8020-38 allows an 8960 to be connected to personal computers, readouts, data loggers, and programmable logic controllers. The converter acts as a bridge using the TTL or USB protocols between readers and the GEOKON RS-485-enabled sensor strings.



FIGURE 20: *Model 8020-38 RS-485 to TTL/USB Converter*

If utilizing a Model 8020-38 to connect the 8960 to a data logger, wire the connections as shown in both tables below. (The data loggers must have the appropriate port available.)

Data Logger Connection	Conductor Color	8020-38 Connection
V+	RED	12 V (IN)
TX	WHITE	TX (IN)
RX	GREEN	RX (OUT)
GND	BLACK	GND
SHD	BARE	SHIELD

TABLE 16: *Data Logger to Model 8020-38 Wiring*

8020-38 Connection	Conductor Color	8960 Connection (RS-485 IN)
12 V (OUT)	RED	12 V
485+	WHITE	485+
485-	GREEN	485-
GND	BLACK	GND
SHIELD	BARE	SHD

TABLE 17: *Model 8020-38 to 8960 Wiring*

For more information, please refer to the Model 8020-38 Instruction Manual (geokon.com/8020-38).

6. READING A VW INTERFACE WITH AN ADDRESSABLE STRING READER (ASR)

6.1 DESCRIPTION

The ASR is a free application that runs on a PC and is available for download at geokon.com/Software. The ASR uses a USB port to communicate with the 8020-38 module described in Section 5.2.

When connected to a PC's USB port, the 8020-38 supplies power to the VW Interface module.

Connect the 8020-38 to the RS-485 IN location of the first 8960 interface of the bus. Use the wiring table below and connect in the same manner as described in Section 3.2.3.

8020-38 Connection	Conductor Color	8960 Connection (RS-485 IN)
12 V (OUT)	RED	12 V
485+	WHITE	485+
485-	GREEN	485-
GND	BLACK	GND
SHIELD	BARE	SHD

TABLE 18: *Model 8020-38 to 8960 Wiring Table*

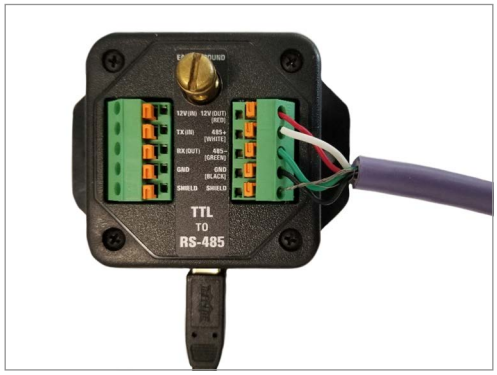


FIGURE 21: *Model 8020-38 Connection to 8960*

6.2 ADDRESSABLE STRING READER

After downloading and installing the ASR, launch the application. The following screen will appear:

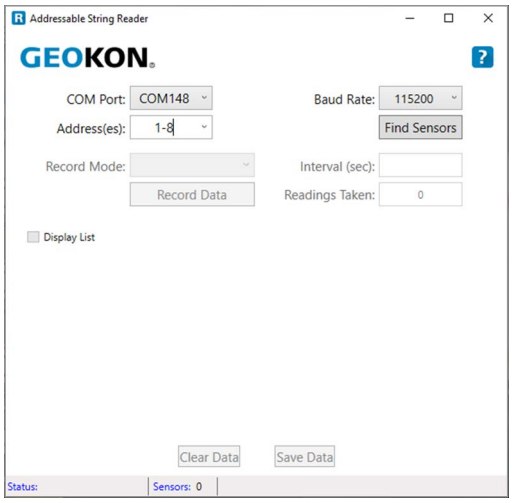


FIGURE 22: *ASR Opening Screen*

1. Enter an address range where the lowest address will typically be 1 and the upper range will be the total number of sensor channels in the string.

   Example: If an 8960-08C-CAB is connected to the PC (via the 8020-38) the range should be entered as "1-8".

2. Ensure that the COM port is correctly set and then click on "Find Sensors". If the VW Interface was successfully found the screen below will be displayed.

In this example the 8020-38 is connected to the PC via COM148, the ASR has found 8 sensor channels and the sensor output for address (channel) 1 is currently being displayed in digits (frequency can also displayed). The individual channels of the 8960 device all share the 8960 unit serial number printed on the enclosure.

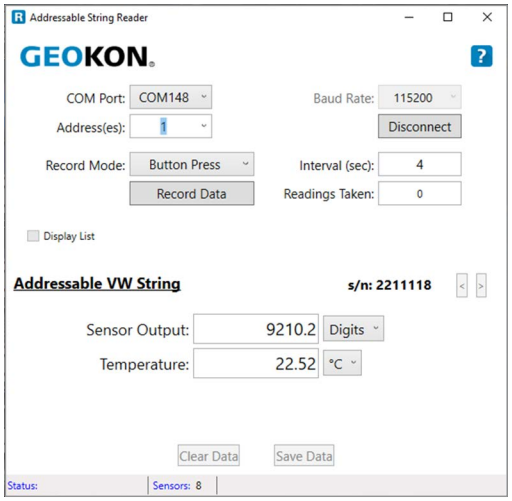


FIGURE 23: *Sensor 1 Output Display*

3. From the "Address(es)" drop-down list, selecting "ALL" (Figure 24) enables the left and right arrow buttons on the right-hand side of the display (see Figure 25) and allows the user to easily scroll between sensor channels.

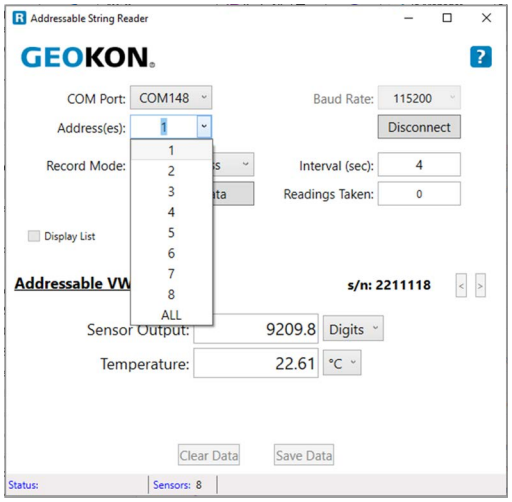


FIGURE 24: *Address Selection*

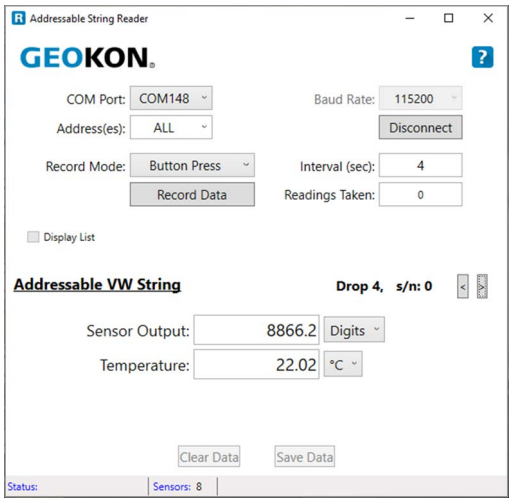


FIGURE 25: *Drop Selection Buttons "<" and ">" Enabled*

4. Readings can be recorded one of two ways:
   - **Record manually:** Confirm "Button Press" is selected from the "Record Mode" drop-down list. Press the "Record Data" button.
   - **Record continuously:** Set a time interval in the "Interval (sec)" field. Select "Continuous" from the "Record Mode" drop-down list.
5. After one or more readings have been recorded, the "Display List" check box is enabled (Figure 26), allowing a "list" of readings to be displayed (Figure 27).

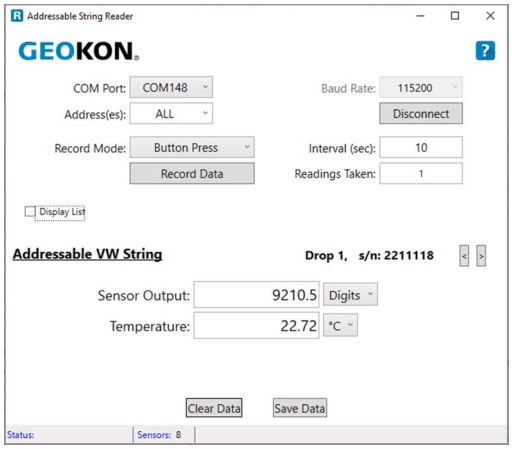


FIGURE 26: *Display List Checkbox Enabled*

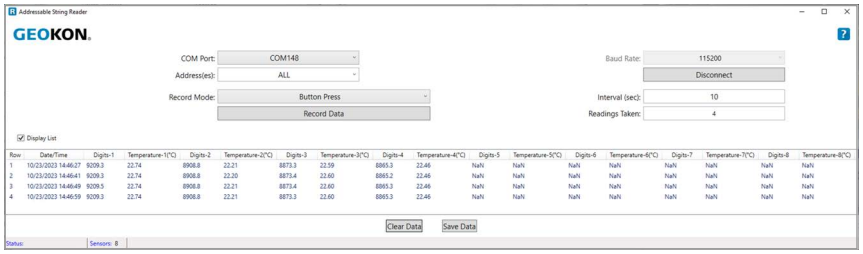


FIGURE 27: *Readings List Enabled*

6. Readings can be saved to a .CSV file at any time by clicking on "Save Data". Help is available by clicking on the "?" button.

APPENDIX A. SPECIFICATIONS

A.1 MODEL 8960 DIGITAL VIBRATING WIRE INTERFACE

Power	
Power Supply	12 VDC
Current Per Sensor	1.2 mA (idle)
Maximum Current	35 mA (180Ω VW Coil) 57 mA (50Ω VW Coil)
Operating Temperature	-40 °C to 80 °C
Communication	
Interface	RS-485, Half-duplex (two-wire differential)
Protocol	Modbus RTU
Baud Rate	115,200 bits/second
Measurements	
Frequency Range	400 Hz to 6,500 Hz
Frequency Trueness	0.082 Hz
Frequency Precision	0.146 Hz (99% Confidence Interval)
Frequency Resolution	>0.002 Hz
Frequency Measurement Duration	< 370 ms
Thermistor Range	-20 ° C to +80 °C
Thermistor Accuracy	±1% (25 °C thermistor point match)
Temperature Resolution	10-bit, non-linear, 0.6 °C (worst case at -40 °C)
Mechanical	
Cable	4 conductor, 2 twisted pairs, 6.35 mm (±0.25mm) diameter
Housing Dimensions	Cable Series (CAB): 100 x 25 mm (3.94 x 0.98") Enclosure Series (CBL): See Appendix F

TABLE 19: *Specifications*

APPENDIX B. MODBUS ADDRESSABLE SYSTEM

B.1 MODBUS COMMUNICATIONS PARAMETERS

Port Setting	Required Value
Bits per Second	115,200
Data bits	8
Parity	None
Stop bits	1
Flow Control	None

TABLE 20: *Modbus Communications Parameters*

B.2 ERROR CODES

Number	Name	Cause	Remedy
2	Temperature Sensor Range	Measured temperature out of range. Thermistor may be too hot, too cold, or damaged.	Use adjacent sensors to validate or estimate temperature.
4	Temperature Sensor Verify	Secondary temperature sensor differed too much from high accuracy primary sensor.	Use adjacent sensors to validate or estimate temperature.
8	System Reset	Unexpected interruption in prior measurement cycle.	Ensure supply voltage is sufficient.

TABLE 21: *Error Codes*

Note: The sensor stores and transmits errors in binary code to compact the information. Though unlikely, two errors could occur in one measurement cycle. The resulting code will be the sum of the error numbers, e.g., error 4 plus error 8 appears as number 12.

APPENDIX C. CRBASIC PROGRAMMING

C.1 SAMPLE PROGRAM

The following program uses a Model 8960 interface to directly connect to any single GEOKON vibrating wire sensor. The 8960 interface uses MODBUS RTU commands and returns a frequency (Hz) reading for the vibrating wire. It returns a resistance reading (Ohms) for the thermistor.

Note: 8960 MODBUS RTU table register numbers begin with 0. Campbell Scientific Data Loggers recognize the table register numbers as beginning with 1. All CRBasic register numbers are +1. Example: ModbusMaster won't send 0x118 unless "&H119" is entered in the command line.

```
'Define address of the 8960-01C
  Const Address = 1                    'address of Interface, used in variable declaration

'Constants used in Steinhart-Hart equation to calculate sensor temperature
'for 3k thermistor
  Const A = 1.4051E-3
  Const B = 2.369E-4
  Const C =1.019E-7

  Public ErrorCode                     'Error Code sent back from ModBus Command
  Public Hz(Address)                   'Frequency (Hz) from incoming data
  Public Digits(Address)               'Calculated Digits
  Public Res(Address)                  'Resistance (Ohms) from incoming data
  Public Celsius(Address)              'Calculated temperature (Celsius)

'Define Data Tables

DataTable(Test,1,-1)
  Sample (Address,Digits(),IEEE4)
  Sample (Address,Celsius(),IEEE4)
EndTable

'Main Program

BeginProg
  'Open COMport with RS-485 communications at 115200 baud rate
    SerialOpen (ComC1,115200,16,0,50,3)        'CR6 program
    SerialOpen (Com1,115200,16,0,50)           'CR1000 program
  'Read the interface/sensor every 30 seconds
    Scan (30,Sec,0,0)
  'Reset temporary storage for both Resistance and Hz so not to retain
  'previous reading
    Res (Address) = 0
    Hz (Address) = 0
  'Flush Serial between readings
    SerialFlush (ComC1)
  'Write to register 0x118 to trigger interface
  'NOTE: ModbusMaster won't send 0x118 unless "&H119" is entered
    ModbusMaster (ErrorCode,ComC1,115200,Count,6,1,&H119,1,1,10,0)
  'Delay after triggering the measurement
    Delay (1,1,Sec)
  'Use Modbus command to retrieve Hertz from string
    ModbusMaster (ErrorCode,ComC1,115200,Count,3,Hz(Address),&H101,1,1,10,0)
  'Calculate Digits from Hertz
    Digits(Address) = (Hz(Address)^2)/1000
  'Use Modbus command to retrieve thermistor resistance
    ModbusMaster (ErrorCode,ComC1,115200,Address,3,Res(Address),&H103,1,1,10,0)
  'Calculate thermistor temperature from Ohms to Celsius using Steinhart-Hart
  'equation
    Celsius(Address) = 1/(A+B*LN(Res(Address))+C*LN(Res(Address))^3)-273.15
  Next
  'Call Table to store Data
    CallTable Test
  NextScan
EndProg
```

APPENDIX D. COMPLETE ADDRESS LIST

D.1 ADDRESS LIST AND SWITCH COMBINATIONS

Available starting addresses and corresponding DIP switches are listed below.

Starting Address	Turn ON DIP Switches	Starting Address	Turn ON DIP Switches	Starting Address	Turn ON DIP Switches	Starting Address	Turn ON DIP Switches	Starting Address	Turn ON DIP Switches
1	1	51	1,2,16,32	101	1,4,32,64	151	1,2,4,16,128	201	1,8,64,128
2	2	52	4,16,32	102	2,4,32,64	152	8,16,128	202	2,8,64,128
3	1,2	53	1,4,16,32	103	1,2,4,32,64	153	1,8,16,128	203	1,2,8,64,128
4	4	54	2,4,16,32	104	8,32,64	154	2,8,16,128	204	4,8,64,128
5	1,4	55	1,2,4,16,32	105	1,8,32,64	155	1,2,8,16,128	205	1,4,8,64,128
6	2,4	56	8,16,32	106	2,8,32,64	156	4,8,16,128	206	2,4,8,64,128
7	1,2,4	57	1,8,16,32	107	1,2,8,32,64	157	1,4,8,16,128	207	1,2,4,8,64,128
8	8	58	2,8,16,32	108	4,8,32,64	158	2,4,8,16,128	208	16,64,128
9	1,8	59	1,2,8,16,32	109	1,4,8,32,64	159	1,2,4,8,16,128	209	1,16,64,128
10	2,8	60	4,8,16,32	110	2,4,8,32,64	160	32,128	210	2,16,64,128
11	1,2,8	61	1,4,8,16,32	111	1,2,4,8,32,64	161	1,32,128	211	1,2,16,64,128
12	4,8	62	2,4,8,16,32	112	16,32,64	162	2,32,128	212	4,16,64,128
13	1,4,8	63	1,2,4,8,16,32	113	1,16,32,64	163	1,2,32,128	213	1,4,16,64,128
14	2,4,8	64	64	114	2,16,32,64	164	4,32,128	214	2,4,16,64,128
15	1,2,4,8	65	1,64	115	1,2,16,32,64	165	1,4,32,128	215	1,2,4,16,64,128
16	16	66	2,64	116	4,16,32,64	166	2,4,32,128	216	8,16,64,128
17	1,16	67	1,2,64	117	1,4,16,32,64	167	1,2,4,32,128	217	1,8,16,64,128
18	2,16	68	4,64	118	2,4,16,32,64	168	8,32,128	218	2,8,16,64,128
19	1,2,16	69	1,4,64	119	1,2,4,16,32,64	169	1,8,32,128	219	1,2,8,16,64,128
20	4,16	70	2,4,64	120	8,16,32,64	170	2,8,32,128	220	4,8,16,64,128
21	1,4,16	71	1,2,4,64	121	1,8,16,32,64	171	1,2,8,32,128	221	1,4,8,16,64,128
22	2,4,16	72	8,64	122	2,8,16,32,64	172	4,8,32,128	222	2,4,8,16,64,128
23	1,2,4,16	73	1,8,64	123	1,2,8,16,32,64	173	1,4,8,32,128	223	1,2,4,8,16,64,128
24	8,16	74	2,8,64	124	4,8,16,32,64	174	2,4,8,32,128	224	32,64,128
25	1,8,16	75	1,2,8,64	125	1,4,8,16,32,64	175	1,2,4,8,32,128	225	1,32,64,128
26	2,8,16	76	4,8,64	126	2,4,8,16,32,64	176	16,32,128	226	2,32,64,128
27	1,2,8,16	77	1,4,8,64	127	1,2,4,8,16,32,64	177	1,16,32,128	227	1,2,32,64,128
28	4,8,16	78	2,4,8,64	128	128	178	2,16,32,128	228	4,32,64,128
29	1,4,8,16	79	1,2,4,8,64	129	1,128	179	1,2,16,32,128	229	1,4,32,64,128
30	2,4,8,16	80	16,64	130	2,128	180	4,16,32,128	230	2,4,32,64,128
31	1,2,4,8,16	81	1,16,64	131	1,2,128	181	1,4,16,32,128	231	1,2,4,32,64,128
32	32	82	2,16,64	132	4,128	182	2,4,16,32,128	232	8,32,64,128
33	1,32	83	1,2,16,64	133	1,4,128	183	1,2,4,16,32,128	233	1,8,32,64,128
34	2,32	84	4,16,64	134	2,4,128	184	8,16,32,128	234	2,8,32,64,128
35	1,2,32	85	1,4,16,64	135	1,2,4,128	185	1,8,16,32,128	235	1,2,8,32,64,128
36	4,32	86	2,4,16,64	136	8,128	186	2,8,16,32,128	236	4,8,32,64,128
37	1,4,32	87	1,2,4,16,64	137	1,8,128	187	1,2,8,16,32,128	237	1,4,8,32,64,128
38	2,4,32	88	8,16,64	138	2,8,128	188	4,8,16,32,128	238	2,4,8,32,64,128
39	1,2,4,32	89	1,8,16,64	139	1,2,8,128	189	1,4,8,16,32,128	239	1,2,4,8,32,64,128
40	8,32	90	2,8,16,64	140	4,8,128	190	2,4,8,16,32,128	240	16,32,64,128
41	1,8,32	91	1,2,8,16,64	141	1,4,8,128	191	1,2,4,8,16,32,128	241	1,16,32,64,128
42	2,8,32	92	4,8,16,64	142	2,4,8,128	192	64,128	242	2,16,32,64,128
43	1,2,8,32	93	1,4,8,16,64	143	1,2,4,8,128	193	1,64,128	243	1,2,16,32,64,128
44	4,8,32	94	2,4,8,16,64	144	16,128	194	2,64,128	244	4,16,32,64,128
45	1,4,8,32	95	1,2,4,8,16,64	145	1,16,128	195	1,2,64,128	245	1,4,16,32,64,128
46	2,4,8,32	96	32,64	146	2,16,128	196	4,64,128	246	2,4,16,32,64,128
47	1,2,4,8,32	97	1,32,64	147	1,2,16,128	197	1,4,64,128	247	1,2,4,16,32,64,128
48	16,32	98	2,32,64	148	4,16,128	198	2,4,64,128	248	8,16,32,64,128
49	1,16,32	99	1,2,32,64	149	1,4,16,128	199	1,2,4,64,128	249	1,8,16,32,64,128
50	2,16,32	100	4,32,64	150	2,4,16,128	200	8,64,128	250	2,8,16,32,64,128

TABLE 22: *Address List and Switch Combinations*

APPENDIX E. THERMISTOR TEMPERATURE DERIVATION

E.1 3KΩ THERMISTOR RESISTANCE (STANDARD)

Thermistor Types include YSI 44005, Dale #1C3001–B3, Alpha #13A3001–B3, and Honeywell 192–302LET–A01.

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.15$$

EQUATION 1: *3KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.4051×10^{-3}
B = 2.369×10^{-4}
C = 1.019×10^{-7}
Note: Coefficients calculated over the –50 to +150 °C span.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	15.72K	-9	2221	32	474.7	73	137.2	114
187.3K	-49	14.90K	-8	2130	33	459.0	74	133.6	115
174.5K	-48	14.12K	-7	2042	34	444.0	75	130.0	116
162.7K	-47	13.39K	-6	1959	35	429.5	76	126.5	117
151.7K	-46	12.70K	-5	1880	36	415.6	77	123.2	118
141.6K	-45	12.05K	-4	1805	37	402.2	78	119.9	119
132.2K	-44	11.44K	-3	1733	38	389.3	79	116.8	120
123.5K	-43	10.86K	-2	1664	39	376.9	80	113.8	121
115.4K	-42	10.31K	-1	1598	40	364.9	81	110.8	122
107.9K	-41	9796	0	1535	41	353.4	82	107.9	123
101.0K	-40	9310	1	1475	42	342.2	83	105.2	124
94.48K	-39	8851	2	1418	43	331.5	84	102.5	125
88.46K	-38	8417	3	1363	44	321.2	85	99.9	126
82.87K	-37	8006	4	1310	45	311.3	86	97.3	127
77.66K	-36	7618	5	1260	46	301.7	87	94.9	128
72.81K	-35	7252	6	1212	47	292.4	88	92.5	129
68.30K	-34	6905	7	1167	48	283.5	89	90.2	130
64.09K	-33	6576	8	1123	49	274.9	90	87.9	131
60.17K	-32	6265	9	1081	50	266.6	91	85.7	132
56.51K	-31	5971	10	1040	51	258.6	92	83.6	133
53.10K	-30	5692	11	1002	52	250.9	93	81.6	134
49.91K	-29	5427	12	965.0	53	243.4	94	79.6	135
46.94K	-28	5177	13	929.6	54	236.2	95	77.6	136
44.16K	-27	4939	14	895.8	55	229.3	96	75.8	137
41.56K	-26	4714	15	863.3	56	222.6	97	73.9	138
39.13K	-25	4500	16	832.2	57	216.1	98	72.2	139
36.86K	-24	4297	17	802.3	58	209.8	99	70.4	140
34.73K	-23	4105	18	773.7	59	203.8	100	68.8	141
32.74K	-22	3922	19	746.3	60	197.9	101	67.1	142
30.87K	-21	3748	20	719.9	61	192.2	102	65.5	143
29.13K	-20	3583	21	694.7	62	186.8	103	64.0	144
27.49K	-19	3426	22	670.4	63	181.5	104	62.5	145
25.95K	-18	3277	23	647.1	64	176.4	105	61.1	146
24.51K	-17	3135	24	624.7	65	171.4	106	59.6	147
23.16K	-16	3000	25	603.3	66	166.7	107	58.3	148
21.89K	-15	2872	26	582.6	67	162.0	108	56.8	149
20.70K	-14	2750	27	562.8	68	157.6	109	55.6	150
19.58K	-13	2633	28	543.7	69	153.2	110		
18.52K	-12	2523	29	525.4	70	149.0	111		
17.53K	-11	2417	30	507.8	71	145.0	112		
16.60K	-10	2317	31	490.9	72	141.1	113		

TABLE 23: *3KΩ Thermistor Resistance*

E.2 8.2KΩ THERMISTOR RESISTANCE

Thermistor Type: Thermometrics BRBR55KA822J

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.15$$

EQUATION 2: *8.5KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.02569×10^{-3}
B = 2.369×10^{-4}
C = 1.019×10^{-7}
Note: Coefficients calculated over the –50 to +150 °C span.

Ohms	Temp	LnR	LnR^3	Calc. Temp	Diff	F.S. Error	Ohms	Temp	LnR	LnR^3	Calc. Temp	Diff	F.S. Error
113898	-30	11.643	1578.342	-30.17	0.17	0.06	407.62	120	6.010	217.118	120.00	0.00	0.00
86182	-25	11.364	1467.637	-25.14	0.14	0.05	360.8	125	5.888	204.162	125.00	0.00	0.00
65805	-20	11.094	1365.581	-20.12	0.12	0.04	320.21	130	5.769	191.998	130	0.00	0.00
50684.2	-15	10.833	1271.425	-15.10	0.10	0.03	284.95	135	5.652	180.584	135	0.00	0.00
39360	-10	10.581	1184.457	-10.08	0.08	0.03	254.2	140	5.538	169.859	140.01	-0.01	0.00
30807.4	-5	10.336	1104.068	-5.07	0.07	0.02	227.3	145	5.426	159.773	145.02	-0.02	-0.01
24288.4	0	10.098	1029.614	-0.05	0.05	0.02	203.77	150	5.317	150.314	150.03	-0.03	-0.01
19294.6	5	9.868	960.798	4.96	0.04	0.01	183.11	155	5.210	141.428	155.04	-0.04	-0.01
15424.2	10	9.644	896.871	9.98	0.02	0.01	164.9	160	5.105	133.068	160.06	-0.06	-0.02
12423	15	9.427	837.843	14.98	0.02	0.01	148.83	165	5.003	125.210	165.08	-0.08	-0.03
10061.4	20	9.216	782.875	19.99	0.01	0.00	134.64	170	4.903	117.837	170.09	-0.09	-0.03
8200	25	9.012	731.893	25.00	0.00	0.00	122.1	175	4.805	110.927	175.08	-0.08	-0.03
6721.54	30	8.813	684.514	30.01	-0.01	0.00	110.95	180	4.709	104.426	180.07	-0.07	-0.02
5540.74	35	8.620	640.478	35.01	-0.01	0.00	100.94	185	4.615	98.261	185.10	-0.10	-0.04
4592	40	8.432	599.519	40.02	-0.02	-0.01	92.086	190	4. 523	92.512	190.09	-0.09	-0.03
3825.3	45	8.249	561.392	45.02	-0.02	-0.01	84.214	195	4.433	87.136	195.05	-0.05	-0.02
3202.92	50	8.072	525.913	50.01	-0.01	-0.01	77.088	200	4.345	82.026	200.05	-0.05	-0.02
2693.7	55	7.899	492.790	55.02	-0.02	-0.01	70.717	205	4.259	77.237	205.02	-0.02	-0.01
2276.32	60	7.730	461.946	60.02	-0.02	-0.01	64.985	210	4.174	72.729	210.00	0.00	0.00
1931.92	65	7.566	433.157	65.02	-0.02	-0.01	59.819	215	4.091	68.484	214.97	0.03	0.01
1646.56	70	7.406	406.283	70.02	-0.02	-0.01	55.161	220	4.010	64.494	219.93	0.07	0.02
1409.58	75	7.251	381.243	75.01	-0.01	0.00	50.955	225	3.931	60.742	224.88	0.12	0.04
1211.14	80	7.099	357.808	80.00	0.00	0.00	47.142	230	3.853	57.207	229.82	0.18	0.06
1044.68	85	6.951	335.915	85.00	0.00	0.00	43.673	235	3.777	53.870	234.77	0.23	0.08
903.64	90	6.806	315.325	90.02	-0.02	-0.01	40.533	240	3.702	50.740	239.69	0.31	0.11
785.15	95	6.666	296.191	95.01	-0.01	0.00	37.671	245	3.629	47.788	244.62	0.38	0.13
684.37	100	6.528	278.253	100.00	0.00	0.00	35.055	250	3.557	45.001	249.54	0.46	0.16
598.44	105	6.394	261.447	105.00	0.00	0.00	32.677	255	3.487	42.387	254.44	0.56	0.19
524.96	110	6.263	245.705	110.00	0.00	0.00	30.496	260	3.418	39.917	259.34	0.66	0.23
461.91	115	6.135	230.952	115.00	0.00	0.00							

TABLE 24: *8.2KΩ Thermistor Resistance*

E.3 10KΩ THERMISTOR RESISTANCE (HIGH TEMP.)

Thermistor Type: US Sensor 103JL1A

Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3 + D(LnR)^5} - 273.15$$

EQUATION 3: *10KΩ Thermistor Resistance*

Where:
T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.127670×10^{-3}
B = 2.344442×10^{-4}
C = 8.476921×10^{-8}
D = 1.175122×10^{-11}
Note: Coefficients optimized for a curve **J** Thermistor over the temperature range of 0 °C to +250 °C.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
32,650	0	7,402	32	2,157	64	763.5	96	316.6	128	148.4	160	76.5	192	42.8	224
31,029	1	7,098	33	2,083	65	741.2	97	308.7	129	145.1	161	75.0	193	42.1	225
29,498	2	6,808	34	2,011	66	719.6	98	301.0	130	142.0	162	73.6	194	41.4	226
28,052	3	6,531	35	1,942	67	698.7	99	293.5	131	138.9	163	72.2	195	40.7	227
26,685	4	6,267	36	1,876	68	678.6	100	286.3	132	135.9	164	70.8	196	40.0	228
25,392	5	6,015	37	1,813	69	659.1	101	279.2	133	133.0	165	69.5	197	39.3	229
24,170	6	5,775	38	1,752	70	640.3	102	272.4	134	130.1	166	68.2	198	38.7	230
23,013	7	5,545	39	1,693	71	622.2	103	265.8	135	127.3	167	66.9	199	38.0	231
21,918	8	5,326	40	1,637	72	604.6	104	259.3	136	124.6	168	65.7	200	37.4	232
20,882	9	5,117	41	1,582	73	587.6	105	253.1	137	122.0	169	64.4	201	36.8	233
19,901	10	4,917	42	1,530	74	571.2	106	247.0	138	119.4	170	63.3	202	36.2	234
18,971	11	4,725	43	1,480	75	555.3	107	241.1	139	116.9	171	62.1	203	35.6	235
18,090	12	4,543	44	1,432	76	539.9	108	235.3	140	114.5	172	61.0	204	35.1	236
17,255	13	4,368	45	1,385	77	525.0	109	229.7	141	112.1	173	59.9	205	34.5	237
16,463	14	4,201	46	1,340	78	510.6	110	224.3	142	109.8	174	58.8	206	33.9	238
15,712	15	4,041	47	1,297	79	496.7	111	219.0	143	107.5	175	57.7	207	33.4	239
14,999	16	3,888	48	1,255	80	483.2	112	213.9	144	105.3	176	56.7	208	32.9	240
14,323	17	3,742	49	1,215	81	470.1	113	208.9	145	103.2	177	55.7	209	32.3	241
13,681	18	3,602	50	1,177	82	457.5	114	204.1	146	101.1	178	54.7	210	31.8	242
13,072	19	3,468	51	1,140	83	445.3	115	199.4	147	99.0	179	53.7	211	31.3	243
12,493	20	3,340	52	1,104	84	433.4	116	194.8	148	97.0	180	52.7	212	30.8	244
11,942	21	3,217	53	1,070	85	421.9	117	190.3	149	95.1	181	51.8	213	30.4	245
11,419	22	3,099	54	1,037	86	410.8	118	186.1	150	93.2	182	50.9	214	29.9	246
10,922	23	2,986	55	1,005	87	400.0	119	181.9	151	91.3	183	50.0	215	29.4	247
10,450	24	2,878	56	973.8	88	389.6	120	177.7	152	89.5	184	49.1	216	29.0	248
10,000	25	2,774	57	944.1	89	379.4	121	173.7	153	87.7	185	48.3	217	28.5	249
9,572	26	2,675	58	915.5	90	369.6	122	169.8	154	86.0	186	47.4	218	28.1	250
9,165	27	2,579	59	887.8	91	360.1	123	166.0	155	84.3	187	46.6	219		
8,777	28	2,488	60	861.2	92	350.9	124	162.3	156	82.7	188	45.8	220		
8,408	29	2,400	61	835.4	93	341.9	125	158.6	157	81.1	189	45.0	221		
8,057	30	2,316	62	810.6	94	333.2	126	155.1	158	79.5	190	44.3	222		
7,722	31	2,235	63	786.6	95	324.8	127	151.7	159	78.0	191	43.5	223		

TABLE 25: *10KΩ Thermistor Resistance*

APPENDIX F. UNIT DIMENSIONS OF ENCLOSURE SERIES

F.1 SINGLE-CHANNEL ENCLOSURE (01C-CBL) MODELS

Note: Dimensions shown below are in inches.

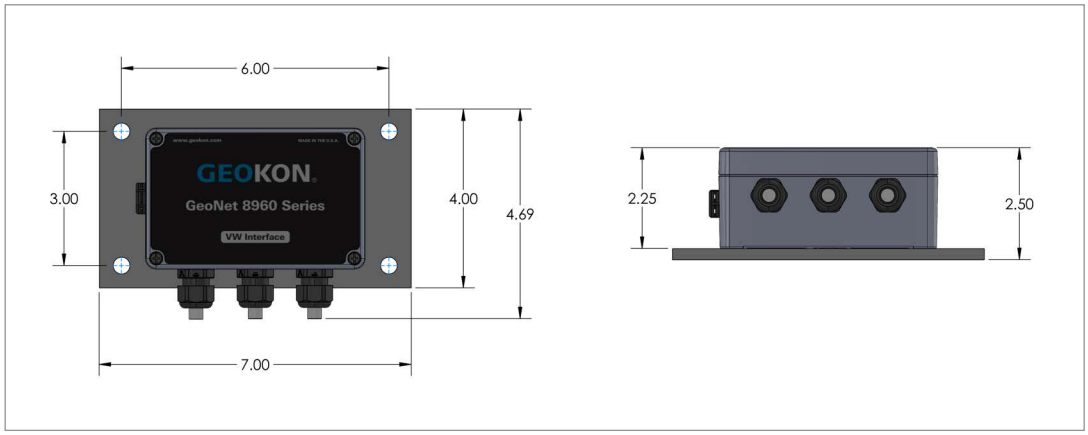


FIGURE 28: *Single-Channel Enclosure (01C-CBL) Models*

F.2 FOUR-CHANNEL ENCLOSURE (04C-CBL) MODELS

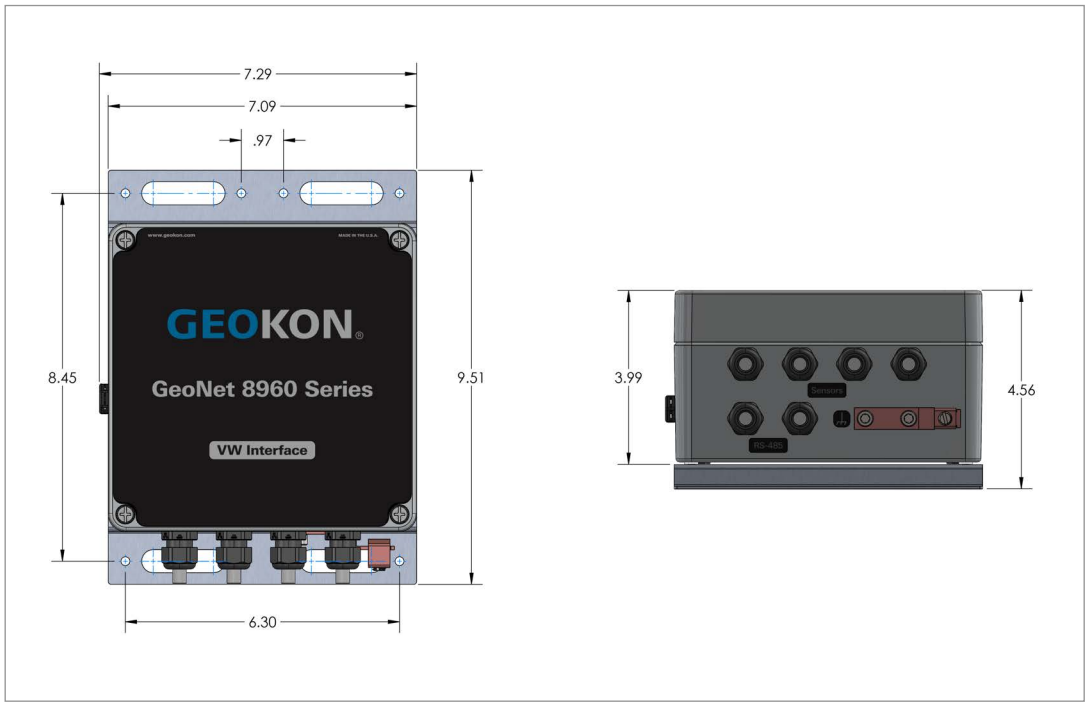


FIGURE 29: *Four-Channel Enclosure (04C-CBL) Models*

F.3 EIGHT-CHANNEL ENCLOSURE (08C-CBL) MODELS

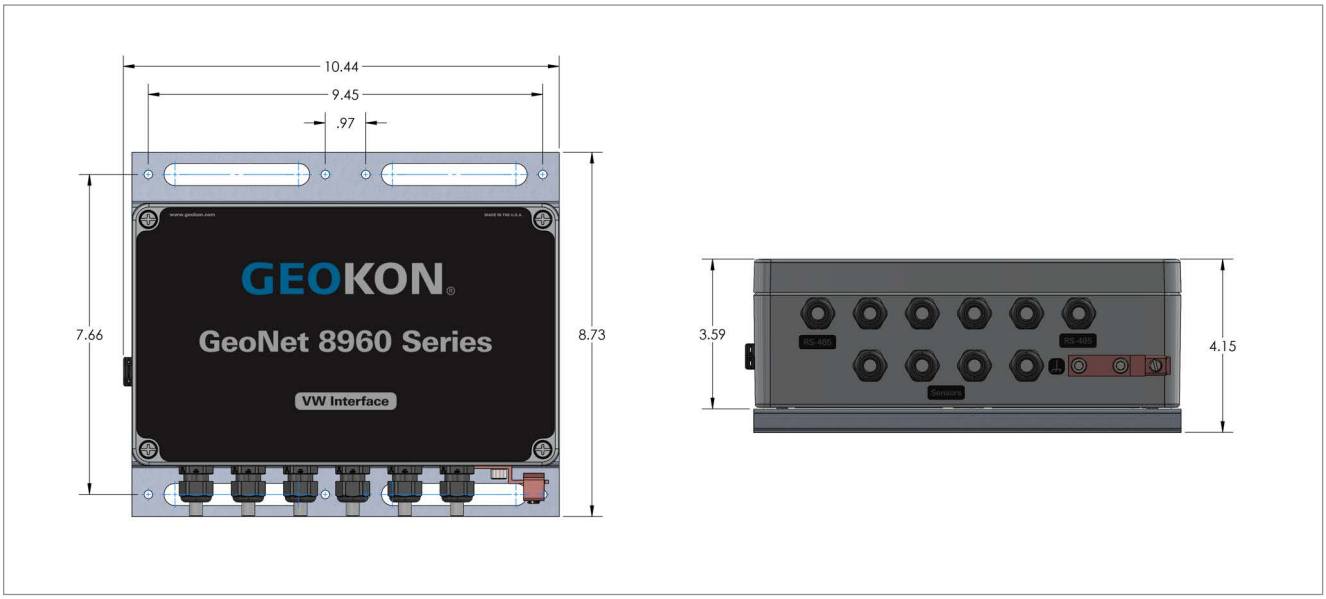


FIGURE 30: *Eight-Channel Enclosure (08C-CBL) Models*

APPENDIX G. MOUNTING BRACKET DIMENSIONS

Note: Dimensions shown below are in inches.

G.1 SINGLE-CHANNEL ENCLOSURE (01C-CBL) MODELS

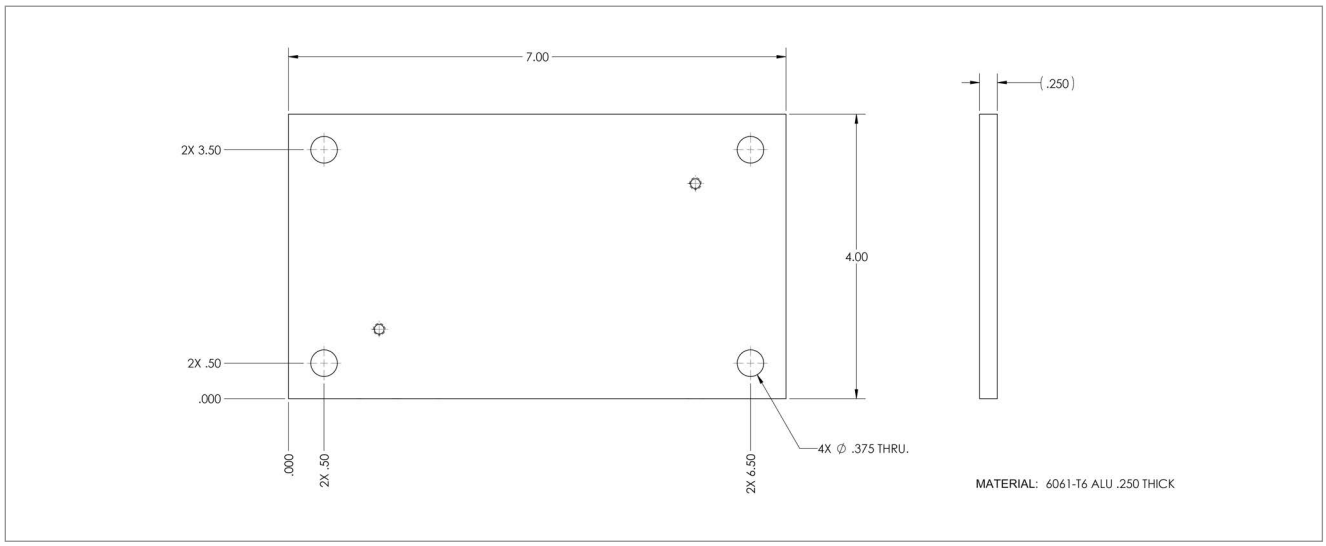


FIGURE 31: *Single-Channel Enclosure (01C-CBL) Models*

G.2 FOUR-CHANNEL ENCLOSURE (04C-CBL) MODELS

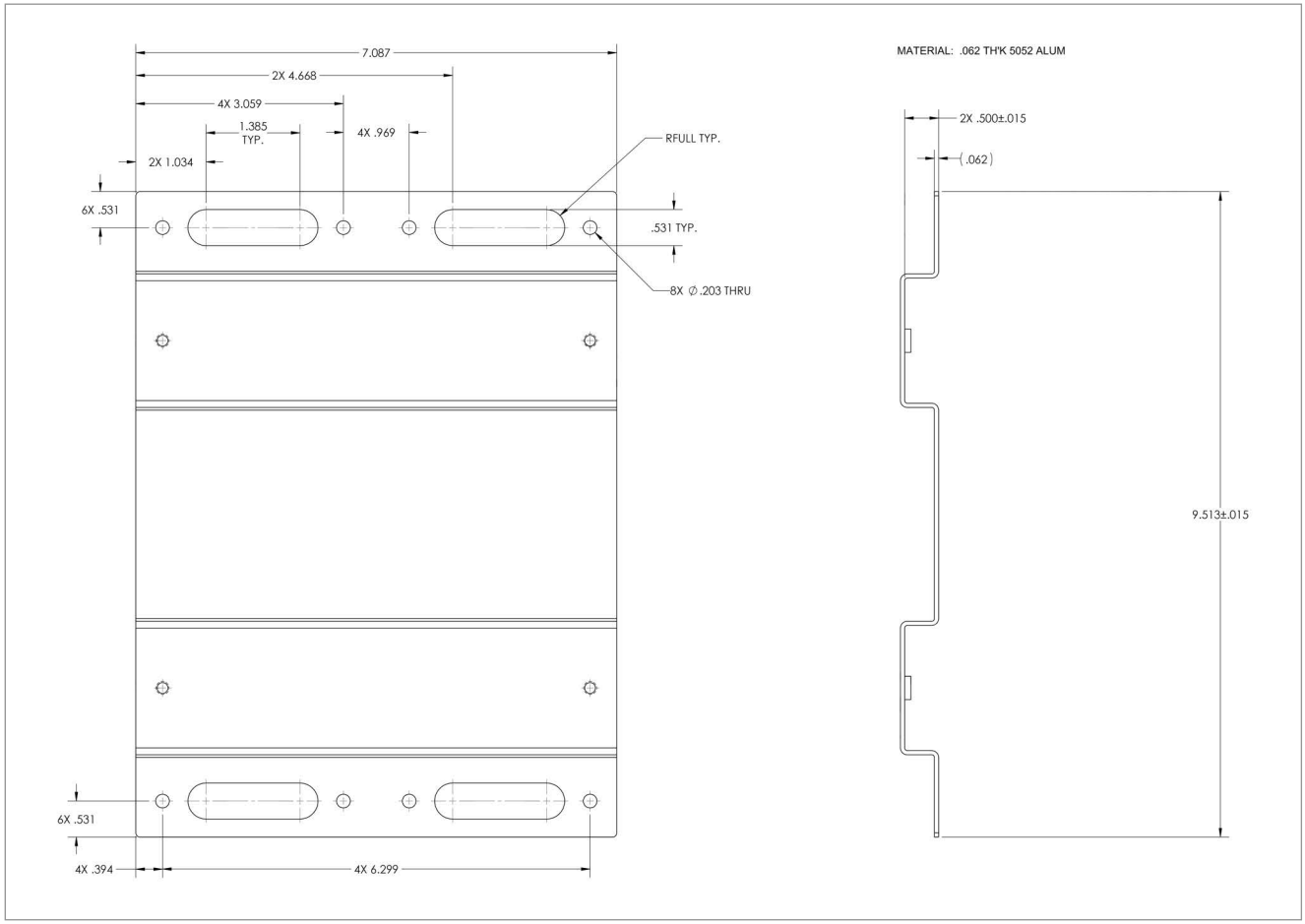


FIGURE 32: *Four-Channel Enclosure (04C-CBL) Models*

G.3 EIGHT-CHANNEL ENCLOSURE (08C-CBL) MODELS

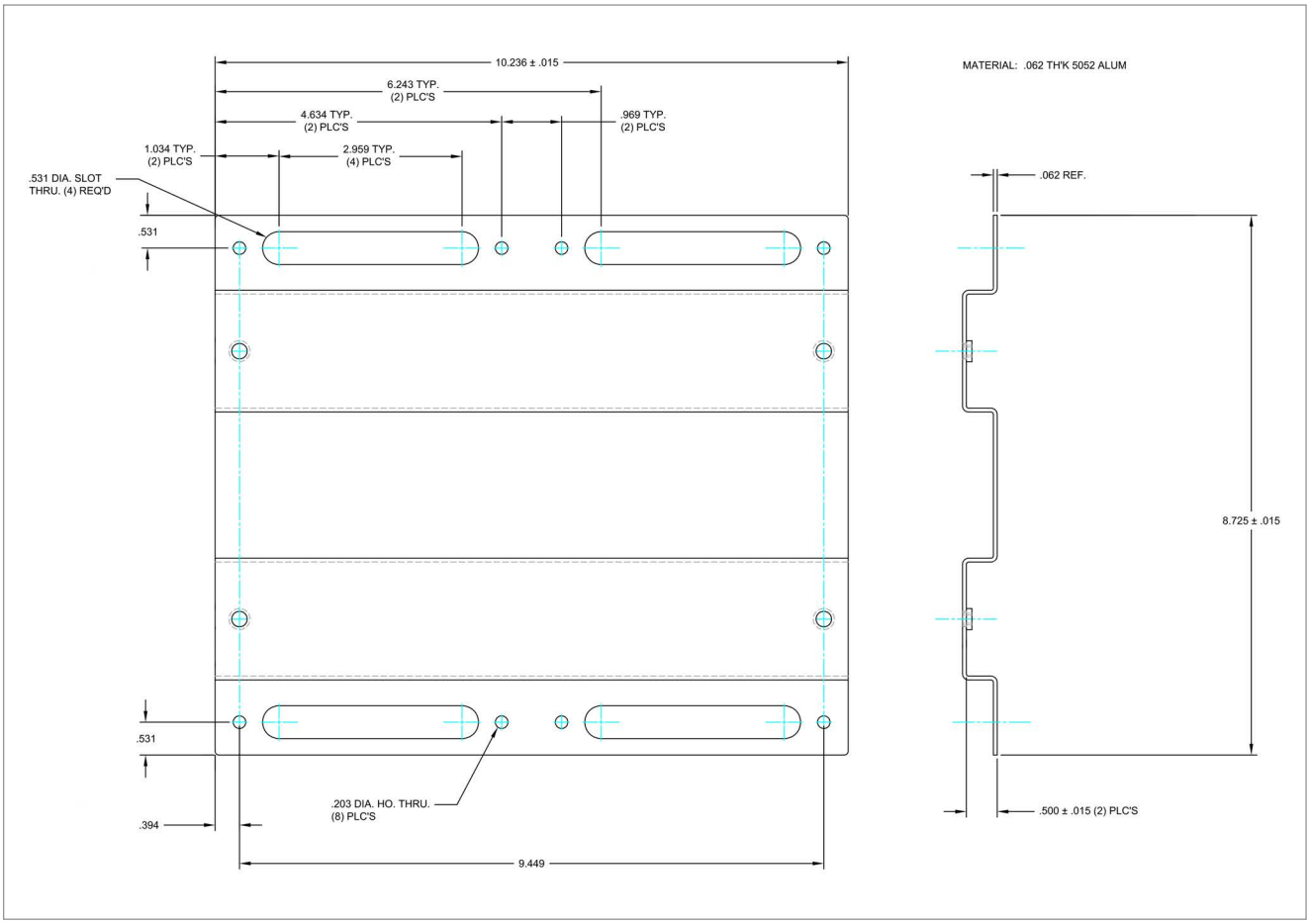


FIGURE 33: *Eight-Channel Enclosure (08C-CBL) Models*

APPENDIX H. COMPONENTS (TYPICAL REPLACEMENT PARTS)

H.1 SINGLE-CHANNEL CABLE (12P AND CAB) MODELS

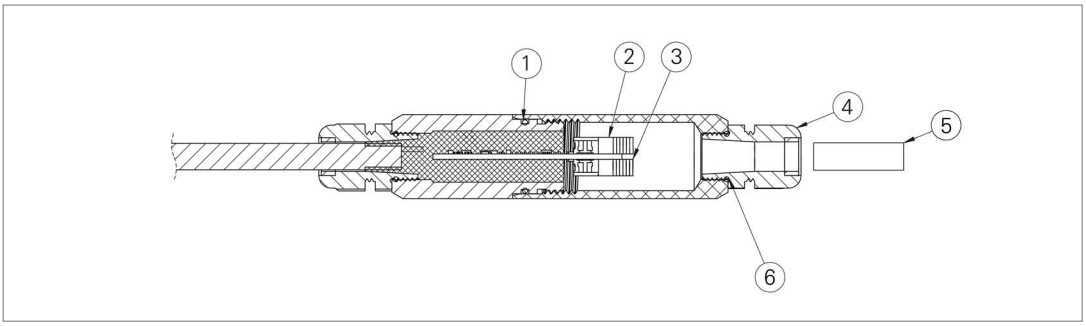


FIGURE 34: *Single-Channel Cable (12P and CAB) Models*

Item No.	Part Number	Description
1	ORB-018	Buna O-Ring
2	CON-959	2 Position Connector
3	CON-960	3 Position Connector
4	CON-A365	Cable Fitting
5	CON-A341	Dowel Pin
6	SEAL-09	Seal Ring for CON-A365

TABLE 26: *Single-Channel Cable (12P and CAB) Models Components Parts List*

H.2 SINGLE-CHANNEL ENCLOSURE (01C-CBL) MODELS

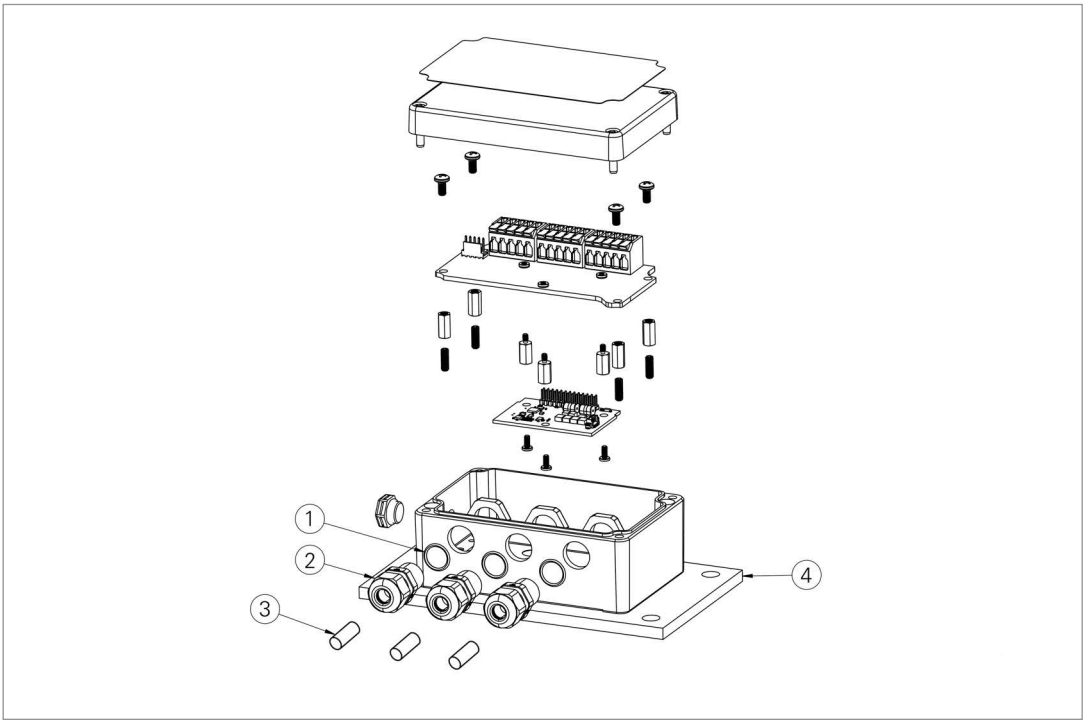


FIGURE 35: *Single-Channel Enclosure (01C-CBL) Models*

Item No.	Part Number	Description
1	SEAL-09	Seal Ring for CON-A331
2	CON-A331	Cable Fitting
3	CON-A342	Dowel Pin
4	A6191-1	Mounting Bracket

TABLE 27: *Single-Channel Enclosure (01C-CBL) Models Components Parts List*

H.3 FOUR-CHANNEL ENCLOSURE (04C-CBL) MODELS

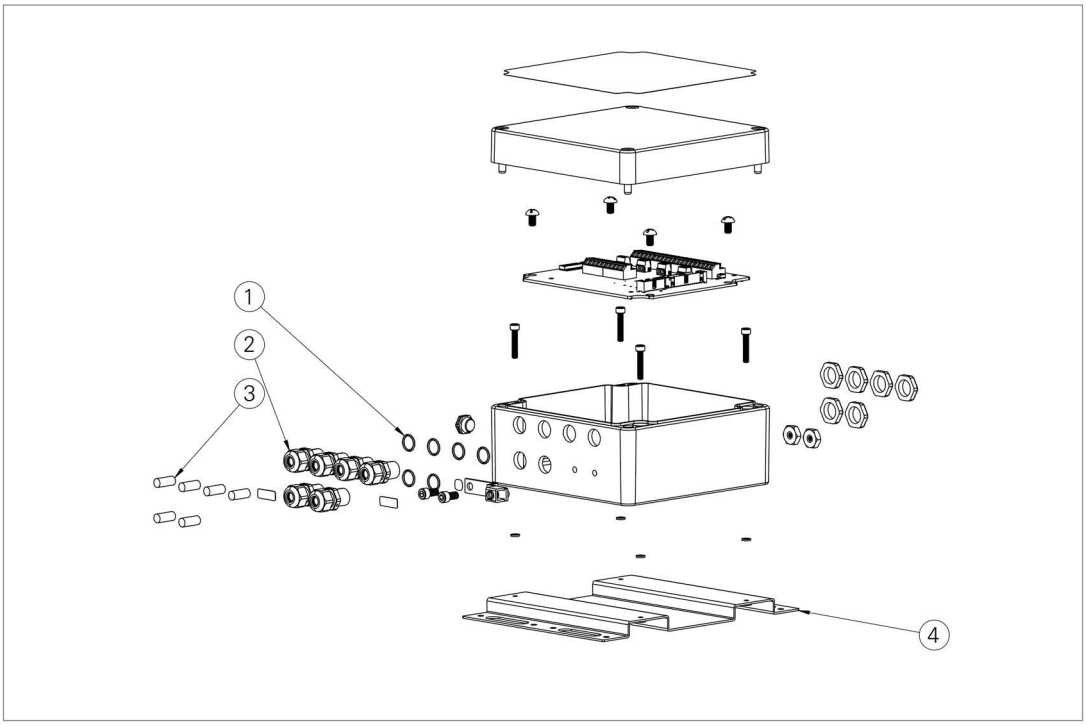


FIGURE 36: *Four-Channel Enclosure (04C-CBL) Models*

Item No.	Part Number	Description
1	SEAL-09	Seal Ring for CON-A331
2	CON-A331	Cable Fitting
3	CON-A342	Dowel Pin
4	C8800-4	Mounting Bracket

TABLE 28: *Four-Channel Enclosure (04C-CBL) Models Components Parts List*

H.4 EIGHT-CHANNEL ENCLOSURE (08C-CBL) MODELS

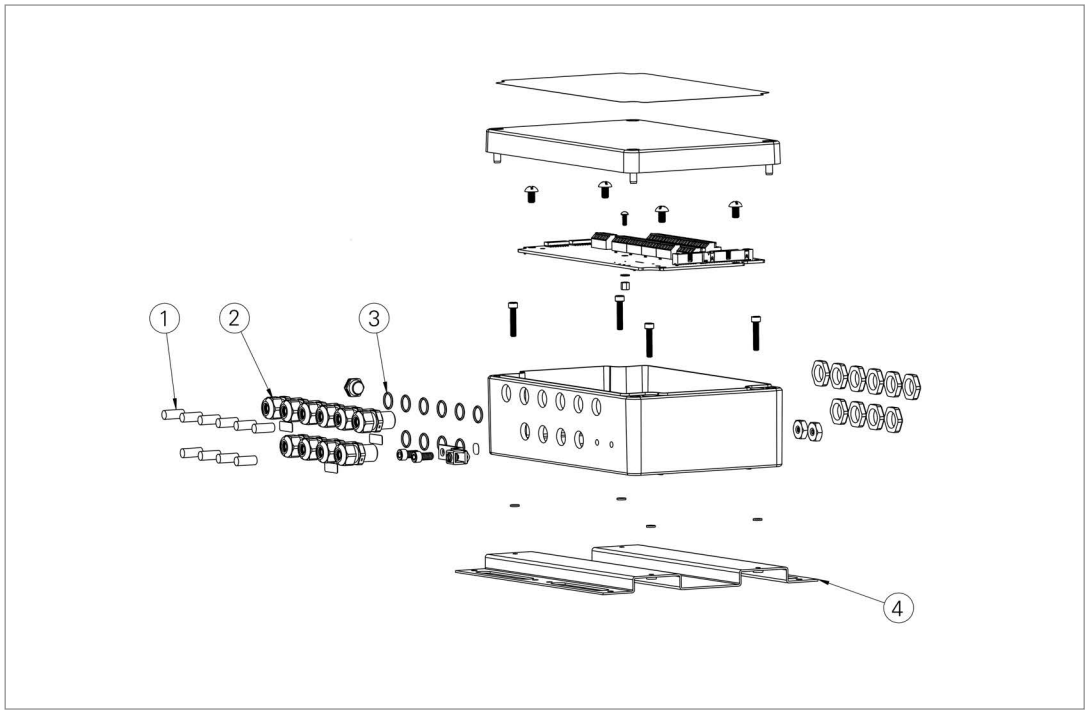


FIGURE 37: *Eight-Channel Enclosure (08C-CBL) Models*

Item No.	Part Number	Description
1	CON-A342	Dowel Pin
2	CON-A331	Cable Fitting
3	SEAL-09	Seal Ring for CON-A331
4	C8800-6	Mounting Bracket

TABLE 29: *Eight-Channel Enclosure (08C-CBL) Models Components Parts List*

APPENDIX I. SENSOR AND RS-485 WIRING PORTS

I.1 MODEL 8960-01C-CBL WIRING PORTS

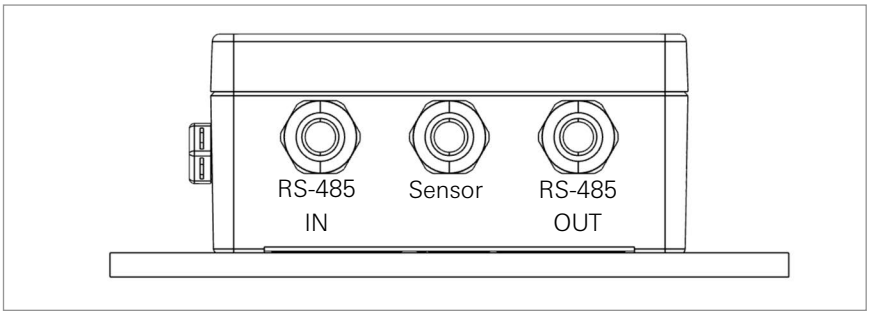


FIGURE 38: *Model 8960-01C-CBL*

I.2 MODEL 8960-04C-CBL WIRING PORTS

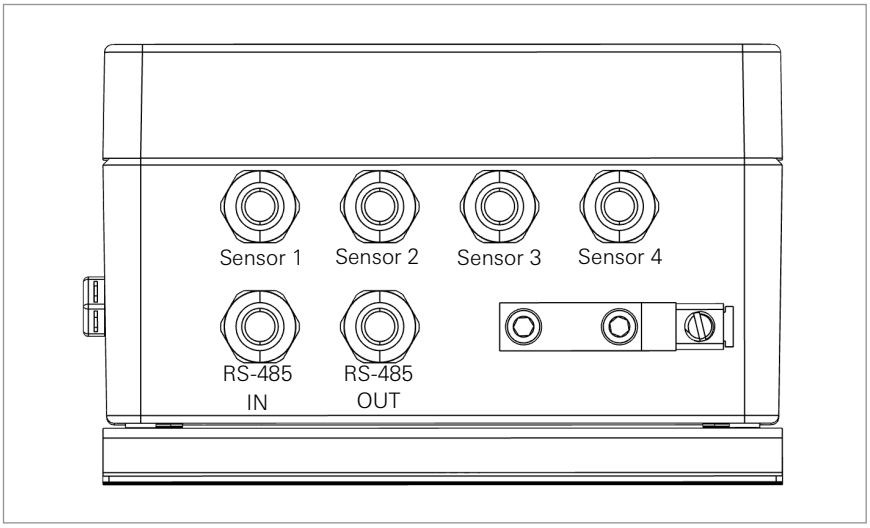


FIGURE 39: *Model 8960-04C-CBL*

I.3 MODEL 8960-08C-CBL WIRING PORTS

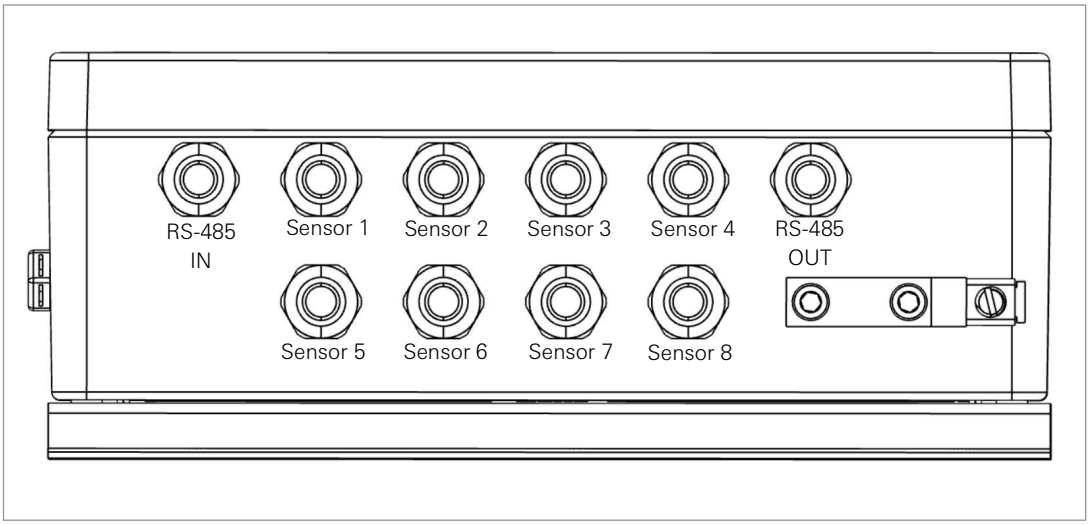


FIGURE 40: *Model 8960-08C-CBL*

APPENDIX J. VIBRATING WIRE LOAD CELL WIRING

J.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 30: *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.

J.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 31: *Load Cell Configuration Switch Settings*

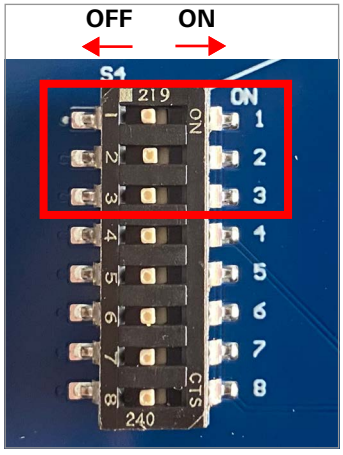


FIGURE 41: *Load Cell Configuration Switch*

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