

EmbedSense®

Wireless Sensor



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Welcome

Welcome to MicroStrain! We make tiny sensors that are used in a wide range of applications, including knee implants, civil structures, advanced manufacturing, unmanned military vehicles, and automobile engines. Our sensors have won numerous awards and we pride ourselves on being both innovative and responsive to our customer's unique requirements.

MicroStrain is based in Williston, Vermont and is a privately held corporation. Founded in 1987, our early development focused on producing micro-displacement sensors for strain measurement in biomechanics research applications. Our first sensors were designed for arthroscopic implantation on human knee ligaments; since then, we expanded our product line through continual product improvement.

We introduced a broader line of micro-displacement sensors that could withstand extreme temperatures, hundreds of millions of cycles, and complete submersion in saline. The aerospace and automotive industry found our sensing systems met their requirements and we've worked on many groundbreaking projects.

As our customer base expanded, we continued to innovate by combining multiple sensors along with advanced micro controllers to enhance system performance. We were one of the first sensor companies to add wireless capability so that low power, miniature digital sensors could communicate easily with personal computers and send data to the internet.

Our inclinometer product line was initially developed to measure angles of limbs to help re-animate the limbs of paralyzed individuals. The tiny, lightweight gyro-enhanced orientation modules that resulted from this effort found immediate acceptance for navigation & control of unmanned systems in military and exploratory robotics applications.

Sensors are literally changing our world; we're inspired to work with our customers to introduce advanced sensing technology that will enable the next generation of smarter and safer machines, civil structures, and implanted devices.

Thank you for purchasing a MicroStrain sensor!

Steve Arms
President and CEO, MicroStrain, Inc.

Supported Firmware and Software Versions

Device	Firmware version	Software version
EmbedSense®	1.0 and higher	EmbedSense® 1.0.1 and higher

Table 1

Guide to Relevant Documents

Device	Document
EmbedSense®	EmbedSense® User Manual
EmbedSense®	EmbedSense® Quick Start Guide

Table 2

Overview

The EmbedSense® Wireless Sensor is a specialized member of MicroStrain's wireless data acquisition systems. The EmbedSense® system comprises 4 main components: 1) passively-powered wireless sensor **Nodes** which acquire and send strain, voltage, temperature, pressure, load and/or other sensor data, 2) an **Interrogation Antenna** which powers the nodes as well as receives the sensor data, 3) a **Reader Assembly** which powers the Interrogation Antenna, digitizes the sensor data, and interfaces the host computer, and 4) software which operates the system.

The EmbedSense® Node provides two measurement channels, being 1) a differential input channel (strain channel) primarily designed to support strain gauges of 1000 ohm resistance or greater, and 2) an internal temperature sensor channel. The combination of the two measurement channels supports a wide range of Wheatstone bridge type sensors including semiconductor temperature sensors, thermocouples, strain gauges, pressure sensors, and load cells.



The EmbedSense® Node is powered passively using an 'inductive' link. The Reader Assembly provides a 125 kHz signal to the Interrogation Antenna. This signal energizes the Interrogation Antenna's coil causing the antenna to emit an AC electromagnetic field. By bringing the Interrogation Antenna into close proximity with the Node, the Node's antenna picks up this energy and uses it to power its micro-processing and sensor circuits. Actual radiated power level is very low and well within FCC Part 15.209 limitations for incidental radiators.

The EmbedSense® Node employs a 16 bit A/D converter to digitize the voltage on the differential input and temperature channels. The digital data is passed to the on-board microprocessor, processed with the embedded algorithm, and in turn passed to the Node's coil antenna for recovery by the Interrogation Antenna.

Sensor data communication between the Node and the Interrogation Antenna is accomplished by the Node shifting the tuning of its internal antenna from a reflective state to an absorptive state. The Reader Assembly sees these shifts as amplitude modulation (AM) on the power signal, converts the AM to a recovered data stream and passes the data on to the host computer.

Node powering and commands from the Reader Assembly to the Node are frequency modulated (FM) between the Interrogation Antenna and the Node.

EmbedSense® Nodes may be embedded on or under the surface of non-metallic materials. The Nodes can tolerate extreme G levels, and low and high temperatures. The Nodes may be queried for the life of the structure.

Host computer software displays the data, records the data to file, scales the data into engineering units, and allows the user to configure and actuate the system.

Installation

We suggest these three steps to install your EmbedSense® Wireless Sensor:

- 1) Place the EmbedSense® CD in your CD-ROM drive and follow the on-screen instructions to install MicroStrain's EmbedSense® software.
- 2) Remove the contents of your EmbedSense® Wireless Sensor starter kit.
 - Connect one end of the BNC cable to the BNC connector on the Interrogation Antenna.
 - Connect the other end of the BNC cable to the BNC connector on the Reader Assembly.
 - Connect one end of the serial cable to the 9-pin RS-232 port on the Reader Assembly.
 - Connect the other end of the serial cable to a 9-pin RS-232 port on your host computer.
 - Connect the 5-pin DIN connector of the power supply to the 5-pin connector on the Reader Assembly.
 - Connect the power supply to the appropriate 100-240 VAC source.
 - Observe that the **green** LED on the front panel of the Reader Assembly illuminates indicating the unit is operating.
 - Place your Node in close proximity to the Interrogation Antenna.
- 3) Follow the step-by-step instructions in the EmbedSense® *Quick Start Guide* which you will find on the CD or on our web site.

Starter Kits and Modules

EmbedSense® is available in starter kits and as individual modules.

Part Number	Model Number	Description
6303-0100	ES-125K-READER-M	ES-125K-READER-M, EmbedSense® Strain and Temperature Reader Assembly with one 125 KHz external powering/interrogation unit with power supply, interrogation coil with 3 foot cable and software.
6303-0200	ES-125K-SG1000-M	ES-125K-SG1000-M, EmbedSense® node, for 125 kHz operating frequency with cable to connect four leads to a full bridge strain measurement channel, integral MicroChip TC1047 semiconductor temperature sensor and on-board 16 bit A/D converter.
6303-0202	ES-125K-SG1000-SK2	ES-125K-SG1000-SK2, EmbedSense® Strain and Temperature Sensing starter kit. Includes two 125 kHz operating frequency EmbedSense® nodes with cable to connect four leads to a full bridge strain measurement channel, integral MicroChip TC1047 semiconductor temperature sensor and on-board 16 bit A/D converter, one EmbedSense® Strain and Temperature Reader Assembly with one 125 KHz external powering/interrogation unit with power supply, interrogation coil with 3 foot cable and software.

Table 3

Product Options

When requested by the customer, MicroStrain can supply the Nodes internally pre-configured for ½ or ¼ bridge configurations. Gain can be factory configured to values other than the standard 250 when requested by the customer. The Nodes can be factory configured for thermocouples. We can supply type K or type J lead wires as specified by the customer.

The EmbedSense® system can be customized to accommodate OEM requirements for various reader coil geometries, mechanical configuration, number of channels, sensor types, high temperatures, high G forces, and other special environmental constraints. Contact MicroStrain Sales for pricing on these options.

Examples of customized systems:

- 6 channels of type K thermocouples, 55,000 Gs, 110 degrees Celsius, ½ inch by ½ inch by ¼ inch profile.
- One way communications, single (customer supplied) thermocouple, used in closed loop machine control of heaters, 125° C maximum operating temperature, modules moving quickly on a conveyor past a fixed reader coil.
- IC temperature sensor with 0.02° C resolution and +/- 0.5° C accuracy.
- 'S' type load cell, with calibration sheet.

Common Terms

These terms are in common use throughout the manual:

- **Address:** Each node has a unique address from 1 to 65534 which identifies the node to the reader assembly and host software.
- **Bits:** The digital equivalent of voltage on the node. The node excites all sensor circuits with +3 Volts. The return from the sensor is 0 to 65535 bits (after 16-bit A/D) representing 0 to 3 volts.
- **Broadcast Address:** A reserved node address (16384) to which all active nodes will respond.
- **Interrogation Antenna:** A system component that powers the Node as well as receives the Node's sensor data.
- **Node:** A system component that is passively powered, and acquires and transmits strain, voltage, temperature, pressure, load and/or other sensor data.
- **Ping:** A byte is transmitted by the reader assembly to a particular node and the node responds by echoing the byte indicating communication exists between the reader assembly and the node.
- **Read/write EEPROM:** Commands transmitted to the node to read or write parameters stored in the node's on-board memory.
- **Reader Assembly:** A system component that powers the Interrogation Antenna, digitizes the sensor data and interfaces the host computer.
- **Streaming:** Streaming is a node action whereby both channels (and the sensors attached to them) are continuously sampled and the data acquired is transmitted to the reader assembly and software.

EmbedSense® Node

Differential Input Channel

The EmbedSense® Node has one differential input channel which presents on channel 2. This channel is designed to accommodate strain gauges with 1000 ohm resistance or greater. Using lower than 1000 ohm gauges is not recommended; range and resolution will be severely reduced. The EmbedSense® Node by default is configured to support a full Wheatstone bridge installation. The EmbedSense® Node can also be ordered from the factory configured to support half and quarter bridge installations. It is important to know how your EmbedSense® Node has been configured before proceeding with use. You may wish to check your invoice or contact MicroStrain support.

The EmbedSense® Node excites the differential input channel with +3 volts DC at up to 3 mA for bridge excitation. The circuit is designed to provide a ‘pulsed’ excitation. The circuit is excited, the strain gauge bridge is allowed to fully energize, the sample is taken and the circuit de-excites. This implementation produces 30 Hz sampling.

Reference is made to the *Electrical Block Diagram* elsewhere in this manual. An instrumentation amplifier is in-line between the strain gauge bridge and the A/D converter. Gain is factory adjustable between 1 and 1000; by default, the Node is shipped with gain set at 250 v/v.

Reference is made to Figure 1 below. To determine output readings versus input values, use the following data:

$$\text{Bits}_{\text{out}} = (\text{gain} * \text{bits_full_scale}) * V_{\text{input}} + \text{Offset}; = ((250 * 65535) * V_{\text{input}}) + 32768$$

where V_{input} is the differential voltage on the green and white wires. For example, if the bridge unbalance is +0.001 volts, the output would be 49152 bits. Full scale is +/- 0.002 volts in this example. Zero volts input will return a bit value of 32768.

To solve for input voltage:

$$V_{\text{input}} = (\text{bits_reading} - 32768) / 16383750$$

It is expected that users will calibrate the differential input channel conducting a shunt calibration using a precision resistor or by applying a known load(s) to the strain gauge bridge. Offset may be removed by manually balancing the strain gauge bridge with user-supplied external resistors.

Finally, the science and use of strain gauges is a large subject. MicroStrain sales and support are always available to discuss your particular requirements.

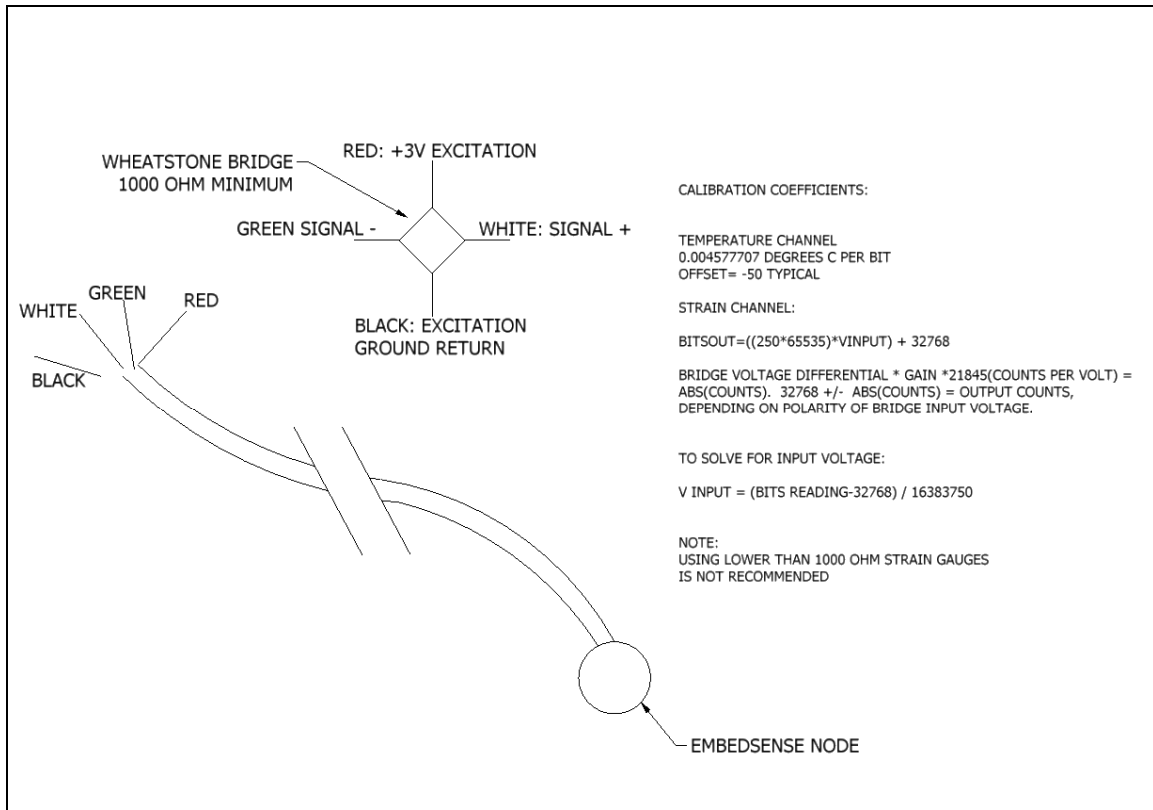


Figure 1

Temperature Sensor Channel

General Information

- The EmbedSense® Node has an on-board, solid state temperature sensor mounted internally on the surface of the circuit board.
- The temperature sensor output is presented on channel 1 of the EmbedSense® Node.
- The temperature sensor has a measurement range of -40° to +125° C range.

In use with EmbedSense® software

The Node temperature sensor outputs 0.004577707° C per bit with a typical offset of -50. The EmbedSense® software uses and any other application should use these coefficients to calculate temperature from this internal temperature sensor.

Interrogation Antenna and Node

The EmbedSense® system cannot communicate power or data through metal barriers or with metals near the Interrogation Antenna or Node. It is recommended that a minimum of 2 inches be left between the Node and/or Interrogation Antenna and any metallic structures. In very carefully controlled and limited circumstances, this system can communicate through some types of metal barriers. MicroStrain engineering can assist on a case by case basis with applications requiring communications through metal structures. There are typically many caveats and much customization may be necessary to accommodate these applications.

Standard Enclosures

The **Reader Assembly** standard enclosure is flame retardant ABS plastic. It is a 2 part assembly with base and removable cover and a temperature range of 0 to 70° C. It is custom manufactured for MicroStrain. Please see the *General Specifications* section of this manual for dimensions.

The **Interrogation Antenna** standard enclosure is Delrin® plastic. It has no disassembly and a temperature range of 0 to 70° C. It is custom manufactured for MicroStrain. Please see the *General Specifications* section of this manual for dimensions.

The **Node** standard enclosure is made with epoxy. It has no disassembly and a temperature range of -40 to 125° C. It is custom manufactured for MicroStrain. Please see the *General Specifications* section of this manual for dimensions.



Figure 2

General Specifications

Number Input Channels	2 Channels. 1 differential input and 1 internal temperature sensor (Other configurations available as custom options)
Input Amplifier	Instrumentation amp, 110 dB CMRR, standard gain 250, factory options from 1 to 1000
Bridge Excitation	3 VDC, regulated to 0.1%, up to 3 mA at 3 VDC available
Sensor Types	Piezoresistive bonded foil & semiconductor strain gauges, pressure/load/torque transducers, thermocouples
A/D Converter	16 bit resolution successive approximation type (standard) Other configurations available as custom options
Identification (ID)	User programmable, 16 bits
Update Rates	30 Hz/channel w/ 125 kHz operating frequency, 16 bit A/D Other configurations available as custom options
Communication Method	Switched reactance, pulse code modulated serial (RS-232), clocked synchronous
Coil-to-coil Separation	Sensor dependent, 37mm minimum, 50mm typical
EmbedSense® Power	200 microamperes at 3 VDC, not including bridge excitation
Operating Temperatures	-40°C to +125°C
Operating G Levels	Independently tested to 50,000 <i>g</i>
Dimensions	Reader Assembly: 200mm length x 160mm (width) x 67mm (height) Interrogation Antenna: 115mm (diameter) x 40mm (height) Embeddable Node: 36mm (diameter) x 7mm (height)
Weight	Reader Assembly: 567 grams Interrogation Antenna: 221 grams Embeddable Node: 17 grams Starter Kit including Reader Assembly, Interrogation Antenna, 2 Embeddable Nodes, cables and power supply: 1910 grams

Table 4

Mechanical Drawings

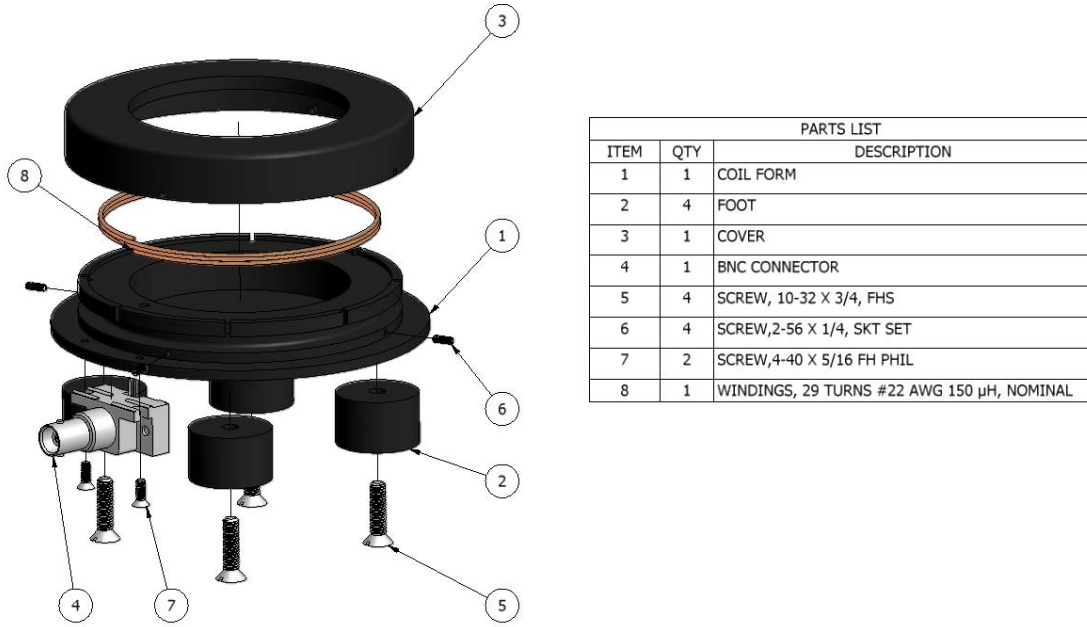


Figure 3

Electrical Block Diagram

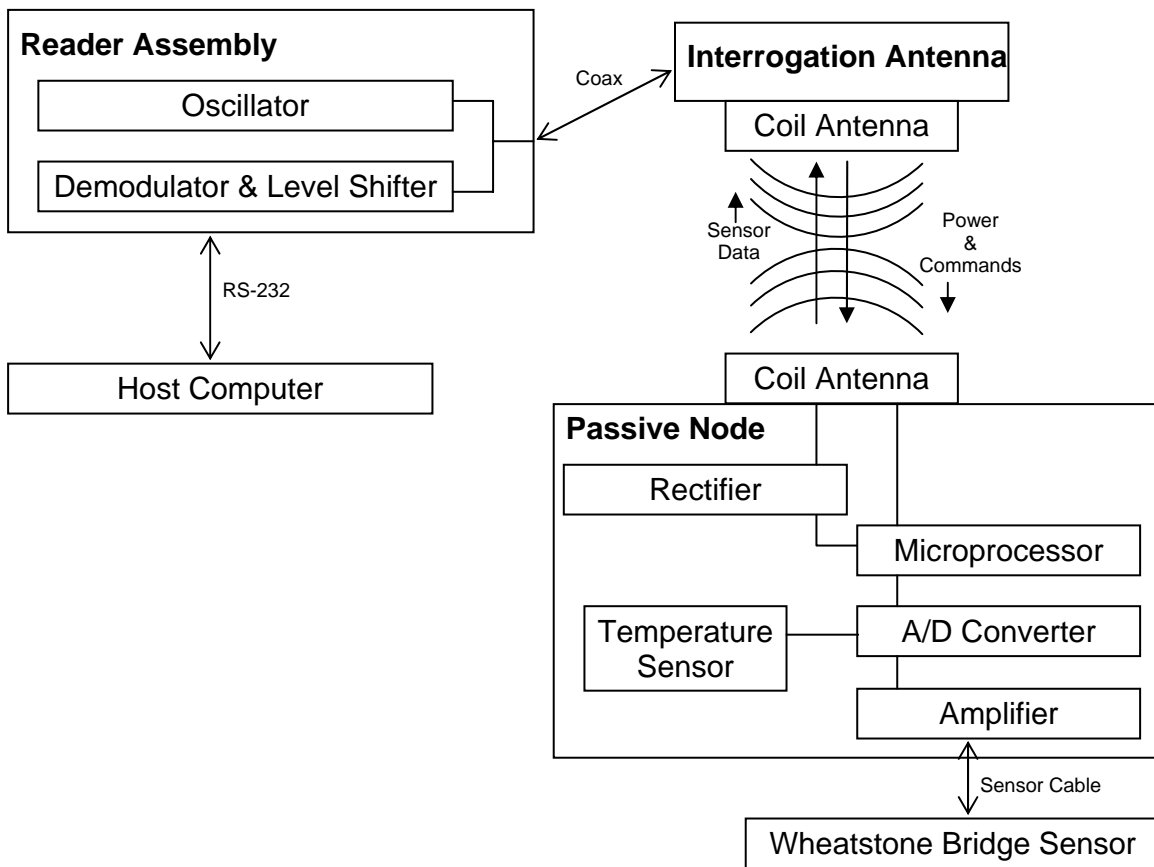


Figure 4

Software

Standard Offering

Each EmbedSense® starter kit is shipped with a CD containing EmbedSense® software. This software supports all the capabilities of the EmbedSense® Wireless Sensor including streaming, pinging, EEPROM reading/writing, configuration, data file saving, real-time sensor display and other features.

System Requirements

To use the EmbedSense® software, your computer must have the following minimum specifications:

- 1 GHz CPU
- Microsoft® Windows XP Professional SP2 operating system
- CD-ROM drive
- Video resolution 800 X 600
- 32MB video card
- Minimum of 256MB of memory
- Minimum of 50MB of free hard disk space for application
- Microsoft®-compatible mouse
- Serial port or USB-to-Serial adapter

Software Installation

- Place the EmbedSense® CD in your CD-ROM drive and follow the on-screen instructions to install MicroStrain's EmbedSense® software.
- A *Quick Start Guide* is provided on the CD to get you up and running.

Data Communications Protocol

Customers and/or developers wishing to develop their own applications for the EmbedSense® Wireless Sensor should contact MicroStrain support engineers for details on the command set.

Support

Overview

- MicroStrain is committed to providing timely, knowledgeable, world-class support to its customers.
- We are open 24 X 7 through our web portal.
- We make every attempt to respond to your email the same business day.
- We are always available by telephone during business hours.
- We provide in-depth FAQs, manuals, quick start guides and technical notes.
- Firmware and software upgrades are made available on-line as they become available.
- Code samples in several languages are posted to aid your development.
- We support our customers as we would want to be supported.

Web

Our home page is at URL: www.microstrain.com

Our support page is at URL: http://www.microstrain.com/support_overview.aspx

Email

MicroStrain's Support Engineers make every attempt to respond to emails requesting product support within the same business day. The more detail you can provide, the quicker we will be able to understand your issues and find solutions. Data files, pictures, screen grabs, etc. are all very helpful in generating a well-thought-out solution.

Please email us at: support@microstrain.com

Telephone

MicroStrain's Support Engineers are available by phone Monday through Friday 9:00AM to 5:00PM local time. When calling MicroStrain, indicate to the receptionist that you are calling for product support and you will be promptly routed to a Support Engineer. Please have your equipment ready to test. Every attempt will be made to solve issues while you are on the line.

1.800.449.DVRT(3878) Toll Free in US

1.802.862.6629 telephone

1.802.863.4093 fax

Local time = GMT -05:00 (Eastern Time US & Canada)

SKYPE

MicroStrain's Support Engineers are available by SKYPE Monday through Friday 9:00AM to 5:00PM local. SKYPE name: **microstrain.wireless.support**

RMA

Warranty Return

As described in our 1 Year Warranty contained in the Terms and Conditions stated elsewhere in this manual, MicroStrain will incur for its own account any cost to repair/replace a MicroStrain product covered under the warranty.

Non-warranty Return

All non-warranty repairs/replacements will receive a minimum charge. The minimum charge for standard wireless, displacement and orientation products is US\$75.00. The minimum charge for non-standard or custom products is US\$150.00. If the repair/replacement charge exceeds the minimum, the minimum is folded into the total repair/replacement cost.

General Instructions

In order to return any MicroStrain product, you must contact us for a Return Merchandise Authorization number (RMA#). Call toll free (800) 449 3878 to obtain an RMA# from a MicroStrain representative.

All returned merchandise must be in the original packaging including manuals, accessories, cables, etc. with the authorization (RMA#) clearly printed on the outside of the package.

MicroStrain is not responsible for shipping costs (from and to the customer) or damage on returned items. Units to be returned should be packed carefully. Please be advised that packages sent by normal US Postal Service cannot be tracked to ensure delivery. Since MicroStrain cannot provide credit for a return without confirming its receipt, we recommend that you use a delivery service that can be tracked and or insured.

Normal turn-around for RMA items is 7 days from receipt of item by MicroStrain.

30 Day Return Policy

All stock product orders from MicroStrain may be returned within 30 days for a full refund. In order to return or exchange all or part of your order, you must contact us for a Return Merchandise Authorization number (RMA#). Call toll free (800) 449 3878 to obtain an RMA# from a MicroStrain representative.

All returned merchandise must be in the original packaging including manuals, accessories, cables, etc. with the authorization (RMA#) clearly printed on the outside of the package. Return requests must be made within 30 days of the receipt date. All free items must be returned together with purchased items in order to receive a full refund. Any shipping and/or handling charges on the original order cannot be refunded. At our discretion, we may levee a restocking fee of 15% of the cost of items returned.

MicroStrain is not responsible for shipping costs or damage on returned items. Units to be returned should be packed carefully. Please be advised that packages sent by normal US Postal Service cannot be tracked to ensure delivery. Since MicroStrain cannot provide credit for a return without confirming its receipt, we recommend that you use a delivery service that can be tracked and or insured.

A 30 Day Return must be initiated by receiving an RMA from MicroStrain.

Terms and Conditions

1. Acceptance of MicroStrain Inc's. Terms and Conditions. By placing an order with MicroStrain, Inc. ("MicroStrain"), Buyer agrees to be bound by these Terms and Conditions of Sale and Software License, if applicable. MicroStrain will not be bound by any of other terms and conditions, regardless of whether Buyer tenders terms and conditions with an order or otherwise and these terms and condition of sale prevail over any conflicting or additional terms of any quote, order, previous agreement, acknowledgment or similar communications between the parties. These Terms and Conditions supersede all prior or contemporaneous oral or written communications, proposals and representations with respect to its subject matter. The term "Products" includes collectively all physical products, Software and Embedded Software (as defined herein).

2. Pricing. All prices are quoted in US dollars, unless otherwise explicitly stated and are valid for ninety (90) days. You shall be responsible for the payment of all shipping charges, costs of freight, taxes, import fees, insurance, duties, value added taxes, and the like. Our minimum order is one hundred (\$100.00) dollars, excluding all additional charges, including shipping, taxes and the like.

3. Payment: Payment shall be made in advance, in U.S. dollars, by credit card, bank draft or letter of credit, unless otherwise agreed in writing by MicroStrain. At the sole discretion of MicroStrain, credit terms of net 30 days up to a pre-approved limit may be offered to buyer. A late payment charge of one and a half (1.5%) percent per month, or the maximum percentage rate permitted by law, if lower, shall be charged on all past due balances. Buyer agrees to pay all costs incurred by MicroStrain including, but not limited to, collection fees, court costs and attorney fees, associated with collection of past-due balance.

4. Shipping Terms. All Products delivered to you by us, shall be F.O.B. our distribution center, with risk of loss passing to you upon our delivery of the Products to a common carrier. MicroStrain will arrange payment for shipping and insurance with the carrier, but such costs are the responsibility of Buyer. Delivery times quoted are estimates only and MicroStrain shall not be liable for delays in delivery.

5. Acceptance & Returns. Shipments shall be deemed to have been accepted by the buyer upon receipt of shipment. Any discrepancy in shipment quantity must be reported within five (5) days of receipt of shipment. Buyer may return starter kits or evaluation units for any reason within thirty (30) days of the date of shipping from MicroStrain. All other returns shall be subject to a restocking fee of the greater of twenty-five (25%) percent of the invoiced amount of the returned products or one hundred (\$100.00) dollars. To qualify for a credit or refund (excluding shipping, duties or taxes), Buyer must contact MicroStrain in writing for a Return Merchandise Authorization (RMA). All Product returns shall comply with MicroStrain's Return Merchandise Authorization (RMA) policies. Custom Products and modifications of standard Products are not eligible

for return. All returns must be shipped by Buyer to MicroStrain C.I.F. our distribution center as provided in the RMA policies provided by MicroStrain.

6. Compliance with Laws, Rules & Regulations. i.) Products sold may be exported from the United States of America only in accordance with US Export Administration Regulations and diversion contrary to US law is prohibited. Buyer acknowledges that it is eligible to receive Products under US law and agrees to abide by all export or re-export restrictions. ii.) Buyer acknowledges and recognizes that Buyer shall be wholly responsible for compliance with any laws, rules and regulations pertaining to the use of any Product(s) which is incorporated into a Buyer product should such governmental approval be required for research, testing or commercial use.

7. Software License. The following terms and conditions are applicable to either MicroStrain software delivered with a Product, the software portion of the Product (“Software”) or software which is embedded in a Product (“Embedded Software”). MicroStrain grants to Buyer a non-exclusive paid-up license to use one copy of the Software on one computer, subject to the following provisions: Except as otherwise provided in this Software License, applicable copyright laws shall apply to the Software and Embedded Software. Title to the medium on which the Software is recorded or stored is transferred to Buyer, but not title to the Software or the Embedded Software. Buyer may use Software on a multi-user or network system only if either, the Software is expressly labeled to be for use on a multi-user or network system, or one copy of the Software is purchased for each node or terminal on which Software is to be used simultaneously. Buyer shall not use, make, manufacture, or reproduce copies of Software or Embedded Software. Buyer may use a copy of the Software on one computer, and is permitted to make additional copies of the Software only for backup or archival purposes. Customer is expressly prohibited from disassembling or reverse engineering the Software or Embedded Software. All copyright notices shall be retained on all authorized copies of the Software and Embedded Software.

8. Limited Warranty. MICROSTRAIN WARRANTS i) ALL PRODUCTS (EXCEPT SPARE PARTS OR REPLACEMENT PARTS AND SPARE KITS) FOR A PERIOD OF ONE (1) YEAR, AND ii) ALL SPARE PARTS OR REPLACEMENT PARTS AND SPARE KITS FOR A PERIOD OF NINETY (90) DAYS, WHICH ARE MANUFACTURED BY MICROSTRAIN SHALL BE FREE FROM MATERIAL DEFECTS IN WORKMANSHIP AND MATERIALS FROM THE DATE OF DELIVERY TO THE CUSTOMER. THIS WARRANTY EXTENDS ONLY TO THE ORIGINAL CUSTOMER OF MICROSTRAIN, AND IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, WHETHER OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR USE, AND OF ALL OTHER OBLIGATIONS AND LIABILITIES OF ANY KIND OR CHARACTER WHICH MAY OTHERWISE APPLY. EXCEPT FOR THE WARRANTY DESCRIBED HEREIN, MICROSTRAIN EXPRESSLY DISCLAIMS ALL WARRANTIES OF MERCHANTABILITY OF THE GOODS OR OF FITNESS FOR ANY PURPOSE. THERE ARE NO OTHER WARRANTIES EXPRESS OR IMPLIED EXCEPT THOSE SPECIFICALLY PROVIDED FOR HEREIN. BY

ACCEPTING THE PRODUCTS FROM MICROSTRAIN, THE BUYER ACKNOWLEDGES AND AGREES: i) THAT THE INHERENT VALUE OF THE PRODUCTS ARE UNRELATED TO THE VALUE OR COST OF ANY PROPERTY IN CONNECTION WITH WHICH THE PRODUCTS MAY BE USED AND THAT MICROSTRAIN MAKES NO WARRANTY THAT THE PRODUCTS WILL AVERT, DETECT OR PREVENT OCCURRENCES OR THE CONSEQUENCES THEREFROM WHICH THE PRODUCTS ARE DESIGNED TO DETECT OR AVERT, OR THAT THE PRODUCTS MAY NOT BE COMPROMISED, DISABLED OR CIRCUMVENTED; ii) THAT MICROSTRAIN HAS MADE NO CONTRARY REPRESENTATIONS OR WARRANTIES OF ANY KIND, EXPRESS OR IMPLIED, TO OR FOR THE BENEFIT OF CUSTOMER; and, iii) THAT ANY NUMBER OF CAUSES MAY CAUSE A “FALSE ALARM” OR “FALSE READING” FROM MICROSTRAIN’S PRODUCTS, AND THAT MICROSTRAIN DOES NOT WARRANT AGAINST SUCH FALSE RESULTS. BUYER REPRESENTS, WARRANTS AND INDEMNIFIES MICROSTRAIN FOR ANY AND ALL LIABILITY PERTAINING TO THE USE OF PRODUCTS INCORPORATED INTO OR OTHERWISE USED IN A BUYER PRODUCT.

9. Limited Software Warranty. MicroStrain warrants that, the software portion of the Product (“Software”), where applicable, will substantially conform to MicroStrain’s then current functional specifications for the Software, as set forth in the applicable documentation, from the date of original retail purchase of the Software for a period of ninety (90) days (“Software Warranty Period”), provided that the Software is properly installed on approved hardware and operated as contemplated in its documentation. MicroStrain further warrants that, during the Software Warranty Period, the magnetic media on which MicroStrain delivers the Software will be free of physical defects. MicroStrain’s sole obligation shall be to replace the non-conforming Software (or defective media) with software that substantially conforms to MicroStrain’s functional specifications for the Software or to refund at MicroStrain’s sole discretion. Except as otherwise agreed by MicroStrain in writing, the replacement Software is provided only to the original licensee, and is subject to the terms and conditions of the license granted by MicroStrain for the Software. Software will be warranted for the remainder of the original Software Warranty Period from the date of original purchase. If a material non-conformance is incapable of correction, or if MicroStrain determines in its sole discretion that it is not practical to replace the non-conforming Software, the price paid by the original licensee for the non-conforming Software will be refunded by MicroStrain; provided that the non-conforming Software (and all authorized copies thereof) is first returned to MicroStrain. The license granted respecting any Software for which a refund is given automatically terminates.

10. Limitation of Liability. IN NO EVENT SHALL THE MICROSTRAIN BE LIABLE FOR SPECIAL, DIRECT, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO LOSS OF PROFIT OR OPPORTUNITY, OR SIMILAR DAMAGES WHICH MAY ARISE IN CONNECTION WITH ANY OF MICROSTRAIN’S PRODUCTS. BUYER’S SOLE AND EXCLUSIVE REMEDY SHALL IN NO EVENT EXCEED THE REPAIR,

REPLACEMENT OR COST OF THE SPECIFIC PRODUCT PURCHASED FROM MICROSTRAIN AS PROVIDED IN THE WARRANTY PERIOD.

11. Warranty Repair. MicroStrain's sole obligation shall be to repair or replace the defective Product during the applicable Warranty Period at no charge to the original owner or to refund at MicroStrain's sole discretion. Such repair or replacement will be rendered by MicroStrain. The replacement Product need not be new or have an identical make, model or part. MicroStrain may in its sole discretion replace the defective Product (or any part thereof) with any reconditioned Product, or similar Product, that MicroStrain reasonably determines is substantially equivalent (or superior) in all material respects to the defective Product. Repaired or replacement Products will be warranted for the remainder of the original applicable Warranty Period from the date of original purchase. If a material defect is incapable of correction, or if MicroStrain determines in its sole discretion that it is not practical to repair or replace the defective Product, the price paid by the original purchaser for the defective Product will be refunded by MicroStrain upon return to MicroStrain of the defective Product. All Products (or parts thereof) that is replaced by MicroStrain, or for which the purchase price is refunded, shall become the property of MicroStrain upon replacement or refund.

12. Non-Applicability of Warranty. The Limited Warranty provided hereunder for Products will not be applied to and does not cover any refurbished product and any Product purchased through an inventory clearance or liquidation sale or other sales in which MicroStrain, the sellers, or the liquidators expressly disclaim their warranty obligation pertaining to the Product and in that case, the Product is being sold "As-Is" without any warranty whatsoever including, without limitation, the Limited Warranty as described herein, notwithstanding anything stated herein to the contrary.

13. Submitting A Claim. The customer shall return the Product to the original purchase point based on its return policy. In case the return policy period has expired and the Product is within warranty, the customer shall submit a claim to MicroStrain as follows: i) The customer must submit with the Product as part of the claim a written description of the Product defect or Software nonconformance in sufficient detail to allow MicroStrain to confirm the same; ii) The original Product owner must obtain a Return Material Authorization ("RMA") number from MicroStrain and, if requested by MicroStrain, provide written proof of purchase of the Product (such as a copy of the dated purchase invoice for the Product) before the warranty service is provided; iii) After an RMA number is issued, the defective Product must be packaged securely in the original or other suitable shipping package to ensure that it will not be damaged in transit, and the RMA number must be prominently marked on the outside of the package. Do not include any manuals or accessories in the shipping package. MicroStrain will only replace the defective portion of the Product and will not ship back any accessories; iv) The customer is responsible for all in-bound shipping charges to MicroStrain. No Cash on Delivery ("COD") is allowed. Products sent COD will either be rejected by MicroStrain or become the property of MicroStrain. Products shall be fully insured by the customer. MicroStrain will not be held responsible for any packages that are lost in transit to MicroStrain. The repaired or replaced packages will be shipped to the customer via UPS Ground or any

common carrier selected by MicroStrain, with shipping charges prepaid. Expedited shipping is available if shipping charges are prepaid by the customer and upon request; v) Return Merchandise is to be shipped to MicroStrain, Inc. at the address indicated below; vi) MicroStrain may reject or return any Product that is not packaged and shipped in strict compliance with the foregoing requirements, or for which an RMA number has not been obtained or is not visible from the outside of the package. The Product owner agrees to pay MicroStrain's reasonable handling and return shipping charges for any Product that is not packaged and shipped in accordance with the foregoing requirements, or that is determined by MicroStrain not to be defective or non-conforming.

14. What Is Not Covered. This Limited Warranty provided by MicroStrain does not cover: Products, if in MicroStrain's sole and exclusive judgment, have been subjected to abuse, accident, alteration, modification, tampering, negligence, misuse, faulty installation, lack of reasonable care, repair or service in any way that is not contemplated in the documentation for the Product, or if the model or serial number has been altered, tampered with, defaced or removed; Initial installation, installation and removal of the Product for repair, and shipping costs; Operational adjustments covered in the operating manual for the Product, and normal maintenance; Damage that occurs in shipment, due to acts of God, failures due to power surge, and cosmetic damage; Any hardware, software, firmware or other products or services provided by anyone other than MicroStrain; or, Products that have been purchased from inventory clearance or liquidation sales or other sales in which MicroStrain, the sellers, or the liquidators expressly disclaim their warranty obligation pertaining to the Product. Repair by anyone other than MicroStrain will void this Warranty.

15. Copyright Statement. No part of this publication or documentation accompanying any Product may be reproduced in any form or by any means or used to make any derivative such as translation, transformation, or adaptation without permission from MicroStrain as stipulated by the United States Copyright Act of 1976, as amended. Contents are subject to change without prior notice. Copyright© 2007 by MicroStrain, Inc. All rights reserved.

16. Choice of Law. These terms and any agreement between MicroStrain and buyer shall be interpreted in accordance with the substantive laws of the State of Vermont, USA, and without regard to its choice of law provisions. Any action to enforce any such terms shall be exclusively in the courts of competent jurisdiction in Chittenden County, Vermont. Any legal action between MicroStrain and buyer shall be decided by a court, acting without a jury.

17. Disclaimer of U.N. Sale of Goods. The United Nations Convention on Contracts for the International Sale of Goods is specifically disclaimed.

18. Force Majeure. Except for the obligations to make payments, neither party shall be bound to meet any obligation if prevented from doing so as a consequence of force majeure. If a situation of force majeure lasts for more than ninety (90) days, the Parties

shall be entitled to terminate this Agreement by canceling it in writing, without any rights to compensation of damages or refunds.

19. No Assignment. This Agreement, and any Licenses or the Software may not be assigned, sublicensed, leased, sold or otherwise transferred without prior written consent from MicroStrain, and any unauthorized transfer is null and void. This agreement and any licenses granted is personal to you and can be used for personal or internal business use only and may not be used on behalf of a client or customer.

20. Notice. All notifications and communications relating to this Agreement shall be made by the parties to the other party, in writing and shall be signed by a person duly authorized to provide such notice.

21. Entire Agreement. This Agreement shall constitute the entire Agreement between buyer and MicroStrain and shall not be modified or rescinded, except in writing, signed by buyer and MicroStrain. The provisions of this Agreement supersede and precede all prior oral and written quotations, communications, agreements and understandings of the parties. Products and services rendered by MicroStrain are done so only in accordance with these Terms and Conditions of Sale. If any provisions within these terms and conditions are found to be invalid by any court having competent jurisdiction, the invalidity of such provisions shall not affect the validity of the remaining provisions of these terms and conditions, which shall remain in full force and effect.

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