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Leap Wireless Sensor System

Strain/Load Cell Sensor & Strain Simulator Device User Manual

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Contents

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1. About this Manual

This User Manual describes specific configuration and usage of the **Leap Strain/Load Cell Sensor Device**, generically called the **Resistive Bridge Sensor** as it's applicable to any resistive bridge.

The **Leap Strain/Load Cell Sensor Device** is designed to work with any resistive bridge circuitry. This includes custom strain gauges as well as commercially available load cells. The Leap Web User Interface allows the end-user to configure this device for use with any resistive bridge sensor.

General usage of the **Leap Wireless Sensor System**, including a system Quick Start Guide, is described in the User Manual linked here:

Leap Wireless Sensor System User Manual

2. Hardware Configuration

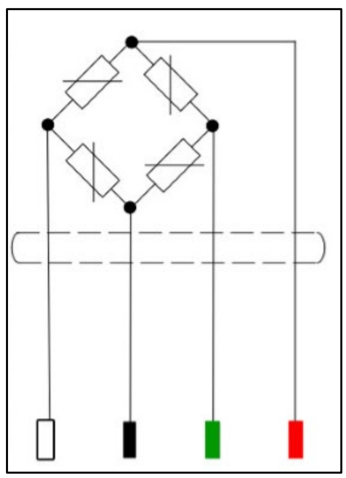
Hardware configuration may be required by the end-user for custom resistive bridge applications.

2.1 Resistive Bridge Wiring

Resistive bridges usually contain four strain sensors configured in a Wheatstone bridge configuration.

Typically, the bridge is set-up with wires of standard colors. The **Leap Strain/Load Cell Sensor Device** follows this typical convention.

- **Red Wire:** Excitation Voltage (supplied by the Leap Device)
- **Black Wire:** Ground
- **White wire:** Signal (-)
- **Green wire:** Signal (+)
- **Bare wire (cable shield):** Connect to the load cell ground



Important: The voltage signals from load cells are very small. To ensure the most accurate readings:

1) Solder all wire connections with quality solder joints to ensure good connection. Insulate connections at the joints to prevent any shorts.

2) Keep the cables as short as reasonably possible.

3) Connect the bare cable shield wire from Leap Device to the load cell ground

Important: **Compression vs Tension Polarity:** After setting up the device and viewing the readings in the Web Interface, if compressing or tensioning the cell is yielding results with the reverse polarity than desired, simply reverse the White and Green signal wires. For example, if the reading value should be positive under load but it's increasing in the negative direction, reversing the signal wires will fix the issue.

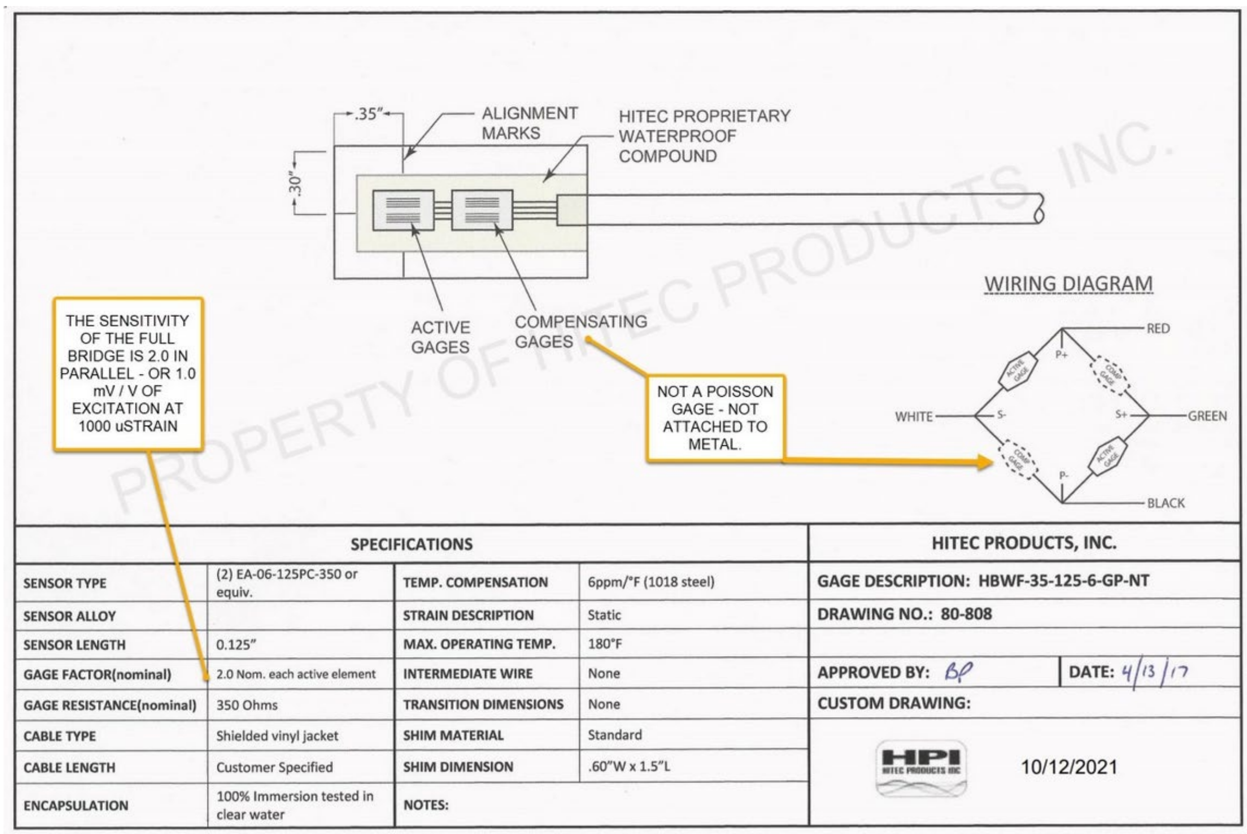
2.2 Weld-on Strain Gauges

2.2.1 Important Considerations

Many applications use two weld-on half-bridge gauges to form a full-bridge. In most cases the sensitivity of a full-bridge strain circuit has a sensitivity of 1.3 mV/V at 1000 με, However, many weld-on gauges use a "compensation resistor" instead of a "Poisson gauge" for a leg of the bridge. The "compensation resistor" is not glued to the metal mounting plate. The result is that:

When using two weld-on half-bridge gauges (with compensation resistors) to make a full-bridge strain sensor, the sensitivity for that full-bridge is 1.0 mV/V at 1000 με, not 1.3 mV/V at 1000 με.

Here is a picture:



SPECIFICATIONS			
SENSOR TYPE	(2) EA-06-125PC-350 or equiv.	TEMP. COMPENSATION	6ppm/°F (1018 steel)
SENSOR ALLOY		STRAIN DESCRIPTION	Static
SENSOR LENGTH	0.125"	MAX. OPERATING TEMP.	180°F
GAGE FACTOR(nominal)	2.0 Nom. each active element	INTERMEDIATE WIRE	None
GAGE RESISTANCE(nominal)	350 Ohms	TRANSITION DIMENSIONS	None
CABLE TYPE	Shielded vinyl jacket	SHIM MATERIAL	Standard
CABLE LENGTH	Customer Specified	SHIM DIMENSION	.60"W x 1.5"L
ENCAPSULATION	100% Immersion tested in clear water	NOTES:	

HITEC PRODUCTS, INC.	
GAGE DESCRIPTION: HBWF-35-125-6-GP-NT	
DRAWING NO.: 80-808	
APPROVED BY: BP	DATE: 4/13/17
CUSTOM DRAWING:	

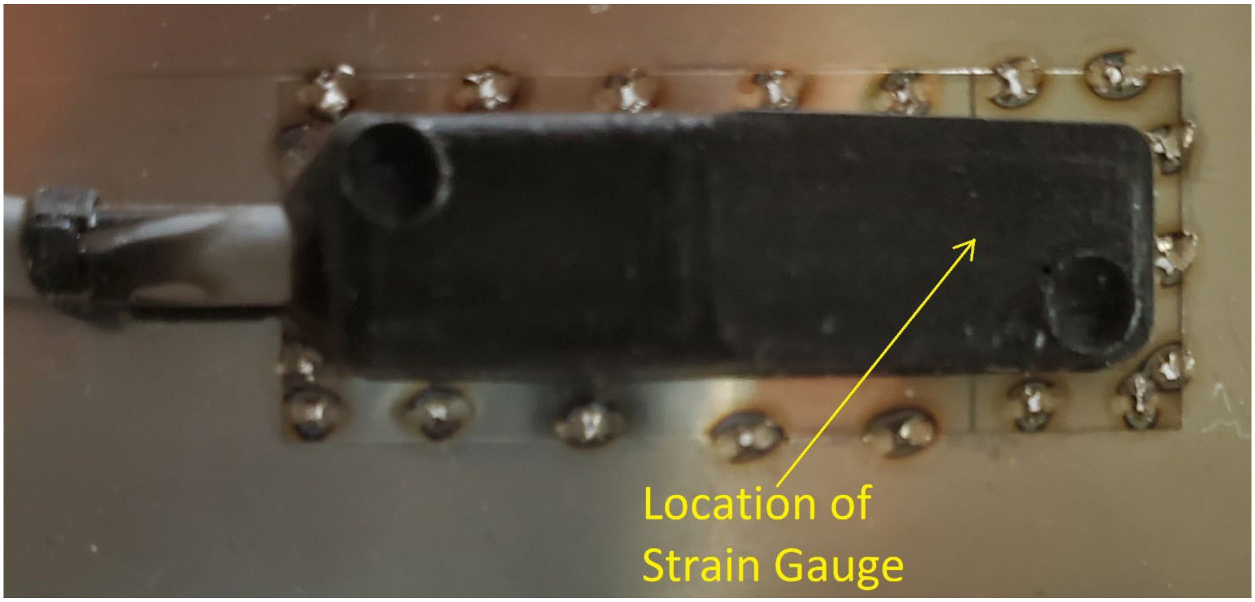
2.2.2 Welding Instructions

The strain gauges for all weld-on strain gauges are mounted on 5 mill thick shims made of 317L stainless steel. Minimal cleaning of the shims is needed to allow for good welding performance. They can be welded to most other steel alloys.

Before welding:

- The surface to which they are to be welded must be clean, flat, and oxide free to allow for a reliable weld connection.
- Check that the shim is flat and doesn't have any significant bends or creases.

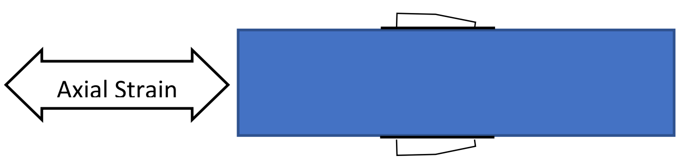
During welding, press the center of the shim against the surface to which it will be welded. Verify it is sitting flat against that surface. Using a spot welder, begin welding at one corner, and proceed around the perimeter of the shim placing a weld every 0.2” or so, for a total of 10 to 18 weld spots around the entire gauge.



2.2.3 Weld-On Strain Gauge Orientations

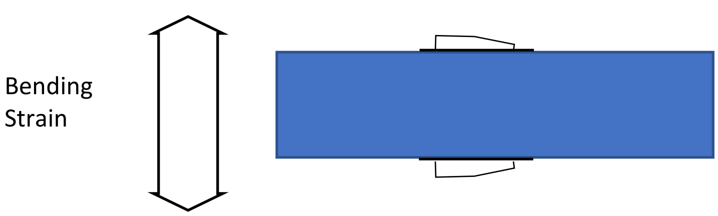
2.2.3.1 Axial Strain Welding Orientation

The 2 strain gauges of an **axial strain sensor** should be welded directly opposite of each other on both sides of the material to measure. Orient the gauges so the long axes of the gauges are **parallel** to the direction of the force on a plane that intersects both gauges.



2.2.3.2 Bending Strain Sensor Gauge Welding

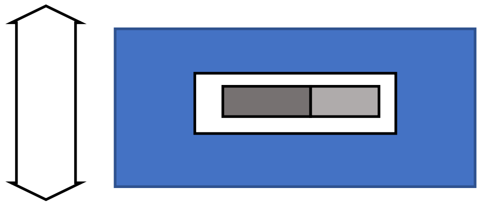
The 2 strain gauges of a **bending strain sensor** should be welded directly opposite of each other on both sides of the material to measure. Orient the gauges so the long axes of the gauges are **perpendicular** to the direction of the force on a plane that intersects both gauges.



2.2.3.3 Torsion (Shear) Strain Sensor Gauge Welding

The single gauge of a **torsion (or shear) strain sensor** should be welded to the surface of the material to measure oriented so the long axis is perpendicular to the direction of the force on a plane parallel to the surface to which the gauge is welded.

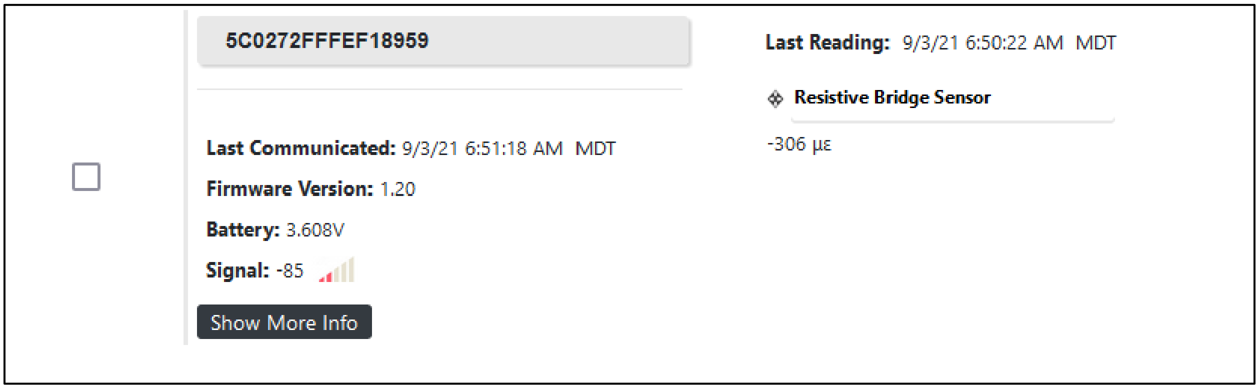
Torsion Strain



3. Device Configuration

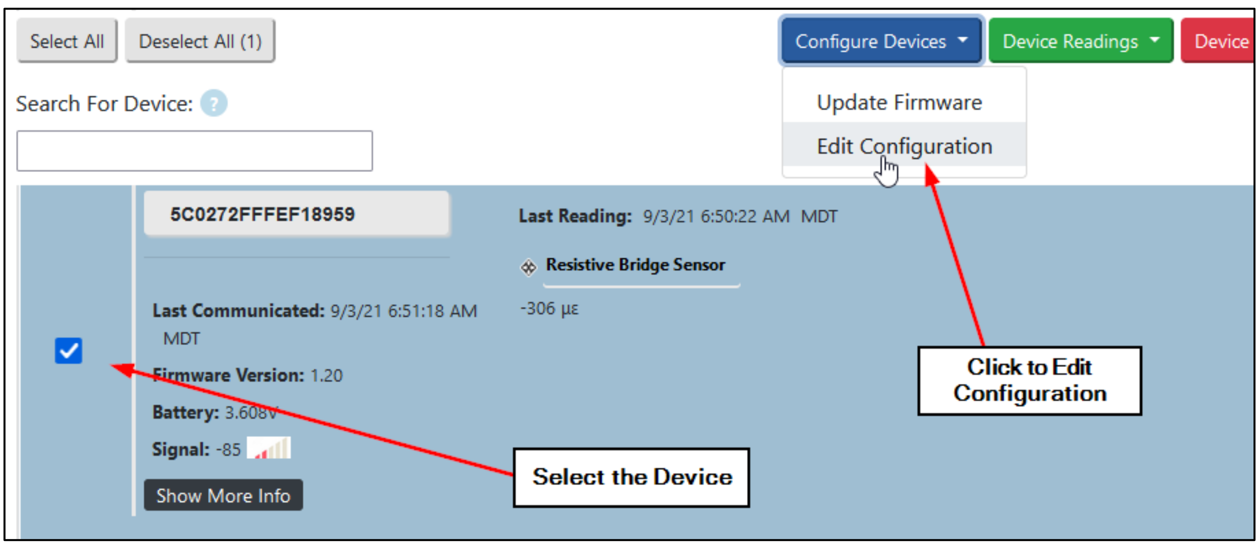
3.1 Device Web UI View

The default **Leap Strain/Load Cell Sensor Device** display in the Leap Wireless Sensor Web Interface looks like this:



3.2 Edit Device Configuration

Edit the Device configuration by selecting the Device panel check box, click **Configure Devices->Edit Configuration**



In the dialog box that appears, scroll down to the **Sensor Options** section to find configuration options for the **Resistive Bridge Sensor** picture here:

See the next section in this document for how to set these values for specific types of calibration. If a sensor is already attached, these values have already been set at the factory and should not be changed. Here's a general description of each option.

- **Bridge Sensitivity (mV/V of excitation):** Sensitivity of the bridge in mV/V. Can also be used as the slope for custom calibration described later in the document.

- **Calibration Load:** The strain gauge or load cell calibration load.

- **Offset:** Zero the sensor by entering the negative of the reading value at no strain/load.

- **Sensor Units:** Change so the display on the Web UI displays the correct units. For example: *με, lbs, kg,* etc.

- **Sensor Label:** Change to display the correct sensor label on the Web UI units. For example: *Strain Sensor, Load Cell*, etc.

- **Reading Decimal Places:** Adjust the precision according to expected accuracy of the sensor.

- **Resistive Bridge Stabilization Delay:** When the device takes a reading the bridge is momentarily excited with a voltage produced by the device. This delay allows the sensing circuitry to stabilize for a reading. For most sensors the default, 1500 ms, is the correct value. Adjust only if instructed by a Phase IV representative.

3.3 Field Calibration

If Phase IV sent the **Leap Strain/Load Cell Sensor Device** with a Sensor already connected it will already be configured and calibrated so adjusting the configuration won't be necessary. If connecting a Resistive Bridge Sensor in the field adjust the configuration options as appropriate as described below for different types of calibration.

3.3.1 Calibrate Custom Strain Sensor in με:

Field calibration of a strain sensor reporting the value in microstrain (με) takes a little bit of effort. Set each configuration value as described:

Bridge Sensitivity: Strain sensor sensitivity is dependent on the Gauge Factor of each strain cell in the bridge, type of bridge, and the strain cell orientation. Use the link below to determine the sensitivity for a given orientation

https://www.ni.com/en-us/innovations/white-papers/07/measuring-strain-with-strain-gages.html

An example of a common configuration is a Full-Bridge Type II configuration. From the linked article it shows that if the 4 strain cells in the bridge have a Gauge Factor of 2.0 mV/V then the overall sensitivity of a Type II Full-Bridge configuration is 1.3 mV/V. Enter *1.3* for the **Bridge Sensitivity** configuration value. For different Gauge Factors in a Type II Full-Bridge configuration do the proportional math. For example, if the Gauge Factor (GF) of the 4 strain cells is 2.13 mV/V then:

$$FullBridge\ Type\ II\ Sensitivity = GF \cdot \frac{1.3}{2} = 2.13 \cdot \frac{1.3}{2} = \mathbf{1.3845\ mV/V}$$

The math is similar for other bridge configurations.

Calibration Load: Gauge factors for strain sensors are given at 1000 με. Enter *1000* in this field.

Offset: If possible, remove any load from the strain sensor, let the device take a few readings, and input the negative of the reported value. For example, if the unloaded reading is -306 με, enter *306* for the **Offset** value.

Sensor Units: Enter *με*

Reading Decimal Places: Enter 0 in this field because a tenth of a microstrain is so small as to be meaningless.

3.3.2 Calibrate Custom Strain/Load Sensor for weight (lbs, kg, etc):

Sometimes an end-user would like custom strain sensor values in a unit of weight like lbs or kg. Internally the **Bridge Sensitivity** configuration value is used as the slope. For this calibration method we'll use this configuration value as the slope in a 2-point linear calibration. Follow these steps to do a 2-point calibration for weight:

1) Set the Device configuration options as follows: **Bridge Sensitivity (the Slope)** = 1**; Calibration Load** = 1; **Offset** = 0; **Sensor Units** = <desired weight unit>; **Sensor Label:** <appropriate sensor name>; **Reading Decimal Places:** Set according to the desired accuracy. For example, a load cell expected to output lbs to the one-hundredth of a lbs, enter 2 for this value so 2 decimal places are reported.

2) Let the device take a few readings at 2 known loads (if possible the loads should be at the extreme ends of the expected measurements)

3) First calculate the Slope; In the equations below the "Values" are the actual weight used for calibration in kg, lbs., etc.; the "Readings" are the sensor reading values displayed on the Web Interface.

$$Bridge\ Sensitivity\ (Slope) = \frac{High\ Load\ Value - Low\ Load\ Value}{High\ Load\ Reading - Low\ Load\ Reading}$$

Enter result of this equation as the **Bridge Sensitivity** configuration value.

4) Then calculate the offset using the Slope calculated in the previous step:

$$Offset = \ Low\ Load\ Value - (Low\ Load\ Reading \cdot Slope)$$

Enter result of the equation as the **Offset** configuration value.

3.3.3 Calibrate for Commercial Strain or Load Cell:

Enter the **Bridge Sensitivity** and **Calibration Load** from the manufacture's datasheet. Change the **Sensor Units, Sensor Label**, and **Reading Decimal Places** appropriately for the device. If desired enter the **Offset** value necessary to set the value to 0 at no strain/load.

4. Strain Sensor Simulator/Tester

4.1 Purpose of the Strain Sensor Simulator/Tester

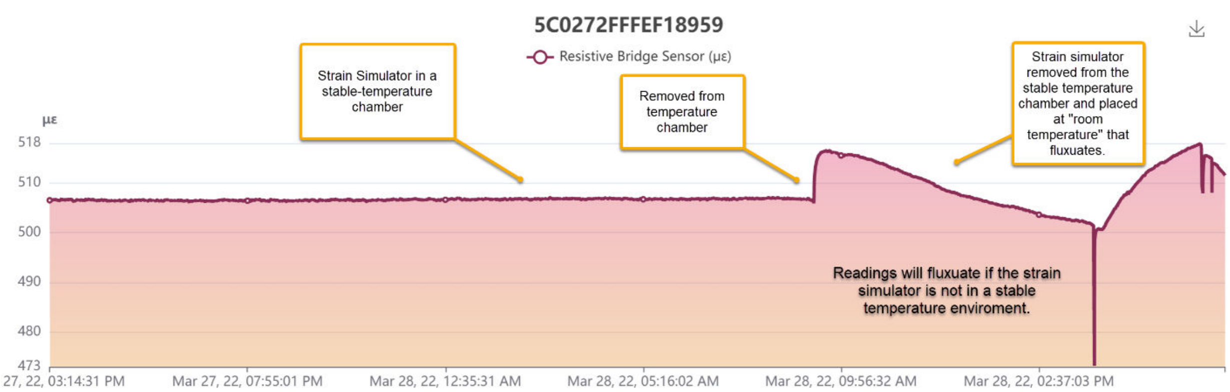
The strain simulator allows the user to test the leap device node to assure it is working properly.

If a problem is encountered with a strain sensor reading being questionable or in an error condition, this device may be used to check if the problem is with the Leap Device Node or the strain sensor itself.

4.2 Temperature Sensitivity – IMPORTANT NOTE

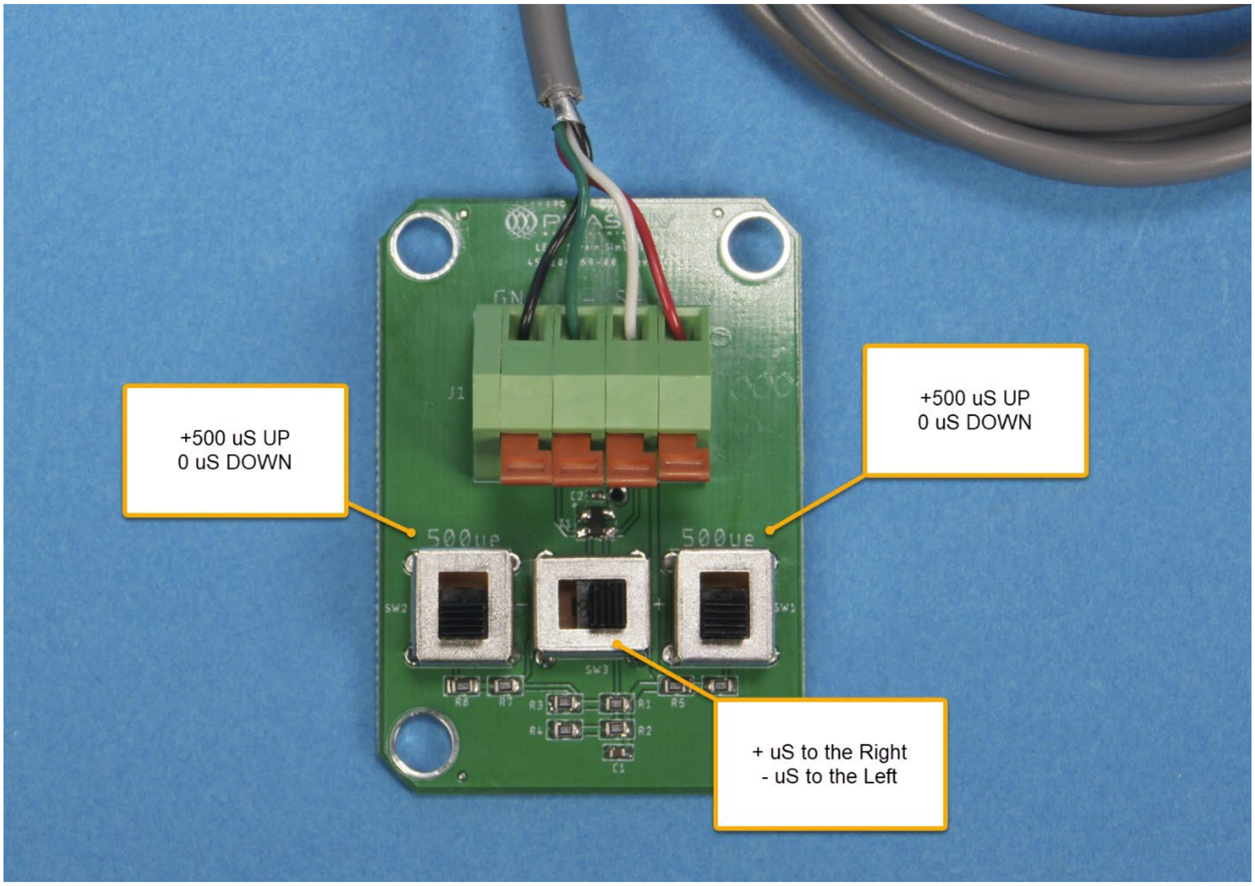
Tests with the Strain Sensor Simulator have shown that it is temperature sensitive.

If instability of the readings are observed with the strain simulator – it is likely that it is due to the temperature sensitivity of the simulator.



4.3 Install the Wires

Strip the wires and install the wires from the Leap Strain Sensor Device Node to the strain tester as shown. Press the brown levers down to install the stripped wires into the terminal block.



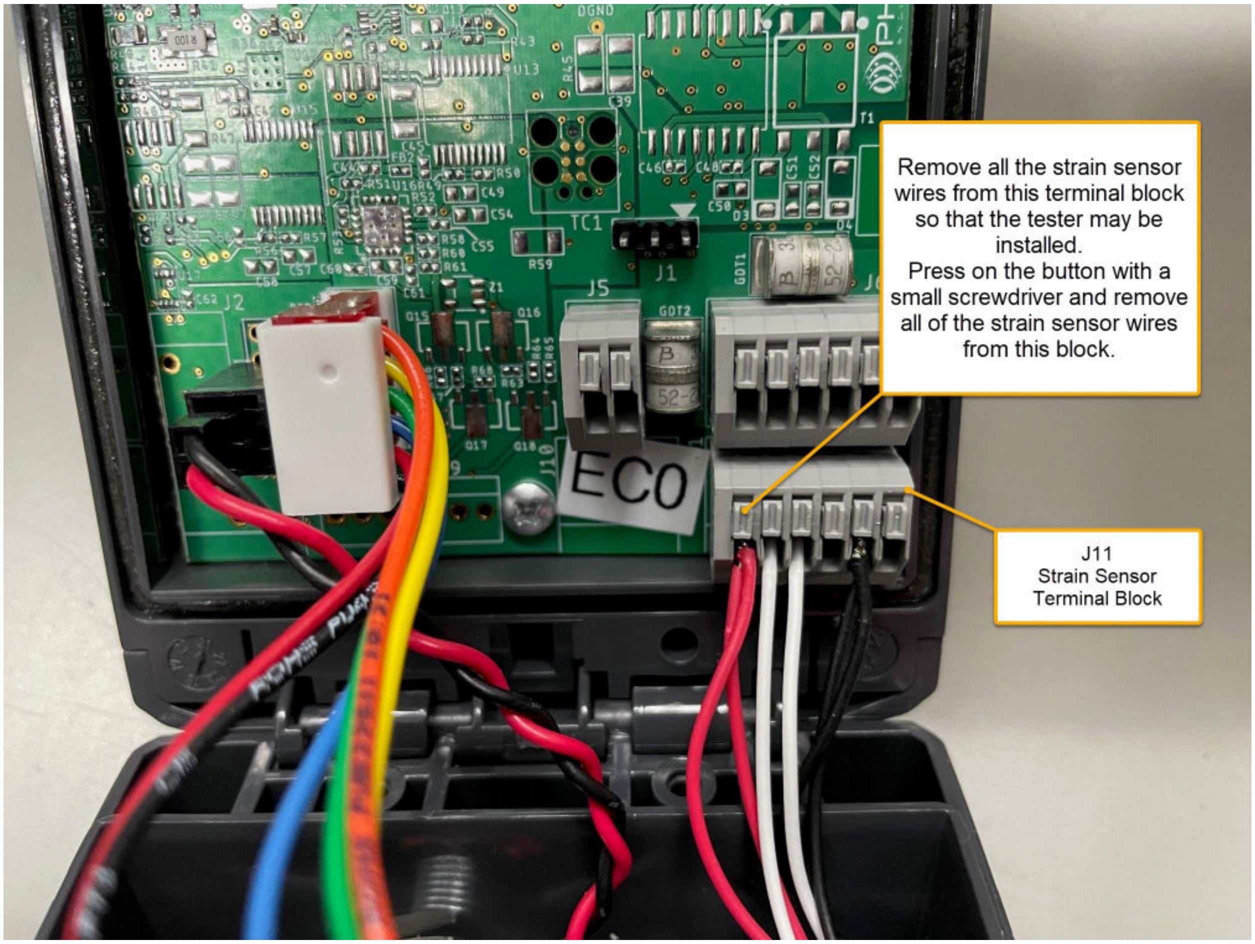
Set the strain Positive, 0 uS. (Left switch Down, Middle switch to the Right, Right switch Down).

4.3.1 Attach the Strain Simulator to the Leap Sensor Node

If strain sensors are already attached to the Leap node, then the best way to connect the Strain Simulator is to connect the other end of the cable to the inside terminal block of the Leap Strain Sensor Node.

First, open the front cover of the strain sensor node. (See the video on how to do this at: https://www.phaseivengr.com/about-us/support/ - See video titled, “Opening and Closing the Transceiver Node Enclosure”.

Dis-connect the strain sensors from the terminal block as shown below.

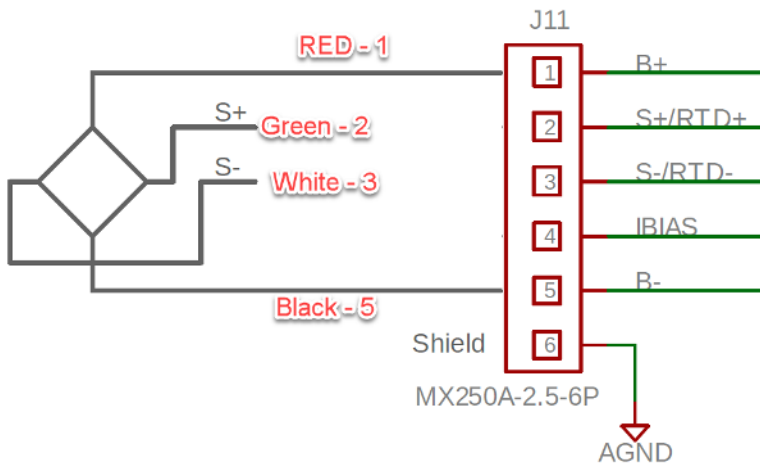


Once the strain sensing wires have been removed, install the strain tester into this terminal block as shown below.

Use a small screwdriver to press on the button above each hole to open the spring-loaded wire-clamp inside each hole. Insert the stripped wire into the hole – then remove the screwdriver to let the terminal block clamp on the wire. Pull on the wire to verify a good connection.

4.3.1.1 Strain Tester Wiring to Terminal Block

To attach the strain tester, leave the sensor node lid open and connect the cable from the strain tester to terminal block J11 as shown below.

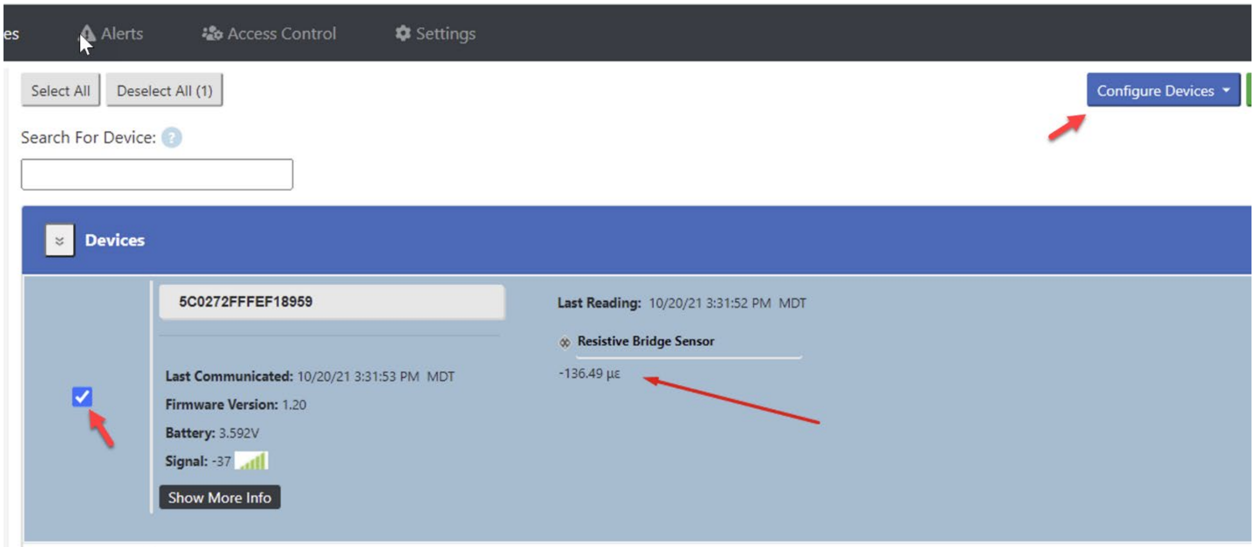


4.4 Set the Zero Offset

Use the Leap software to see the output from the strain tester/simulator.

The strain sensor simulator is unlikely to report 0 uStrain when first attached. A zero-offset needs to be set in the software.

In the example below, an offset of +136.49 needs to be added to zero-out the strain sensor tester.

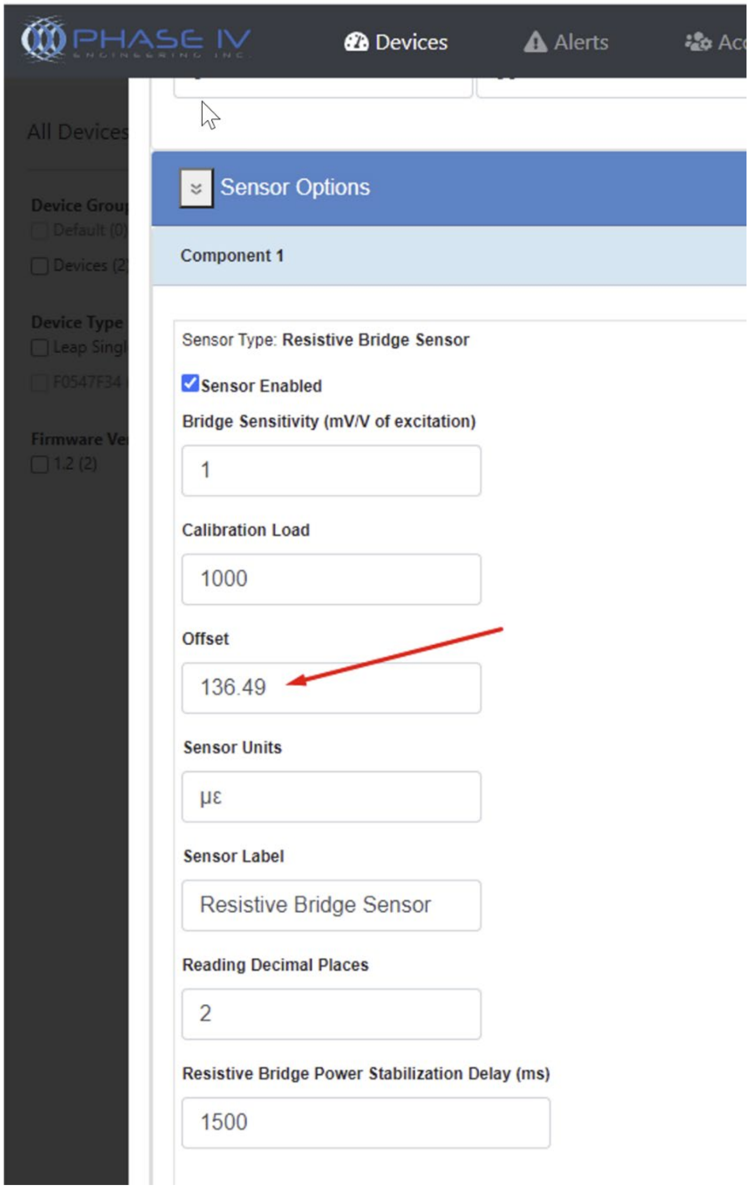


Click on the checkmark to select this device node.

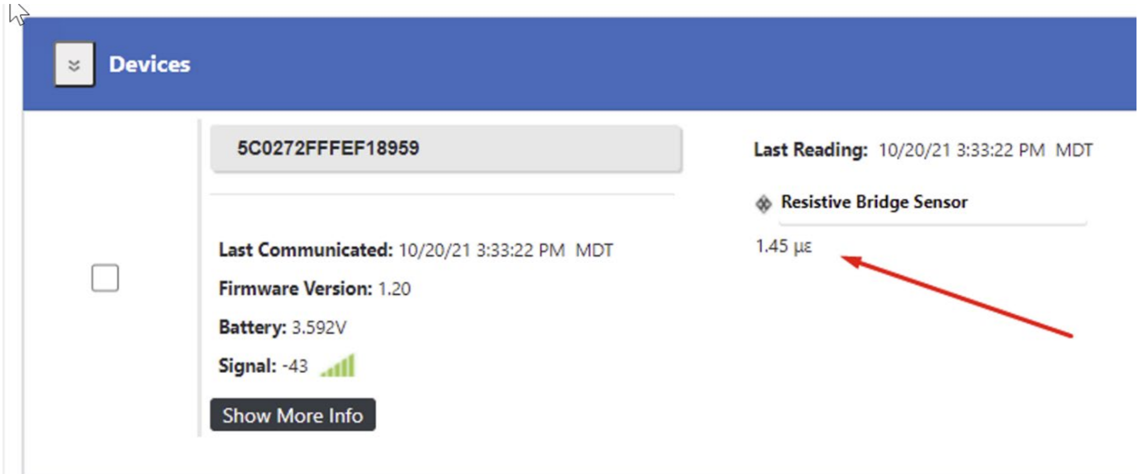
Then, click on Configure Devices.

Scroll down the page and add the offset.

Then, click Save.



After the offset adjustment, the strain sensor should show a value nearly zero, +/- 3 uS.



4.5 Testing 0, 500, and 1000 uStrain

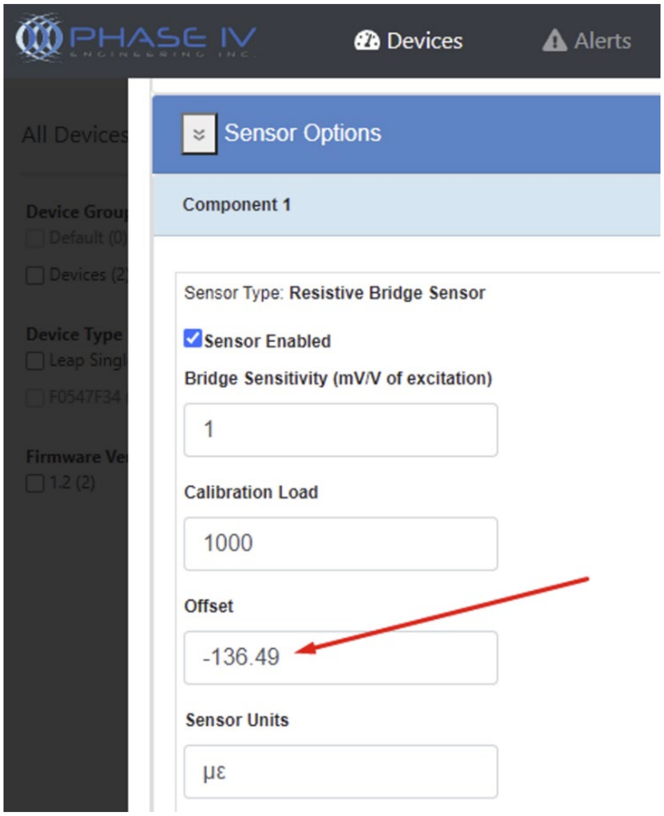
Once the zero-offset is input, the Leap Device Node can be tested at 0, +500, and +1000 uStrain.

Use the switches to change the strain settings. The switches on the right and left of the tester will add 500 uStrain. With both switches up, the Device Node should read 1000 uStrain.

+/- 5 uStrain is typical at 500 and 1000 uStrain.

4.6 Switching to Negative Strain – IMPORTANT NOTE

IMPORTANT NOTE: When switching from positive to negative strain, the offset also needs to change from positive to negative.



Switch the sign on the offset when flipping the positive/negative strain switch. In the example above, the offset was +136.49 when displaying positive strain and needed to be changed to -136.49 when moving the tester switch to negative strain.

4.6.1 Removing the Tester and Re-Attaching the Strain Sensors

Once the testing with the strain testing module is complete, remove the strain tester from terminal block J11 and re-attach the strain sensors as shown in section 4..3.1.

5. Technical Support

For more information about our products and services, or for technical assistance:

Visit us at: www.phaseivengr.com
Tel: +(303) 443 6611 (USA – MST 8:00 a.m. to 5:00 p.m., Mon.-Fri.)
E-Mail: support@phaseivengr.com

If you need assistance, please provide the product part number, product serial number, and product version.