

TC-Link[®]

Wireless Thermocouple Node



©2009 by MicroStrain, Inc.
459 Hurricane Lane, Suite 102
Williston, VT 05495
Phone 802-862-6629
Fax 802-863-4093
www.microstrain.com
support@microstrain.com

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Welcome

Steve Arms, President and CEO



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!

Overview

The TC-Link® is a wireless thermocouple node and is a specialized member of MicroStrain's Wireless Sensing Systems. The Wireless Sensing Systems comprise 3 main components: 1) sensor nodes which acquire and transmit strain, voltage, temperature, acceleration and/or other sensor data, 2) base stations which receive and pass the data to a host, and 3) software which operates the system.

The TC-Link® supports thermocouple types J, K, R, S, T, E, B, N and accommodates up to 6 separate thermocouples at a time. The TC-Link® also has an optional on-board relative humidity sensor.

The TC-Link® employs a high resolution 24 bit Delta-Sigma A/D converter to digitize the thermocouple and relative humidity sensor voltage. The thermocouple digital data is processed by a sophisticated algorithm using NIST polynomial coefficients to produce temperature.



The TC-Link® samples, processes and time-stamps the thermocouple and relative humidity sensor data and transmits it over the air to the base station. The base station is connected to a host computer and is controlled by the user through software.

Host computer software displays the data, provides analysis tools, records the data to file and allows the user to configure and actuate the system.

The TC-Link® may be deployed up to 70 meters (line-of-sight) from its base station, 100 meters or more with added antenna options.

The TC-Link® has a long life battery and may be remotely deployed in any number of applications including bridges, machinery, cold storage facilities, aircraft, production lines and the like.

Multiple TC-Link®'s may be deployed around a single base station, each transmitting its data to the base station coincidentally, with the data being passed on to the software for aggregation.

Starter Kits, Modules and Options

The TC-Link® is available in starter kits, as individual modules and with options.

6310-1000	TC-LINK-6CH-2400-M	TC-LINK-6CH-2400-M, TC-LINK wireless thermocouple node. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.
6310-1011	TC-LINK-6CH-2400-SKA	TC-LINK-6CH-2400-SKA, TC-LINK starter kit includes one TC-LINK wireless thermocouple node, one analog/digital output base station with power supply, charger and Agile-Link software. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.
6310-1041	TC-LINK-6CH-2400-SK1	TC-LINK-6CH-2400-SK1, TC-LINK starter kit includes one TC-LINK wireless thermocouple node, one USB base station, charger and Agile-Link software. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.
6310-1042	TC-LINK-6CH-2400-SK2	TC-LINK-6CH-2400-SK2, TC-LINK starter kit includes two TC-LINK wireless thermocouple nodes, one USB base station, charger and Agile-Link software. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.
6310-2000	TC-LINK-6CH-2400-RH-M	TC-LINK-6CH-2400-RH-M, TC-LINK six channel wireless thermocouple node with RH sensor. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.
6310-2011	TC-LINK-6CH-2400-RH-SKA	TC-LINK-6CH-2400-RH-SKA, TC-LINK six channel starter kit includes one TC-LINK six channel wireless thermocouple node with RH sensor, one analog/digital output base station with power supply, charger and Agile-Link software. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.

6310-2041	TC-LINK-6CH-2400-RH-SK1	TC-LINK-6CH-2400-RH-SK1, TC-LINK six channel starter kit includes one TC-LINK six channel wireless thermocouple node with RH sensor, one USB base station, charger and Agile-Link software. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.
6310-2042	TC-LINK-6CH-2400-RH-SK2	TC-LINK-6CH-2400-RH-SK2, TC-LINK six channel starter kit includes two TC-LINK six channel wireless thermocouple nodes with RH sensor, one USB base station, charger and Agile-Link software. Operates on 2.4 GHz direct sequence spread spectrum, IEEE 802.15.4 radio.

Table 1

Installation

We suggest these three steps to install your TC-Link®.

- 1) Install the TC-Link® Node Monitor software by following the directions given in the *Software Installation* section of this manual.
- 2) Remove the contents of your TC-Link® starter kit.
 - Install the antenna on the base station antenna connector. Tighten hand tight; do not over tighten.
 - If you have a serial base station (see Figure 1), connect the RS-232 cable to a serial port on your PC and to the serial base station RS-232 connector. Connect the external power supply to the power connector on the serial base station and plug it into a proper power receptacle. Turn the serial base station power switch on and the green LED will illuminate indicating the base station is powered
 - If you have a USB base station, plug the USB connector into any USB port on your PC. The blue LED will illuminate indicating the base station is powered.
 - If you have an analog base station, connect the USB cable to any USB port on your PC and to the analog base station USB connector on the back panel. Connect the external power supply to the power connector on the back panel of the analog base station and plug it into a proper power receptacle. Depress the red power button on the front panel and the green LED will illuminate indicating the base station is powered.



Figure 1

- Turn off the TC-Link® and connect the external power supply barrel connector into the TC-Link® and plug the cable into a proper power receptacle. The red LED to the left of the barrel connector will illuminate indicating that the internal battery is charging. When the red LED goes out and the green LED illuminates, full charge has been reached. Remove the power supply and turn the TC-Link® on. You will notice a momentary flashing of the green LED to the left of the switch indicating that the TC-Link® has booted up. The LED will begin to flash every 1 second which is the default sampling rate.
- 3) Follow the step-by-step instructions in the TC-Link® *Quick Start Guide* which you will find on the CD or on our web site.

Operation

Let's first look at how the TC-Link® itself operates. Reference is made to the *Electrical Block Diagram* contained elsewhere in this manual. The voltage generated by thermocouples is captured by the TC-Link® and fed into the 24 bit Delta-Sigma analog-to-digital (A/D) converter. This A/D converter has an accuracy of ~2 parts per million, thereby providing a very high resolution measurement of the thermocouple voltage. The differential voltage generated by the relative humidity sensor is also fed into the same A/D process. The TC-Link® also feeds the differential voltage generated by the cold junction compensation temperature sensor into the A/D. These voltages are digitized and passed to the TC-Link®'s microprocessor.

The microprocessor and its embedded algorithm process the thermocouples' digital signal into temperature. Using a sophisticated library of NIST-published polynomial coefficients ⁽¹⁾ maintained on-board the TC-Link®, thermocouple voltage is scaled into °C (degrees Celsius). The algorithm additionally uses the cold junction compensation temperature to correct the error generated at the thermocouple connectors by the mating of dissimilar metals. At the same time, the relative humidity is calculated using the OEM's scaling. When a sweep across the active channels is completed processing, a real-time on-board clock time-stamps the data.

The time-stamped data is next passed either to the on-board flash memory for storage and later download, or passed to the 2.4 GHz transceiver (radio) for immediate transmission, or both.

Looking at the larger system, the host side software and base station work in conjunction to communicate with the TC-Link®. The user employs the software to configure the TC-Link® with such parameters as sampling rate, number of active channels, datalogging on/off, etc. When instructed, the software and the base station go into sampling mode and await transmissions from the TC-Link®. As the TC-Link® generates and transmits data, the base station receives and passes the data onto the software. The software in turn displays and saves the data to file.

⁽¹⁾ <http://srdata.nist.gov/its90/main/>

Thermocouple Support

The TC-Link® supports thermocouple types J, K, R, S, T, E, B, N and accommodates up to 6 separate thermocouples at a time.

Note: Thermocouple types can not be mixed during operation. The TC-Link® can only support the same thermocouple type at any given time.

The TC-Link® may be set to capture 3 ranges of temperature for each thermocouple type. The table below shows these ranges.

Type	Range	Minimum Temp in °C	Maximum Temp in °C
J	Wide	-210	760
J	Standard	-210	650
J	Narrow	-170	170
K	Wide	-200	1370
K	Standard	-200	880
K	Narrow	-200	220
R	Wide	-50	1664
R	Standard	-50	1000
R	Narrow	-50	890
S	Wide	-50	1664
S	Standard	-50	1664
S	Narrow	-50	960
T	Wide	-200	400
T	Standard	-200	400
T	Narrow	-190	190
E	Wide	-200	1000
E	Standard	-200	490
E	Narrow	-100	140
B	Wide	250	1820
B	Standard	250	1820
B	Narrow	250	1410
N	Wide	-200	1300
N	Standard	-200	990
N	Narrow	-200	290

Table 2

The TC-Link® is designed to accept thermocouples via its 6 female connectors mounted side-by-side on the sidewall of the unit. These female connectors accept male mini (or miniature) flat pin connectors as pictured below.



Figure 2



Figure 3

Relative Humidity Sensor

The TC-Link® has an optional relative humidity sensor which comes installed ported out the side wall of the enclosure. The port is covered by a filter cap which protects against water, dust and other contaminants.

The relative humidity sensor has a manufacturer stated Measurement Range of 0-100% RH.

The relative humidity sensor has a manufacturer stated Absolute RH Accuracy of +/-3% RH.

The relative humidity sensor is manufactured by Sensirion and is model SHT11.

http://www.sensirion.com/en/02_sensors/03_humidity/00_humidity_temperature_sensor/02_humidity_sensor_sht11.htm

The relative humidity sensor filter cap is manufactured by Sensirion and is model SF1.

http://www.sensirion.com/en/02_sensors/03_humidity/00_humidity_temperature_sensor/04_humidity_sensor_sht1x_filter_cap.htm

LEDs

The TC-Link® has 3 LEDs indicators.

Charging LED

The **red** Charging LED illuminates when the external power supply is connected and continues to illuminate while the internal battery charging circuit is active. When the internal battery is fully charged, the LED turns off in favor of the **green** Charge Completed LED. The **red** Charging LED will also turn off if the external power supply is removed prior to full charge.

Charge Completed LED

The **green** Charge Completed LED will illuminate only during a charging session and only when the battery is fully charged. The **green** Charge Completed LED will turn off if the external power supply is removed.

Device Status LED

The **green** Device Status LED indicates the current state of the TC-Link®. When the TC-Link® is switched on, the green Device Status LED will rapidly flash several times and in a moment, begin ‘blipping’ (flashing the LED) every 2 seconds. The rapid flashes indicate a successful boot-up. The blipping indicates that the TC-Link® is active, sampling and transmitting its thermocouple data with every blip. The data sampling rate (and therefore the blip) is 2 seconds by default. As described elsewhere in this manual, if the sampling rate is changed, the **green** Device Status LED will blip accordingly. When the TC-Link® has been ‘awakened’ for configuration (see the *Quick Start Guide*), the LED will begin an ‘on-off throb’; gradually come on and then go off, continuously. No sampling and data transmission occurs during this state. When the TC-Link® is instructed to sample again, the blipping will again start.

LED activity other than as detailed above is a strong indicator of fault.

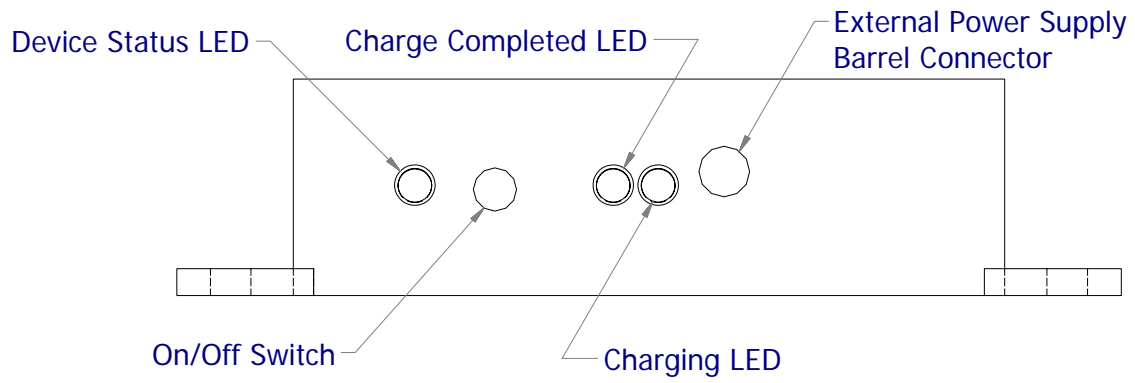


Figure 4



Figure 5

Radio and Antenna

The TC-Link® employs a 2.4 GHz IEEE 802.15.4 Compliant and ZigBee™ Ready RF Transceiver to communicate with the Wireless Sensing Systems base stations. The base stations contain the same transceiver. The radio complies with ETSI EN 300 328, EN 300 440 class 2, FCC CFR-47 part 15 and ARIB STD-T66. The radio is license free worldwide.

The radio is a spread spectrum radio and can be configured to operate on any of 16 separate frequencies ranging from 2.405 GHz to 2.480 GHz. The TC-Link® is shipped with its frequency set at 2.475 GHz (default). The Wireless Sensing Systems family aliases these frequencies as channel 11 through channel 26 and the TC-Link® default setting is equivalent to channel 25.

The TC-Link® has a 2.4 GHz omni-directional “chip” antenna mounted on the surface of its circuit board (inside the enclosure). There is no external antenna mast extending from the body of the enclosure.

The stated range for the TC-Link® is up to 70 meters line-of-sight from its base station. An optional high gain antenna may be added to the base station to increase the range up to 100 meters line-of-sight.

Please review our technical note *Maximizing Wireless Communication Range* at: http://www.microstrain.com/pdf/TechNote_2400_RangeExtendingAntennae.pdf

Power

The TC-Link® is normally powered by its internal rechargeable battery and may also be powered by an external source.

Internal Battery

The TC-Link® contains an internal rechargeable Ultralife® brand 3.7 volt Lithium Ion battery Model UBP003 <http://www.ultralifebatteries.com/datasheet.php?ID=UBP003>.

The internal battery should only be charged with the Phihong brand external power supply Model PSA05R-090 <http://www.phihong.com/assets/pdf/PSA05R.pdf> provided in the TC-Link® starter kit. The power supply is a 'switching' supply and may receive an input from 100 to 240 Volts AC. It outputs +9 Volts DC. A set of 4 plug adapters are provided to accommodate most countries' electrical services.

The TC-Link® should be fully charged before each use. Charging may take up to several hours depending on battery depletion.

Charging procedure:

- Turn off the TC-Link® On/Off Switch.
- Insert external power supply male connector into the TC-Link® barrel connector.
- Insert power supply into wall or other electrical service.
- Observe that red Charging LED illuminates.
- After charging has completed, observe that red Charging LED turns off and green Charge Completed LED illuminates.
- Remove external power supply male connector.
- Turn on the TC-Link® On/Off Switch.
- **Note:** The TC-Link® should normally be operated with the external power supply disconnected and therefore not charging the battery.

The TC-Link® internal battery has a manufacturer stated Nominal Capacity as follows:
740 mAh @ C/5 Rate @ 23° C.

The TC-Link® internal battery has a manufacturer stated Recharge Cycle Life as follows:
>500 cycles @ C/5 to 80% of initial capacity. A rule-of-thumb would be to expect at least 500 recharges (from fully depleted to full charge) before discharge capacity begins to drop.

Actual testing of the TC-Link® battery life (from full charge to depletion) has indicated the following characterizations:

- If set at 2 samples per second, the device consumes ~0.8mA and will run for ~1 month before re-charging is required.
- If set at 1 sample per second, the device consumes ~0.48mA and will run for ~2 months before re-charging is required.

power the on-board clock. Therefore, one should charge the internal battery before going to external power mode and one should never remove the internal battery from the TC-Link®. The clock requires very little power so the internal battery will operate for months while the TC-Link® receives external power.

Do not use external batteries or any other external power source to charge the TC-Link® internal battery. Always use the switching power supply provided.

Base Stations

The TC-Link® is designed to operate with any of the Wireless Sensing Systems' base stations. These base stations include the USB base station, the Analog base station and the Serial base station. Please refer to the Wireless Sensing Systems Base Station manual which is contained on the CD and on our web site for detailed instructions on their use with TC-Link®.

USB Base Station

The MicroStrain USB base station is a transceiver which provides a communication link between a host computer and the TC-Link®. The USB base station employs a 2.4 GHz radio with 16 selectable channels to communicate with the remote nodes. The USB base station is connected to a host computer via a USB connection and is operated with MicroStrain's TC-Link® Node Monitor software. The USB base station, under instruction from the software, wirelessly communicates with the TC-Link® nodes, alternately sending commands and configurations, and receiving responses and data. The USB base station sends all of the commands available to the nodes including ping, datalog, stream data, erase, read and write EEPROM, etc. The USB base station in turn receives acknowledging responses from the nodes and passes datalogging downloads, streaming data, high speed streaming data and low duty cycle data to the host computer.



Analog Base Station

The MicroStrain Analog base station is a transceiver which provides a communication link between a host computer and the TC-Link®. The Analog base station employs a 2.4 GHz radio with 16 selectable channels to communicate with the remote nodes. The Analog base station is connected to a host computer via a USB or an RS-232 connection and is operated with MicroStrain's TC-Link® Node Monitor software. The Analog base station, under instruction from the software, wirelessly communicates with the TC-Link® nodes, alternately sending commands and configurations, and receiving responses and data. The Analog base station sends all of the commands available to the nodes including ping, datalog, stream data, erase, read and write EEPROM, etc. The Analog base station in turn receives acknowledging responses from the nodes and passes datalogging downloads, streaming data, high speed streaming



data and low duty cycle data to the host computer. The Analog base station also features direct analog output of TC-Link® node data on its back panel and is deployable in a stand-alone condition without need of host computer.

Serial Base Station

The MicroStrain Serial base station is a transceiver which provides a communication link between a host computer and the TC-Link®. The Serial base station employs a 2.4 GHz radio with 16 selectable channels to communicate with the remote nodes. The Serial base station is connected to a host computer via an RS-232 connection and is operated with MicroStrain's TC-Link® Node Monitor software. The Serial base station, under instruction from the software, wirelessly communicates with the TC-



Link® nodes, alternately sending commands and configurations, and receiving responses and data. The Serial base station sends all of the commands available to the nodes including ping, datalog, stream data, erase, read and write EEPROM, etc. The Serial base station in turn receives acknowledging responses from the nodes and passes datalogging downloads, streaming data, high speed streaming data and low duty cycle data to the host computer.

Software

Standard Offering

The TC-Link® is shipped with a CD containing TC-Link® Node Monitor software. This software supports the full capability of the TC-Link® including low duty cycle data, datalogging, configuration, data download, data file saving, real-time sensor display and other features.

System Requirements

To use the TC-Link® Node Monitor software, your computer must have the following minimum specifications:

- 300 MHz microprocessor
- Microsoft® Windows XP SP3 operating system
- CD-ROM drive
- Video resolution 800 X 600
- 16MB video card
- Minimum of 16MB of memory
- Minimum of 15MB of free hard disk space for application
- Microsoft®-compatible mouse

Software Installation

- Place the Agile-Link™ CD in your CD-ROM drive and follow the on-screen instructions to install MicroStrain's Agile-Link™ software.
- Installation of this software is required to install drivers necessary to support the TC-Link® base station.
- Agile-Link™ software **should not be used** to operate the TC-Link®.
- Install the TC-Link® Node Monitor 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 customize the TC-Link® are encouraged to utilize the TC-Link® Data Communications Protocol. The Data Communication Protocol manual can be found on the CD or downloaded at www.microstrain.com.

The Data Communications Protocol provides the application builder with all the necessary commands and responses to build robust wireless sensor applications for the TC-Link®.

Sampling Rates

The TC-Link® supports sampling rates of from 2 samples per second to 1 sample every 17.05 minutes. A software settable value is kept in EEPROM with a range of 0-1023.

- 0 represents 2 samples per second
- 1 represents 1 sample per second
- 2 represents 1 sample every 2 seconds
- 10 represents 1 sample every 10 seconds
- 100 represents 1 sample every 100 seconds
- 1023 represents 1 sample every 1023 seconds or 17.05 minutes

Datalogging Memory

The TC-Link® has 2 megabytes of flash memory for datalogging storage. Data may be logged to the memory during use (software selectable) and downloaded after the fact for analysis.

The memory is parceled into 90,090 data sets. Each data set is structured as follows:

- Date-Time Stamp
- Channel 1 Thermocouple Temperature in °C
- Channel 2 Thermocouple Temperature in °C
- Channel 3 Thermocouple Temperature in °C
- Channel 4 Thermocouple Temperature in °C
- Channel 5 Thermocouple Temperature in °C
- Channel 6 Thermocouple Temperature
- Cold Junction Compensation Temperature in °C
- Relative Humidity Sensor Percentage

Each data set will be reported out of memory in full. If the any of the channels or the relative humidity sensor are configured as inactive, 0 (zero) value will be reported.

If a datalogging session is run beyond the capacity of the device to store data sets, the writing of data sets will continue by wrapping around to the start of datalogging memory. Data sets initially written will be overwritten in consecutive order. The date-time stamp will provide the user with notification of this event.

The user at any time may erase (via software) the datalogging memory in its entirety and begin a new session at the start of memory. The user may also choose (via software) to continue datalogging at the end of a previously stored session.

As described elsewhere in this manual, sampling rates can be set within a range of 2 samples per second to 1 sample every ~17 minutes. Examples are given below of how to calculate memory consumption by time. We will assume the memory has been erased.

If you set the sampling rate to 1, 1 sample will be recorded every 1 second. At this rate datalogging memory will be consumed in ~25 hours.

- $90,090 \text{ data sets} * 1 \text{ second} = 90,090 \text{ seconds} = \sim 25 \text{ hours}$

If you set the sampling rate to 2, 1 sample will be recorded every 2 seconds. At this rate datalogging memory will be consumed in ~50 hours.

- $90,090 \text{ data sets} * 2 \text{ seconds} = 180,180 \text{ seconds} = \sim 50 \text{ hours}$

If you set the sampling rate to 10, 1 sample will be recorded every 10 seconds. At this rate datalogging memory will be consumed in ~250 hours.

- $90,090 \text{ data sets} * 10 \text{ seconds} = 900,900 \text{ seconds} = \sim 250 \text{ hours}$

Enclosure

The TC-Link® enclosure is flame retardant ABS plastic. It is a 2 part assembly with base and removable cover. It is originally manufactured by Polycase® Model LP-21F. MicroStrain remanufactures the base to accommodate the female thermocouple connectors. More details may be had at: <http://www.polycase.com/item/lp-21f.html>.



Figure 7

Operating Temperature

The TC-Link® with its standard internal battery and standard enclosure will operate between -20° C and +60° C. The battery and enclosure limit this range.

The TC-Link® electronics alone will operate between -40° C and +85° C.

Extended temperature ranges can be achieved with custom batteries and enclosures. Please contact a MicroStrain Sales Engineer with your requirements.

Factory Calibration and Testing

Calibration

MicroStrain provides a Certificate of Calibration with each TC-Link® to document the accuracy of the device.

The Certificate states the model number, serial number and the calibration date. A set of actual data is contained which includes an analysis of the performance during a voltage in/voltage out test and a J-type thermocouple simulation. Specialized software together with a National Instruments® DAQPAD-6016 is used at the factory for performance and calibration testing.

The voltage in/voltage out analysis plots the results of a 15 point (~0 to 27 mV) test and plots the performance error.

The J-type thermocouple simulation analysis plots the results of a 15 point test (~24 to 520° C) and plots the performance error.

The calibration is NIST traceable.

Functional Test Checklist

MicroStrain provides a Functional Test Checklist with each TC-Link® to document the final testing and configuration of the device.

General Specifications

Thermocouple Inputs Supported	Software selectable: Type J, K, R, S, T, E, B, N six input channel, one ambient CJC channel. Optional internal relative humidity sensor.
Standard Thermocouple Measurement Range	J -210 to 760°C K -200 to 1372°C R -50 to 1664°C S -50 to 1664°C T -200 to 400°C E -200 to 1000°C B 250 to 1820°C N -200 to 1300°C
Temperature Measurement Accuracy	0.1% full scale or 0.2°C whichever is greater (does not include errors due to TC wire or transducer)
Temperature repeatability	0.1°C (does not include errors due to TC wire or transducer)
Temperature resolution	0.0625°C
Cold Junction Compensation Range	-20 to 85°C
Thermocouple Connector	Six type 1 standard mini (SM) connectors for flat pin TC inputs
Optional Relative Humidity (RH) Sensor	Range 0 to 100% RH, accuracy $\pm 2\%$ RH (from 10 to 90% RH), repeatability $\pm 0.1\%$ RH
Analog to Digital (A/D) Converter	24 bit Delta-Sigma A/D
Sample Rate	Programmable from 2 samples/second to 1 sample/17 minutes for datalogging or LDC modes
Datalogging Mode	Log up to 90,000 data sets(630,000 data points)
Nodes Per Base Station	Supports up to 100 nodes per base station
Sample rate stability	Datalogging and LDC modes 25 ppm
Radio Frequency (RF) Transceiver Carrier	2.4 GHz, direct sequence spread spectrum, license free worldwide (2.405to 2.480 GHz) - 16 channels, radiated power 0 dBm (1mW)
Range for Bi-directional RF Link	Up to 70 m line of sight, up to 100 m with high gain antenna on base station

RF Data Packet Standard	IEEE 802.15.4, open communication architecture
Internal Li-Ion Battery	Rechargeable 3.7 volt lithium ion, 740 mAh capacity. Customer may also supply external power from 3.2 to 9 volts
Power Consumption (battery life)	2 samples per second - 0.8 mA (1 month) 1 sample per second - 0.48 mA (2 months) 3 samples per minute - 0.1 mA (8 months) 1 sample per minute - 0.09 mA (10 months)
Operating Temperature	-20°C to +60°C with standard internal battery and enclosure, extended temperature range optional with custom battery and enclosure. -40°C to +85°C for electronics only
Maximum Acceleration Limit	500 g standard (high g option available)
Dimensions	111 mm x 62 mm x 28 mm (enclosure without antenna) 77 mm x 68 mm x 18 mm (circuit board assembly only) For dimensioned print go to Documentation tab
Weight	116 grams (with enclosure) 33 grams (circuit board assembly only)
Enclosure Material	ABS plastic
Software	TC-Link® Node Monitor Windows XP/Vista compatible
Compatible Base Stations	USB, RS-232, Analog, WSDA®

Table 3

Mechanical Drawing

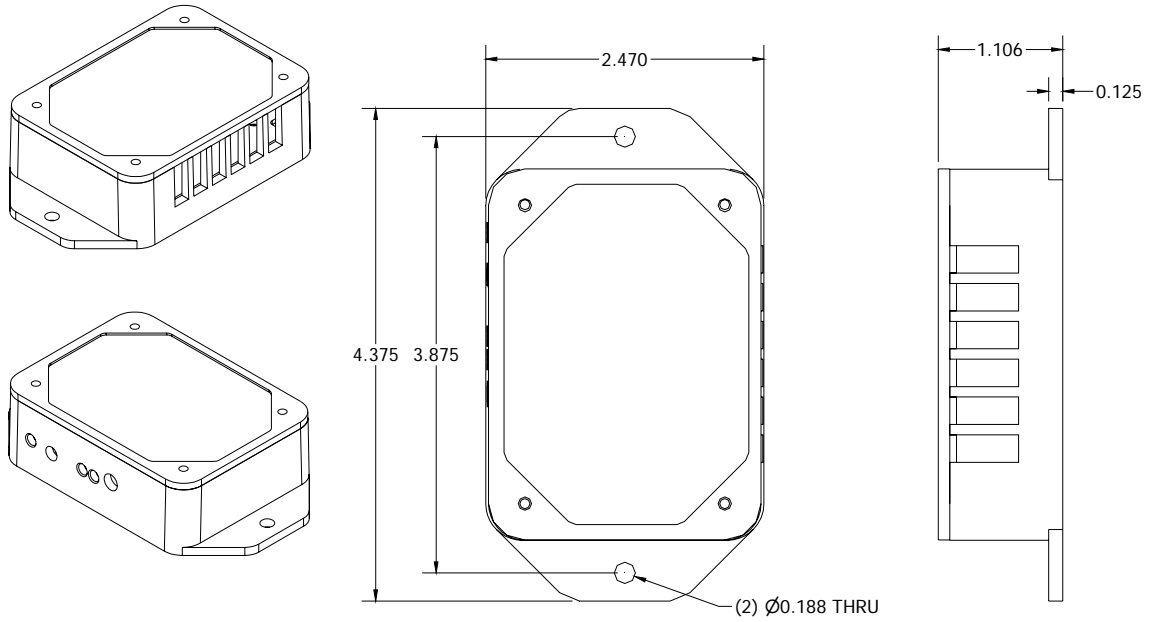


Figure 8
Enclosure Dimensions (in inches)

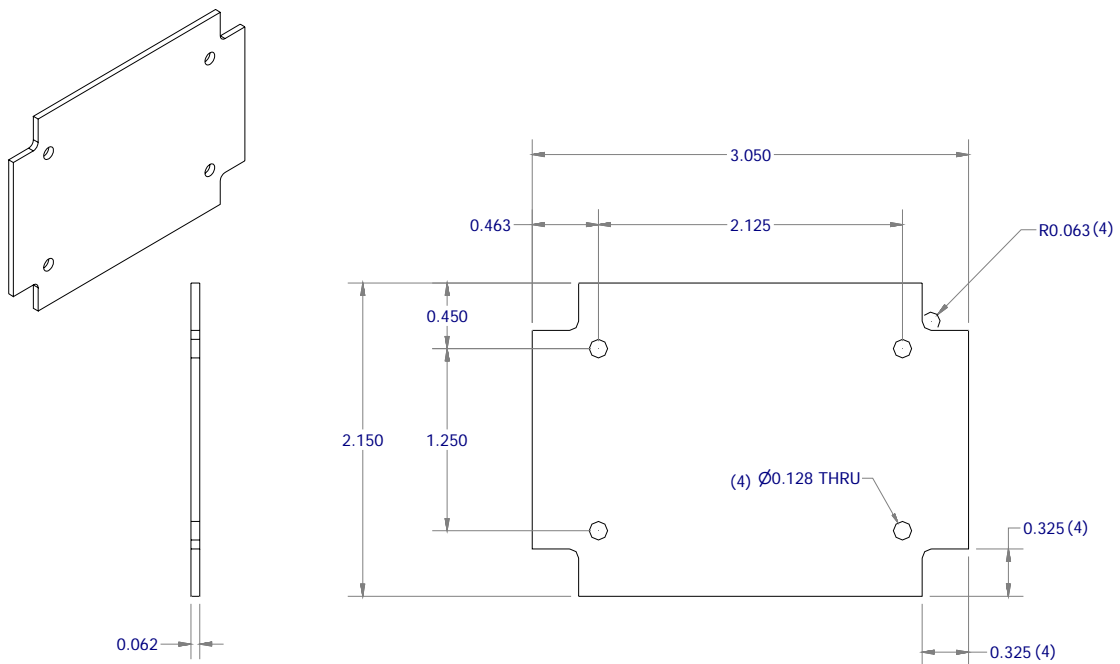


Figure 9
Circuit Board Dimensions (in inches)

Electrical Block Diagram

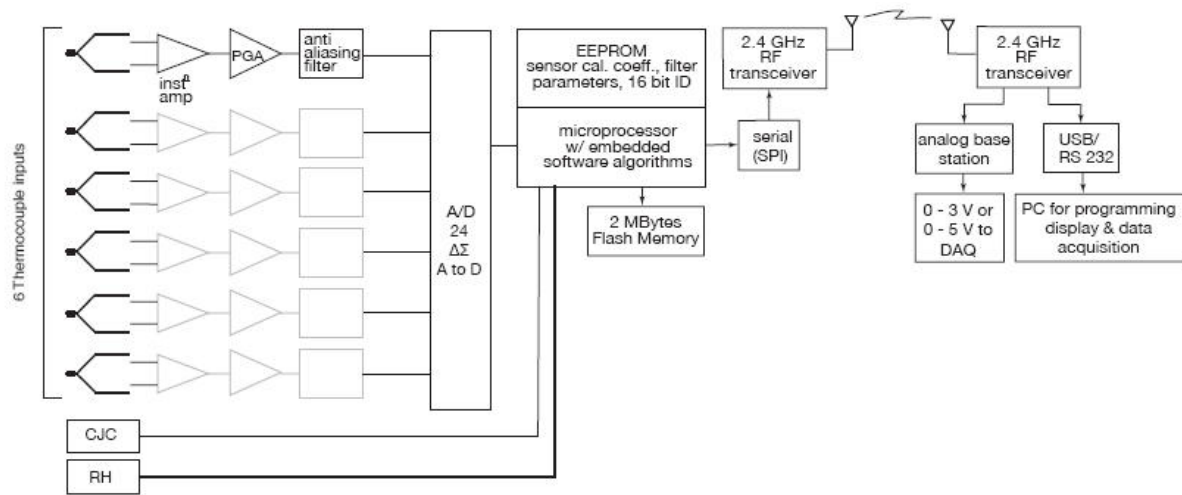


Figure 10

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 conditions 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 terms "Product" and "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. Buyer 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 balances.

4. Shipping Terms. All Products delivered to Buyer by MicroStrain, shall be F.O.B. our distribution center, with risk of loss passing to Buyer 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, Customized Products, modifications of standard

Products, Products altered by Customer 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. 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. Buyer acknowledges and recognizes that Products manufactured and sold by MicroStrain which may be used for biomedical purposes are only to be used for research purposes, and that any approvals required by the United States Food and Drug Administration, Internal Review Board (IRB), Human or Animal Experimentation Committee, or similar agencies in the United States, and in foreign countries, must be obtained by Buyer, and further, MicroStrain expressly disclaims any compliance with such laws, rules, and regulations, and Buyer accepts all responsibility for any such compliance, hereby indemnifies MicroStrain from and against any and all liability arising out of the use of the Product.

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 FROM THE INVOICE DATE FROM MICROSTRAIN, OR MICROSTRAIN’S AUTHORIZED DISTRIBUTOR, AND IN NO EVENT SHALL BE MORE THAN EIGHTEEN (18) MONTHS FROM THE DATE SHIPPED FROM MICROSTRAIN’S DISTRIBUTION CENTER; AND, ii) ALL SPARE PARTS OR REPLACEMENT PARTS AND SPARE KITS FOR A PERIOD OF NINETY (90)

DAYS, WILL SUBSTANTIALLY CONFORM WITH MICROSTRAIN'S THEN PUBLISHED SPECIFICATIONS FOR THE PRODUCT OR PART. THE FOREGOING WARRANTY APPLIES TO ALL PRODUCTS MANUFACTURED BY MICROSTRAIN WHICH SHALL BE FREE FROM MATERIAL DEFECTS IN WORKMANSHIP. THIS WARRANTY EXTENDS ONLY TO THE ORIGINAL CUSTOMER OF MICROSTRAIN, OR MICROSTRAIN'S AUTHORIZED DISTRIBUTOR, 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 OR FOR A PARTICULAR PURPOSE. THERE ARE NO OTHER WARRANTIES EXPRESS OR IMPLIED EXCEPT THOSE SPECIFICALLY PROVIDED FOR HEREIN. BY ACCEPTING THE PRODUCTS FROM MICROSTRAIN, OR MICROSTRAIN'S AUTHORIZED DISTRIBUTOR, 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 MAY BE 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 FROM AND 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 MICROSTRAIN BE LIABLE FOR SPECIAL, DIRECT, INDIRECT, INCIDENTAL, PUNATIVE 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.

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 Buyer or to refund the purchase price 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 Buyer for the defective Product will be refunded by MicroStrain upon return to MicroStrain of the defective Product. All Products (or parts thereof) that are 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 Buyer shall return the Product to the original purchase point. In case the return policy period has expired and the Product is within warranty, the Buyer 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 Buyer 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 Buyer and only upon request; v) Return Merchandise is to be shipped to MicroStrain, Inc. at the address indicated below or such other address as provide with the RMA; 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. The 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.

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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 Buyer 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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