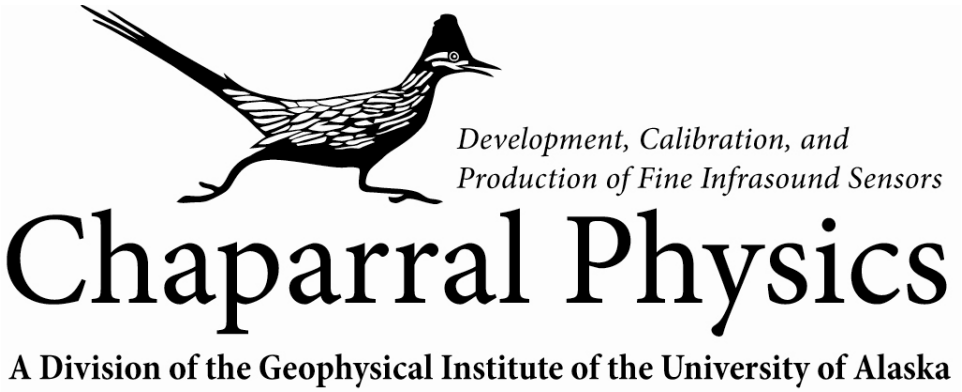
Operation manual

for the

Model 24
Infrasound Sensor

For use in the near infrasound band



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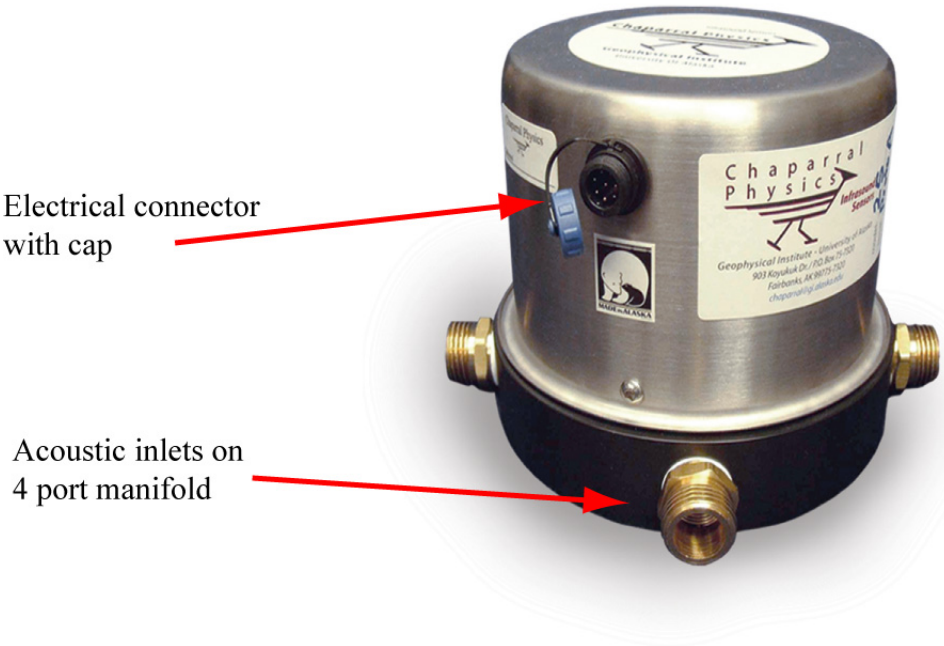
Manual Revision 1 (11/12/2008)

Chaparral Physics
Model 24 Infrasound Sensor

also referred to as a differential low air pressure sensor, an ultra low frequency microphone, or a microbarometer



A Chaparral Physics Model 24 infrasound sensor with 4 inlet ports.

Chaparral Physics sensors combine rugged construction with wide bandwidth and low noise to ensure accurate measurements in the most demanding of environments. They have no need for altitude adjustments, and are carefully designed to reduce the effect of environmental temperature variations and mechanical vibrations. From the Ross ice-shelf in Antarctica through the rain forests of Central America to Alaska's tundra, Chaparral Physics microphones have proven their reliability and value as the finest infrasound measuring instruments in the world.

For installation suggestions, servicing, and repairs please contact:
chaparral@gi.alaska.edu or 907-474-7107 or

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Model 24
SPECIFICATIONS

Nominal Sensitivity:

0.4 volts/Pa @ 1 Hz, 90 Pa full scale range

Individual sensor's calibrated value is +/-5% from nominal. Calibration value is traceable to the Los Alamos National Laboratory (LANL) calibration chamber.

Output:

Output type	Differential
Maximum	36 volts peak-to-peak (signal+ to signal-) ±9 volt max, signal to ground
Frequency Response	Flat to within +0, -3 dB from 0.1 Hz to 200 Hz Flat to within +0, -0.5 dB from 0.3 Hz to 50 Hz
Self noise	Less then 0.63μPa^2/Hz @ 1 Hz (-62dB Pa^2/Hz, rel to 1 Pa) Less than 3 mPa RMS 0.1 to 40 Hz Less than 0.8mPa RMS 0.5 to 2 Hz
Dynamic range	101dB low gain (@ 0.8mPa RMS self noise)
Output Impedance	150Ω non-reactive (recommended load > 10 kΩ) (Recommend less than 10,000pf capacitive loading)
Short circuit protected	signal+ to signal– and signal to ground

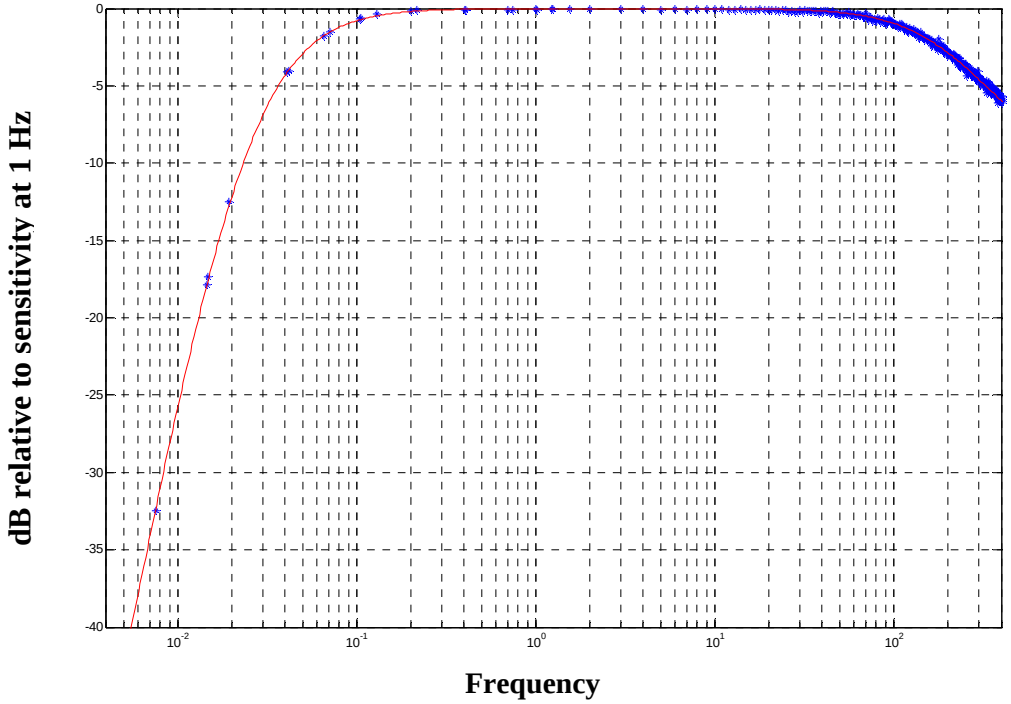
Power Requirements:

DC Source	12 volts, (9-18 volts) DC, reverse voltage protected.
Current Drain	Less than 40 ma @ 12 v

Physical:	Sensor will function in any position or attitude. Sealed to IP-67 with acoustic inlets sealed and mating electrical connector or cap installed
Operating Temperature	-40º C to +65º C
Humidity	95% (non-condensing)
Dimensions	5.5" (14 cm) maximum overall height 9" (23 cm) maximum diameter, with 4 inlet ports
Weight	5.3 lbs (2.4 kg), for 4-port version
Acoustic inlet(s):	Standard: 4 inlet ports (maximum 12), male, Garden-Hose-Thread.

We reserve the right to modify and improve the sensor's performance.

Typical Frequency Response



This plot shows the roll off at either end of the nominal 0.1-200 Hz band pass of the Model 24. The blue stars represent tests on Model 25 sensors. The red curve is the best fit of the data.

The transfer function is:

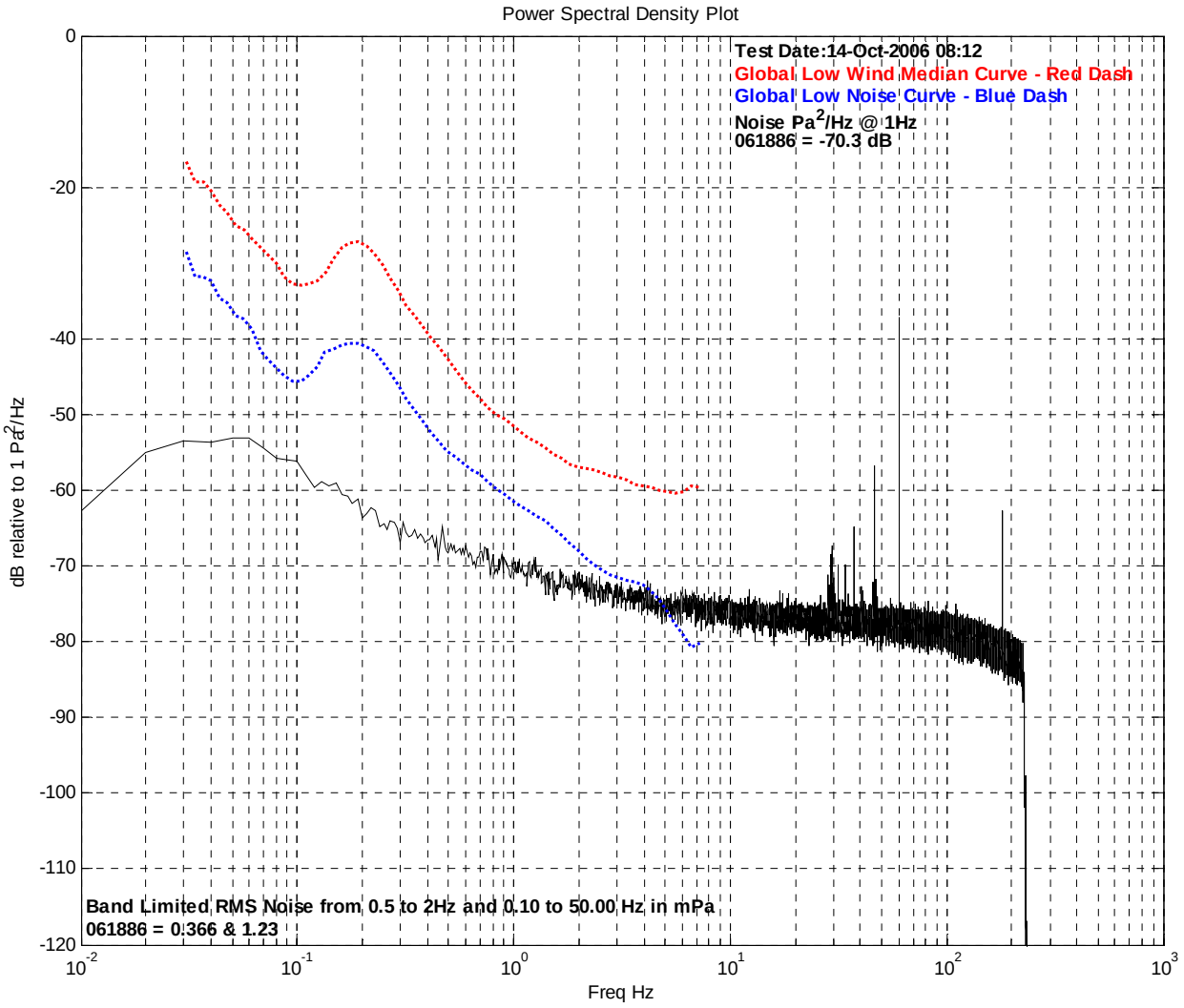
$$H(f) = K\frac{Poly(zeros)}{Poly(poles)}$$

Transfer function is only valid below 400Hz.

Table 1: Poles and Zeros for Model 24

Poles	Zeros	K
-1190	0	0.2917
-0.157±3.00E^{-6} i	0	
-0.157	0	
	-4080	

Typical Sensor Self Noise vs. Frequency



The black trace is from a Model 25 (sn061886) sensor in high gain with the acoustic inputs capped. The spikes are from building vibrations and 60 Hz pickup. The self noise is approximately the same in both high and low gain once the output is converted to Pa. The red and blue traces are from data collected world wide. The red curve is a low wind median, while the blue curve is a 5% confidence lower bound for noise.

This test was conducted at 500 sps with an anti-alias filter at ~240 Hz.

Installation Suggestions for the Model 24 sensors

The Chaparral Physics Model 24 infrasound sensor is a physically robust scientific instrument that can be successfully deployed in a variety of environments. While it will adequately function in nearly any setup that meets the specifications found in this manual it takes some care and consideration to obtain maximum performance, data quality, and sensor longevity.

Infrasound sensors are inherently sensitive to rapid temperature fluctuations (ideal gas law), vibrations (Newton's second law), and elevation change (vertical atmospheric pressure gradient). While Chaparral Physics sensors are designed to significantly reduce the environmental noise from these physical limitations a careful installation can further reduce them to the point where they fall below the noise floor.

Infrasound sensors produce the best data in a dry environment with thermal and mechanical stability. Steps to provide these conditions should be part of every permanent installation plan. The most effective installations utilize an insulated enclosure or vault that seals out wind and rain. This provides both the environmental stability necessary and allows waste heat from the electronics to guard against condensation.

For quick set-up the Model 24 sensor can be installed directly in the environment, even in the rain. Care must be taken though to ensure that water does not enter the acoustic inlets and reach the diaphragm. Water on the diaphragm will cause the sensor to function improperly or become damaged. This will be easier to prevent if the sensor is supported above the ground with any hose or pipe connections sloping down and away from the sensor. The electronics are only sealed when the vent screw and cap or mating electrical connector are installed. This style of installation will result in noisier data, but can be a good solution for rapid installation of an array or when the signals of interest are large relative to the noise floor.

Installation Instructions

CHECK LIST

- Unpack and inspect sensor for shipping damage.

  Important: Do not disassemble the sensor.

- **Read entire manual.**

- Assemble electrical cable with the supplied mating connector as shown on page 9, *Model 24 Cable Connection*. Check the power on the connector pins for correct voltage and polarity.

- Place sensor in the chosen location.

- Install vent screw as referred to on page 8. During shipping, two vent screws are stored in a plastic bag. Store the extra vent screw in safe location.

- Connect wind noise reducing array to acoustic inlet(s).

- Connect the electrical cable and turn on power supply for the sensor.

- Check that your recording or display apparatus is functioning properly.

- When removing sensor, reverse the steps above.

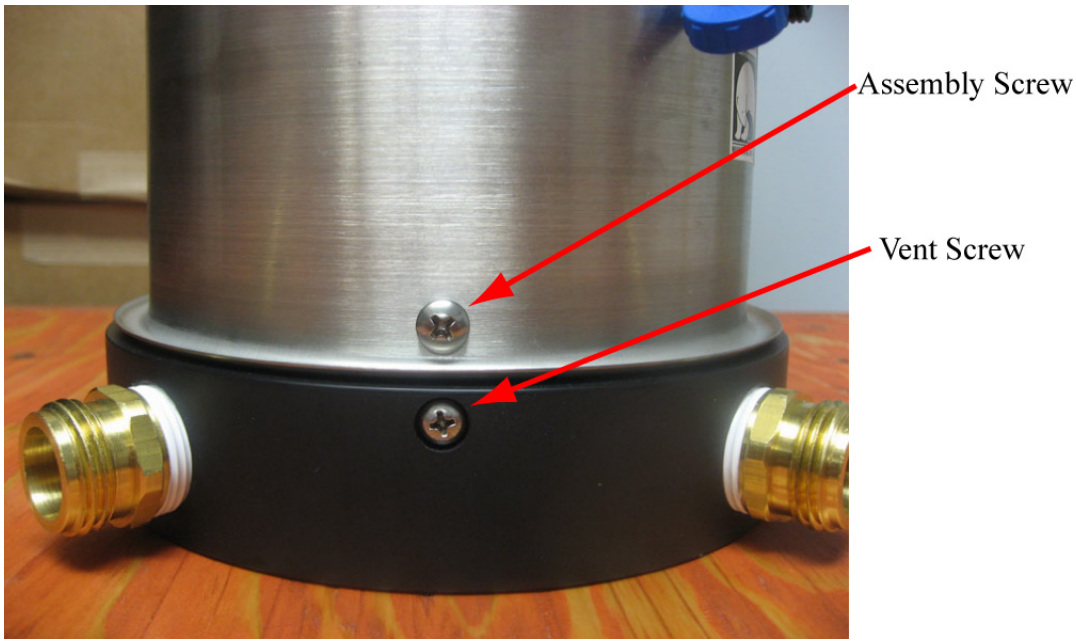
- **Retain heavy-duty box and shipping materials to return sensor for recalibration or repair.**

Important:

Read before first use of sensors or before further shipments of previously installed sensors

Vent Screw

The Model 24 has a sealed electronic chamber to prevent moisture damage. In order to relieve any pressure differential that may be caused by extreme and/or rapid altitude changes, common in air shipments, the Model 24 has been designed with a vent in the manifold.



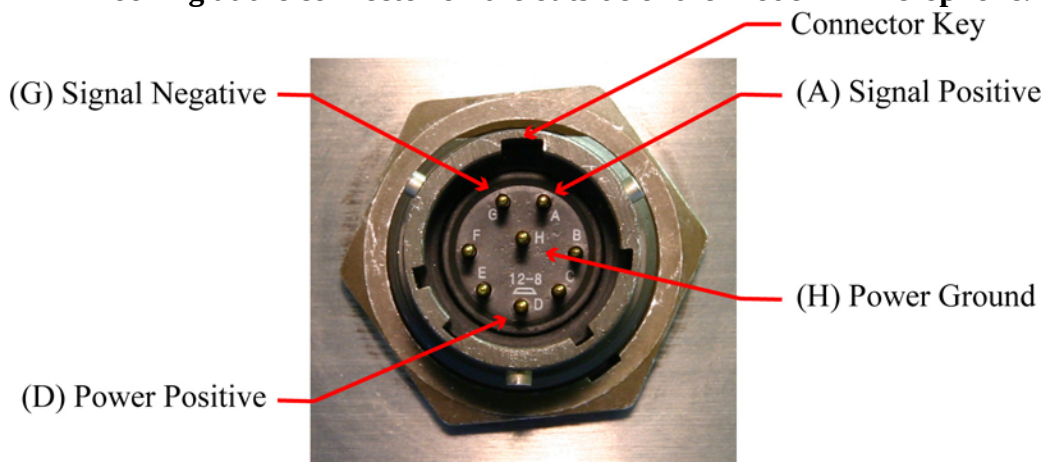
Upon arrival a vent screw must be installed to protect the electronics. A light coating of grease should be used on the o-ring to assist sealing. Two vent screws are included with each sensor and only these special screws with their integral o-ring should be used for the purpose. Be sure to remove the vent screw before shipping the sensor at a later date. The rubber o-ring will wear with use so inspect the vent screw and replace as needed. These screws can be purchased from McMaster-Carr (www.mcmaster.com) part # 90825A800.

Vent Screw showing rubber o-ring

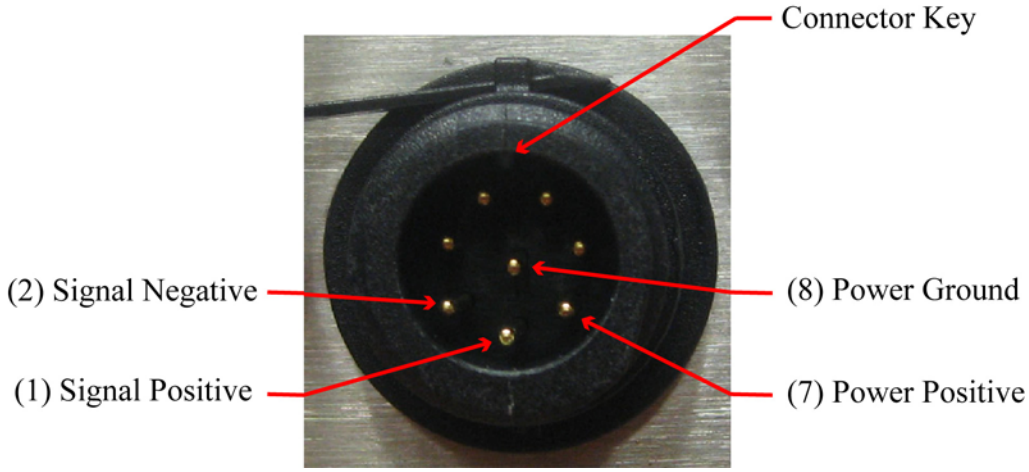
MODEL 24 Cable Connection

Your sensor has one of the two following connectors depending on which option was chosen during purchase.

Looking at the connector on the outside of the Model 24 microphone.



The connector is a PT07E-12-8P. The mating connector is a PT06E-12-8S-SR or a MS3116F12-8S; these two part numbers are functionally equivalent. This is an environmental connector and is sealed with or without the dust cap.



The connector is a Bulgin Buccaneer 400 series. The mating connector is part # PX0410/08S/6065 for 6.0 to 6.5mm diameter cables. Bulgin can supply other cable clamp fittings for other cable diameters. The connector is IP68 rated when mated or capped.

Chaparral Physics recommends that users connect the signal ground of the digitizer or recording device to the power ground of the power supply.

Operating Environment

The Model 24 sensor is a differential pressure sensor operating down to 0.1 Hz. To perform at these frequencies requires a reference volume and a high resistance acoustic leak. Because of this, Model 24 sensors should be operated in a temperature-stable environment. While operating temperature does not affect the sensor itself, rapid temperature changes (5°/hour) will affect the sensor's output signal.

Once powered in a temperature-stable environment, the Model 24 sensor will begin to operate after about 30 seconds of turn-on transients. While it will be ready for calibrated use in approximately 10 minutes, full sensor specifications will not be achieved until the unit has equilibrated to its environment.

Please contact Chaparral Physics for further information or clarification if needed.

Seismic Sensitivity

Chaparral Physics sensors are relatively immune to seismic or vibrational noise. However, one must remember that any change in elevation is a pressure change, since there is almost no difference between a microbarometer and a microaltimeter. For example, data will register during a large earthquake, not because of the vibrations themselves, but because the earthquake caused the ground to move up and down.

Since the Model 24 builds on Chaparral Physics's unique technology it is expected that the Model 24 will have a seismic response similar to the Model 5. The French DASE and the Comprehensive Nuclear-Test-Ban Treaty Organization's International Monitoring System have jointly studied and published a paper on the responses of the MB2000 and the Chaparral Physics Model 5. The paper's abstract notes the difference between the sensors tested, and highlights the low seismic sensitivity of the Chaparral Physics sensor:

> "*The MB2000 mechanical response has been found to be similar to that of the strong motion Guralp accelerometer CMG5T (flat in acceleration from DC - 50Hz) with sensitivity 0.802 V/m/s^2. The Chaparral5 microbarometer has about 40 times less sensitivity to mechanical vibrations than the MB2000.*"

A link to the full paper can be found on Chaparral Physics website chaparral.gi.alaska.edu.

Selection and Use of Infrasound Sensors

Infrasound sensors are generally used in multiple-sensor-array configurations. To obtain good results the sensors used in an array should be matched for response and phase. All Chaparral Physics sensors are well matched over their specified pass band for use in multiple-sensor arrays. Chaparral Physics sensors differ slightly from each other outside of their stated band pass. For example, while Model 24 sensors are guaranteed from 0.1 to 200 Hz, individual Model 24s will pickup strong signals much lower than 0.1 Hz. Because amplitude and phase varies it is not recommended that Chaparral Model 24 sensors be used in arrays to detect signals lower than 0.1 Hz. It is not recommended that different sensor types or brands be mixed into a single array, as the useful bandwidth will be limited to the portion where all of the sensor bandwidths overlap. All Chaparral Physics Model 20, 21, 24, and 25 sensors have the same bandwidth and can be used together in an array.

Warranty

The sensor is warranted for a period of one year from the original date of shipment as stated in the Chaparral Physics *terms and conditions*. For the full terms and conditions of sale see the document on the Chaparral Physics website. **Warranty is void if the unit is opened without prior express permission of Chaparral Physics.** Calibration is void and the unit may fail to function if opened, tampered with, or adjusted in any manner. There are no user serviceable parts or adjustments inside the unit.

Chaparral Physics Models 2.5, 5.1, 2.2 no-leg, 2.2, 25, and 50.