Jewell Instruments
ECL™ eCompass
User's Guide

Revisions

November 2002, Rev A, First Release
March 2003, Rev B, New J2 Wiring Instructions
March 2006, Rev C, No PDA instructions
January 2008, Rev D, Revise Mag Calibration
March 2018, Rev E, Miscellaneous updates
July 2018, Rev ECL-A

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Introduction

The ECL™ eCompass is a strap-down electronic compass designed specifically for commercial, industrial, and military users. ECL™ will be of particular interest to ROV and AUV manufacturers who are concerned with power usage and accurate heading in all types of challenging conditions. In standby mode, it draws a mere 50 µA and requires only 15 mA in run mode. It provides accurate heading data in less than a tenth of a second from wakeup. An extended range tilt sensor is available that allows for +/-60° of pitch and roll.

The ECL™ eCompass combines a precision 3-axis solid-state magnetometer and a rugged 2-axis electrolytic tilt sensor that have been factory calibrated to provide accurate heading and tilt measurements. The unit has been verified for accuracy at room temperature in an environment free from magnetic, electrical, and mechanical disturbances. The eCompass can be immediately tested in a location away from any ferrous material and isolated from severe vibration.

A good first test is to hold the compass steady at different attitudes (heading, pitch, and roll), take readings, and verify that the horizontal field strength remains roughly the same for different orientations. Expect to see some variation in the horizontal field strength, but it should be less than one or two percent if the compass is steady and tilt is less than 20°.

Before installing the eCompass, make note of the dip angle measurement and compare it to the published value for your location. The two values should be very close, usually within 0.5°. It is also a good idea to capture and save a vertical reference as described in the section on *Calibrating the eCompass*. After the compass is mounted in-situ, this reference is used to partially compensate for any local permanent magnetism (hard-iron) that may be present.

Contents of the Evaluation compass kit

The ECL™ Evaluation compass kit contains the following primary items described in detail in this section. Optional items may be included.

- ECL™ eCompass module
- eCompassTest Software CD
- Serial or optional USB Cable
- Users Guide

ECL™ eCompass

The ECL eCompass represents the state of the art in magnetic compassing. It consists of a PC card housed in an ABS or optional aluminum enclosure. The base of the enclosure has 4 mounting holes for permanent installation. Only brass or non-magnetic stainless-steel screws should be used. Connection to the compass may be made via the RJ12 connector or by the 8-pin header (for system wiring). See the diagram(s) included with the cable(s).



eCompass Features

The ECL™ eCompass is a strap-down device that delivers high accuracy for its small size, low cost, and low power consumption. It provides RS-232 and TTL communication links. For battery operation, a low-power standby mode is incorporated to reduce required current to 50 µA. Wake up from standby requires only one millisecond.

Additional features of the eCompass include:

- Run (continuous) or Sample mode operation
- NMEA 0183 output data format with the following available sentences:
  - ⇒ HDT (True heading – standard sentence)
  - ⇒ HDG (Heading, deviation, and variation – standard sentence)
  - ⇒ XDR (Transducer data: pitch, roll, magX, magY, and magZ – standard sentence)
  - ⇒ HTM (Heading, tilt, and magnetic field – proprietary sentence)
  - ⇒ NCD (Normalized compass data – proprietary sentence)
  - ⇒ CCD (Conditioned compass data – proprietary sentence)
- Output data available:
  - ⇒ Heading, pitch, and roll
  - ⇒ Magnetometer X, Y, Z, and calculated total field
  - ⇒ N, E, H, and V - normalized magnetic field components
  - ⇒ Magnetic inclination (dip angle)

- Angles in degrees (0.0 to 359.9°), mils (0 to 6399), milliradians (0 to 6282), or 16-bit integer (0 – 65535)
- Tunable alarm on H field deviation in Run mode
- Selectable averaging time in Sample mode
- Separate magnetic and tilt IIR single-pole filters in Run mode
- Tunable heading filter in Run mode for quick response in hand-held applications where fast movements should be ignored
- Magnetic field measurement range: ±1.6 G (gain 100)
- Magnetic field measurement sensitivity: 0.3 mG (30 nT, gain 500)
- Serial EEPROM for calibration coefficients and setup parameters

eCompassTest Software CD

The CD contains the eCompassTest interface software for a Microsoft® Windows™ PC. When the CD is loaded into a CD-ROM drive, a display similar to the one shown in Figure 1 will automatically appear if the auto-run feature is enabled.

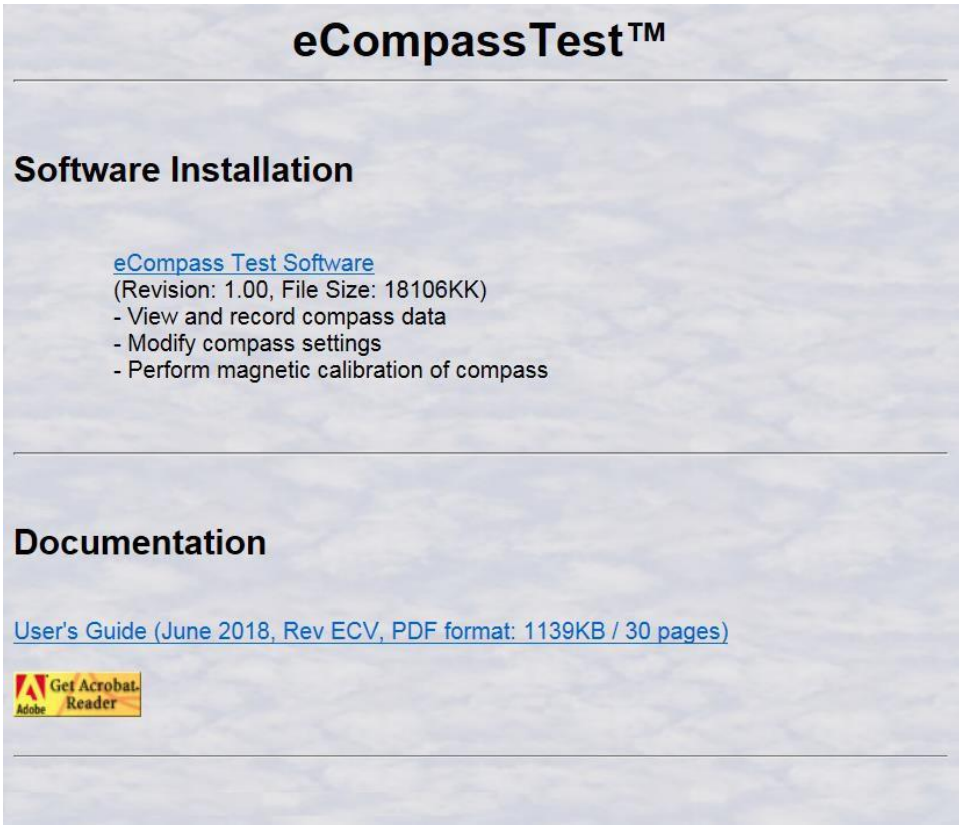


Figure 1

eCompassTest Software Features

The eCompassTest application is designed to run on Microsoft Windows XP or newer. There are two main components:

- A VB.NET program (eCompassTest.EXE) that provides the graphical user interface, recording, and logging functions, and
- A windowless DLL (CompassLib.DLL) that implements the compass serial interface and calibration functions.

Functions provided by the eCompassTest software are:

- Cockpit attitude display of heading, reciprocal heading, pitch, and roll
- Display and capture NMEA sentence data
- Modify ECL operating parameters
- Perform hard and soft-iron calibration procedures
- View and maintain communication logs

Serial Cable

The following serial cable assembly is included (with evaluation kits) and is shown in Figure 2.

4-Wire PC to Compass: 8 ft. cable with DB9F connector and 9V battery strap going to 6-pin RJ12 plug.



Figure 2

Getting to Know the eCompassTest Software

System Requirements

- Microsoft® Windows™ XP with .NET Framework 2.0 or greater
- VGA or greater
- Keyboard
- 10 Mb disk space (more for log files and recorded data files)
- RS-232 serial port for serial cable or USB port for USB cable

System Recommendations

- Microsoft® Windows™ 7 with .NET Framework 2.0 or greater
- SVGA 1024 x 768, High Color (16-bit), Large Fonts or greater
- Keyboard and Mouse
- 50 Mb disk space
- RS-232 serial port for serial cable or USB port for USB cable

ECompassTest Software

The eCompassTest software allows you to use your PC to communicate with the ECL™ eCompass. To install the eCompassTest software, insert the CD into the CD-ROM drive of your PC. If the CD does not autorun, run the eCompassTest Setup.exe application from the Jewell Instruments folder on the CD. The InstallShield® wizard will guide you through the installation process.

During the installation, you may select the folder in which the eCompassTest software will be installed or accept the default folder of C:\Jewell Instruments\eCompassTest. Once you run the eCompassTest software, the LogFiles subfolder will be created to store log files. Once you record data using the eCompassTest software, the RecordedData subfolder will be created to store files of data recorded from the compass. Once you use the zip files option, a ZipFiles subfolder will be created to store the desired files.

Is important to note that starting with Microsoft Windows 7, an application installed in the Program Files or Program Files (x86) folder cannot create or modify folders or files under the Program Files folders. Instead, the subfolders must be stored in the AppData folder structure. For this reason, the eCompassTest installation will default to installing the application in C:\Jewell Instruments\ECompassTest. If you do install the application in a Program Files folder, the LogFiles, RecordedData, and ZipFiles folders, their subsequent files, and application INI and XML files will be stored in the appropriate AppData folder automatically.

The following list describes some of the files placed in the application folder:

- eCompassTest.exe — eCompassTest software application
- eCompassTest.ini — INI file of user-modifiable settings
- eCompassTest Settings.xml — XML file of settings changed by software
- eCompassTest.chm — Help file for eCompassTest software

- CompassLib.dll — Dynamic Link Library for communicating with ECL™ eCompass
- Air.ocx — ActiveX control used for attitude display
- Various DLLs — Dynamic Link Libraries used to accomplish various tasks
- Readme.txt — Readme file explaining installation logic

To remove the eCompassTest software, use the *Add/Remove Programs* or *Uninstall A Program* function from the Control Panel, or run the eCompassTest setup again and choose Remove. Do not simply delete the eCompassTest folder and files. Please note that any log files, recorded data files, or other files created since the software was installed will not be deleted by the uninstall process. Once you have properly uninstalled the software, you may freely delete the additional files.

Preliminary Compass Evaluation

How the ECL™ eCompass is Prepared

After factory calibration, test, and verification, the ECL™ is set up as follows:

- 19200 baud serial data rate
- Run mode – no automatic NMEA data output
- 0.4 s magnetometer time constant (Mag TC)
- 0.8 s pitch and roll time constant (Tilt TC)
- 4.0 s magnetic field alarm time constant (Alarm TC)
- 2.0 s magnetic field alarm acquire time (Acquire Time)
- 5% magnetic field deviation limit (Alarm Limit)
- 1.5 s sample averaging time (used in Sample mode only)
- 35° pitch and roll warning level
- 44° pitch and roll alarm level (heading blanks above this)

The three time constants are for single pole, low-pass IIR filters that are enabled in Run mode. If you switch to Sample mode, these filters are reset and the magnetic field alarm is disabled.

The magnetometer gain is factory set to accommodate a full-scale range of approximately ± 750 mG (± 75 µT). The gain can be reduced to allow more hard-iron without saturating, or it can be increased to provide greater sensitivity. A magnetic calibration procedure must be performed after changing the gain.

Prior to factory calibration, the eCompass is demagnetized to eliminate any residual magnetic fields from the circuit components. If the eCompass is exposed to a strong magnetic field of 10 gauss or more, then it should be demagnetized again before performing a magnetic calibration.

In the Magnetic category of the Settings page, you can see the results of factory calibration of the magnetometer. The X, Y, and Z offsets can only be viewed on this form. X, Y, and Zr are changed automatically after acquiring data using the Calibrate Magnetics option on the Tools menu. The value for Vref will be 32767 if a vertical reference has not been saved. Vref is changed automatically when a good vertical reference is calculated using the “Capture Vertical Reference” option on the Tools menu.

Pitch and Roll Check

This is a simple test to check pitch and roll accuracy near zero degrees tilt. Place the compass on a flat surface and take readings for pitch and roll angles. Now rotate the compass precisely 180° and take another set of readings. The second pitch and roll readings should be the same magnitude but opposite signs of the first, i.e. the sum of the two pitch readings should be zero and the sum of the two roll readings should be zero.

This test is valid even when the flat surface is oriented at a steep angle of 20° to 40°. It does not, however, verify the scale factor accuracy of the tilt sensor. A known angle reference is needed to verify that the scale factor is also correct.

Magnetometer Check

To verify that the magnetometer is calibrated and operating properly, place the compass on a flat surface along the edge of a fixed, non-magnetic straight-edge, like a wooden ruler. Make sure the compass environment is magnetically clean (no motors, ferrous materials, etc.). Using the query button on the View NMEA Sentences page in Sample mode, capture CCD samples to see MagX, MagY, and MagZ measurements from the magnetometer.

Rotate the eCompass and straight edge until either MagX or MagY approaches zero. Once there, hold the straight edge and rotate the eCompass exactly 180° by aligning the opposite side with the straight edge.[1] Capture additional CCD samples to verify that the measurement that was near zero, MagX or MagY, is still near zero and ideally the opposite sign. Any variation should be within 1% of the magnitude of the other measurement which is near full scale.

This technique works with a flat surface at any orientation; it doesn't have to be perfectly level. The test verifies that the magnetometer offset is null. Additional steps can be performed to verify that the full-scale readings for MagX and MagY are the same.

Using the eCompassTest Program

Running the eCompassTest Software for the First Time

The first time you run the eCompassTest software, you will see a dialog similar to the one in Figure 3 prompting you to enter the serial communication port and baud rate. The baud rate defaults to 19200 which is the rate used by the eCompass when it is shipped. Once you have established communication with the eCompass, you will not be prompted in this way unless the software is unable to communicate with the eCompass.

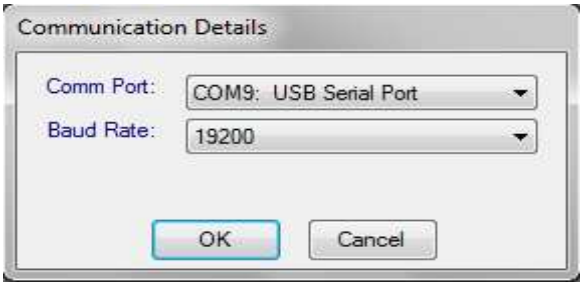


Figure 3

[1] When indoors, rotate the compass so the magnetometer end (opposite connector) stays in the same place. Ferrous material in the building structure can warp the earth's field in a way that changes its magnitude and direction over short distances.

If the software cannot communicate with the compass, you will receive a dialog similar to the one in Figure 4:

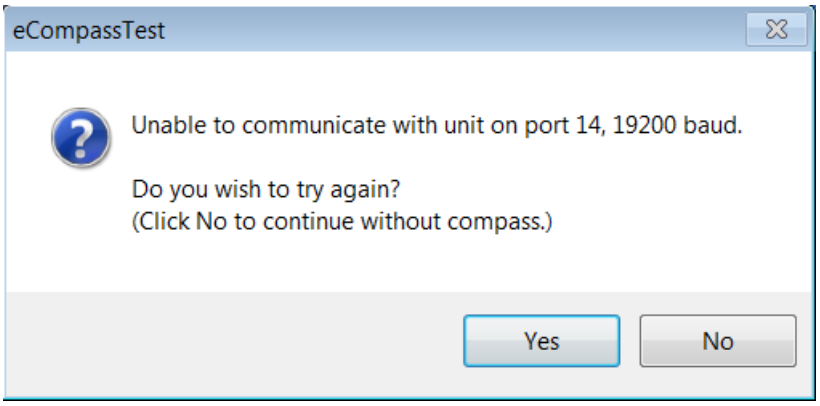


Figure 4

Click Yes from the dialog in Figure 4 to try again. You will be prompted to enter the communication port and baud rate as in Figure 3. Clicking No allows you to proceed without connecting the eCompass.

If the software is able to communicate with the eCompass, a window similar to the one in Figure 5 (showing correct version information for the compass) will appear centered in the application's main window.

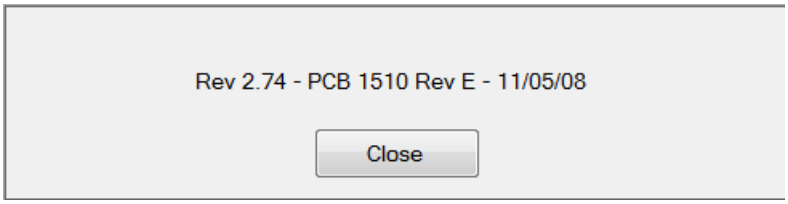


Figure 5

If you choose to proceed without connecting the eCompass, the window in Figure 6 will appear centered in the application's main window.

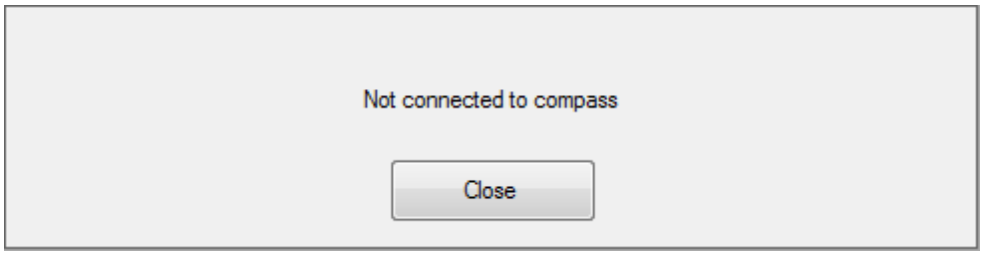


Figure 6

Any menu items and toolbar buttons requiring an eCompass will be disabled, but you will still be able to do the following functions:

- View log information
- View settings log information
- Modify software options
- Reconnect to the eCompass
- Create zip file to be sent to Jewell Instruments for debugging purposes
- View help

Description of the Software Main Screen

The eCompassTest Software Main Screen contains a menu, toolbar, information bar, and a scrollable area to hold application dialogs and windows. The toolbar allows easy access to a subset of the menu items. The information bar shows the Compass ID, Port, Baud rate, unique Unit ID, and Angles value. The Main Screen appears as shown in Figure 7.

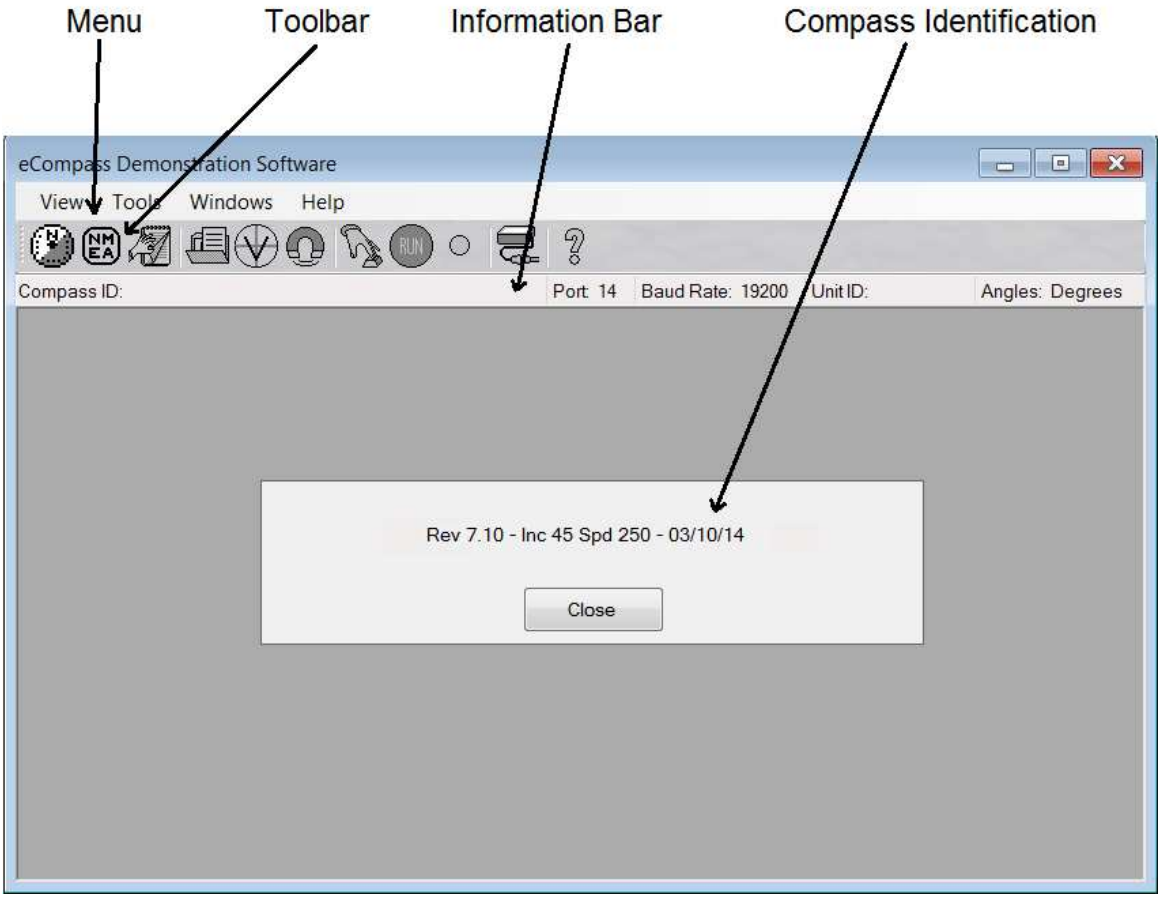


Figure 7

eCompass Installation

Before installing the eCompass, consider the following:

- Verify that the compass performs as expected in a test location free from magnetic interference and mechanical vibration.
- If the target location is free of local magnetic fields (permanent and induced), then the magnetic calibration procedure should not be necessary.
- If a magnetic calibration will be needed, you may need to capture a vertical reference in a magnetically clean location. Refer to the section on Capturing a Vertical Reference. The reference value is used to calculate a Z-axis offset when sufficient pitch and roll cannot be reached for a full 3D calibration.
- If system wiring is going to be used, install the cable before permanently mounting the eCompass.

Location

Choose a location with as little magnetic interference as possible. If there is a lot of ferrous metal, it may be necessary to decrease magnetometer gain to keep the X, Y, and Z signals from saturating. In this case, heading accuracy will decrease. The magnetization of the disturbing material may also change over time, which will require repeated calibrations to maintain eCompass accuracy.

Magnetic fields that arise from 50 or 60 Hz AC currents are significantly attenuated because the eCompass averages magnetometer signals over 18.2 milliseconds, which corresponds to 55 Hz. However, intermittent magnetic fields generated by motors or solenoids being turned on and off may not be compensated. Also, nearby wires carrying DC current can affect the magnetometer. If the generated field is static, it can be compensated. Otherwise, the field may affect the eCompass reading.

Since horizontal components of acceleration affect eCompass accuracy and cannot be compensated, choosing a location near the center of a vehicle is best. For example, mounting the eCompass on a mast to get it away from a ship's steel hull may result in acceptable accuracy only in calm seas. A compromise location that minimizes both influences may yield the best overall performance.

Finally, consider mechanical vibration to minimize its effect on the tilt sensor. Most of the noise caused by a piston engine can be compensated by tuning algorithms in the eCompass firmware. However, it may be desirable to orient the eCompass on an axis that is not aligned with the vehicle so that engine noise affects pitch and roll equally. Use the Deviation setting to electronically shift the heading into alignment with the vehicle.

Mounting

Use brass or stainless-steel screws to secure the compass in place. The label on the ECL™ enclosure indicates directions for positive pitch, roll, and magnetometer readings. The eCompass indicates North when the magnetic field is maximum in the positive X direction, and null in Y.

If the mounting platform is not level, pitch and roll offsets can be zeroed without affecting compass accuracy. An auto-zero function is provided on the tilt settings page in the eCompassTest software. Although it can be mounted in any orientation within range, the best eCompass accuracy is achieved for small tilt angles because scale factor errors do not affect the tilt readings near zero.

Wiring to the Internal Connector (J2)

Perform the following sequence of steps to install the system wiring cable provided in the ECL eCompass kit. If a cover is not required, it can be removed and the MTA connector can simply be plugged into J2 as shown in Figure 8. In this case, the connector will not be retained in place by the cover.

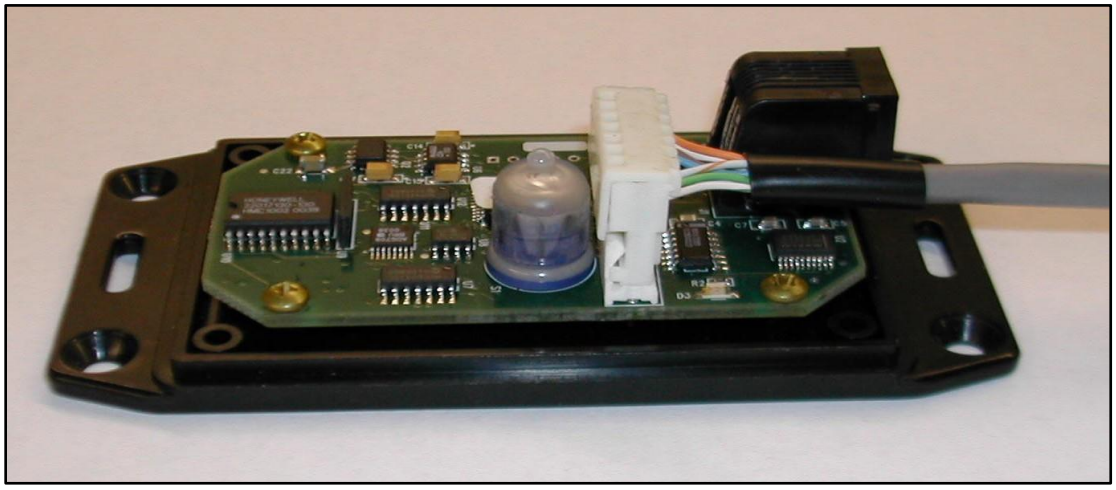


Figure 8

1. Remove the ECL's cover by unscrewing the 4 stainless steel screws from the bottom of the case. If the screws are lost, replace with 10mm, M3-05, flat, Philips-head, non-magnetic #316 stainless. With the screws out, lift the cover first from the end opposite the connectors to remove.

   TAKE CARE. DO NOT DISTURB THE POSITION OF U9.
   This is a vertical, thru-hole IC (HMC1002). Bending this sensor from its factory-set position will invalidate the magnetometer factory calibration.

2. Remove the black, snap-in plug from the 5/16" hole in the cover.
3. Insert a grommet into the hole. Make sure it is properly seated on both sides and that the opening for the wire is uniformly circular.
4. Feed cable (4-pair, #24 AWG, CAT5, non-plenum) through the grommet starting from inside the cover. The entire length of the wire will have to be fed through the grommet.
5. Rotate the wire to align the connector so that it can be plugged into the header on the card. Pin 1 will line up naturally so there is little chance of reversing the connection.
6. Plug the connector onto the 8 J2 header pins, making sure all 8 pins are inside the body of the connector. Also make sure that the connector is fully seated onto the pins.

7. If there will be any tension on the wire, it may be desirable to clamp a plastic cable tie or non-magnetic clamp around the wire on the inside edge of the grommet to relieve strain. Otherwise, cable stress will be transferred directly to the connector.
8. Pitch the cover down at the connector end and work it back over the RJ12 connector until it is properly seated.
9. Turn the eCompass over and replace the 4 stainless steel screws.

Calibrating the eCompass

Once the ECL™ eCompass is mounted in its target location, the detrimental effects of local magnetic fields, both permanent and induced, can be largely compensated. An advantage of an electronic compass over its mechanical predecessor is that the compensation can be performed without additional hardware. A strap-down electronic compass like the ECL can be compensated more precisely than a mechanically gimbaled compass because the magnetometer remains fixed in its surroundings.

Compensation for permanent and induced fields is generally separated and referred to as hard-iron and soft-iron calibration. Hard-iron errors are usually most severe and have the effect of shifting the center of a sphere from the origin within a 3-dimensional coordinate system. The purpose of a hard-iron calibration procedure is to determine where the center of the sphere lies so that appropriate X, Y, and Z offsets can be subtracted from the corresponding magnetometer signals to return the center to the origin. In algebraic form, hard-iron is represented by the a, b, and c coefficients in:

$$(x - a)^2 + (y - b)^2 + (z - c)^2 = r^2,$$

where x, y, and z are orthogonal components of the earth's magnetic field and r is the total field strength, which is an unknown constant.

Soft iron effects distort the shape of the sphere into an ellipsoid. The purpose of a soft-iron calibration procedure is to determine parameters of the ellipsoid, such as the relative lengths of the 3 axes and their orientation in space, so that an appropriate transformation can be generated that will reshape the ellipsoid into a sphere.

In both cases, it can be difficult or impossible to get good calibration data. The compass must remain fixed in its environment (vehicle, robot, boat, etc.) and both must be rotated together in the earth's magnetic field, ideally in all three dimensions. Since the effects of local magnetic fields remain fixed relative to the magnetometer as it rotates, they can be determined and compensated.

Since a boat or vehicle of any size cannot be inverted, Jewell Instruments offers a two-step calibration that relies on first acquiring a vertical reference outside the influence of the vehicle, then performing a simple, two-dimensional rotation while roughly level to determine all three components of hard iron. The rotation can be performed continuously, or individual samples can be captured. In both cases,

the data collection algorithms are designed to ensure that in-range data from a complete rotation is collected before being analyzed.

The eCompassTest software also implements “least squares” algorithms that determine both hard-iron and soft-iron compensation coefficients. For 2D data collection, a minimum of 7 sampled data points or one complete rotation is required. After data is collected and new coefficients are calculated, the variation in total magnetic field is calculated using both old and new coefficients to determine which are best. Results are presented with suggested best choices for the user to accept or override.

For the case where it is possible to collect good 3D data, the eCompassTest PC software also offers an option for 3D hard and soft iron compensation. After collecting 3D data, the software calculates a set of 9 independent coefficients that best compensate for both sources of error. The iterative algorithm works to find the ellipsoid that best fits the collected data by minimizing the sum of the squared geometric distances between the collected data and the parametric ellipsoid.

Capturing a Vertical Reference

Select Capture Vertical Reference from the Tools menu to see a dialog (Figure 9) that instructs you on obtaining a vertical reference.

You may adjust the number of units per division on the vertical scale of the graph, the number of readings to be taken, and whether or not the graph will update automatically; however, you cannot modify these values while collecting data. If you notice that the PC cannot keep up with the incoming data (on slower computers) and that you cannot stop the data collection, turn off the automatic update option. In this case, the PC will not be bogged down with updating the graph during data collection, and the graph will be drawn once after all data has been collected.

Locate the compass in an open place away from large metallic objects or structures, position the compass approximately level, and click the Read Data button. As valid readings are taken, the graph will plot the value (if automatic update is enabled), and the status bar will show progress. Once the specified number of readings have been taken, the Vertical Reference is calculated based on the data. You may then choose to apply the new value.

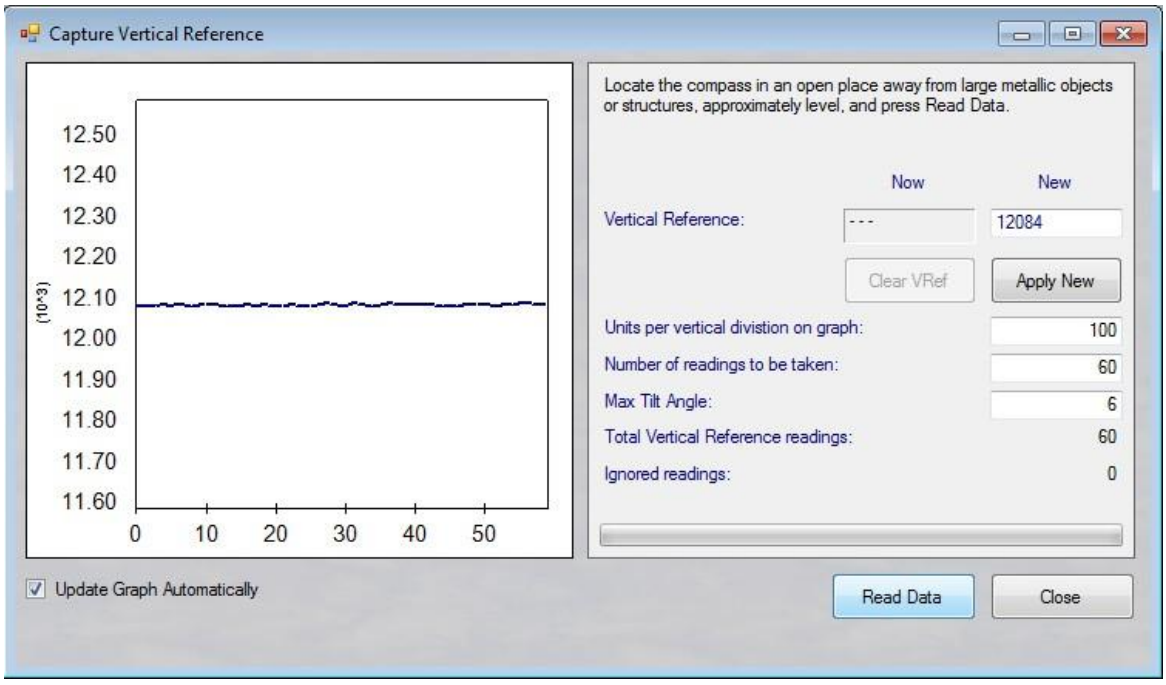


Figure 9

External Magnetic Calibration

Select Calibrate Magnetics from the Tools menu to perform magnetic calibration using the software algorithm residing on the computer being used. You may select 3D data geometry where sample points are not coplanar or 2D where sample points are in an approximate horizontal plane. Use 3D only when large tilt angles can be achieved to generate enough variation in Z-axis data to produce a reliable offset. Use 2D if the compass is mounted in a boat, truck, RV, or other vehicle that only operates near level. If you have captured a vertical reference, you may select 2D with Vertical Reference where Vref is used in combination with a measured component to estimate the Z Offset.

Once you have selected the data geometry option, select the data collection option: Capture Every [n] Readings, Capture Readings Every [n] Degrees of Rotation (2D only), or Multi-step Samples Triggered Manually. Based on the selected option, you may specify various values such as the number of readings to take, the number of degrees between captures, the number of readings to average for each captured sample, etc.

The relationship between “Readings [n] to skip between captures” and ”Number of readings to take” is important for timed data collection. The reading rate is 825 per minute and the maximum number of readings to take is 3000. If n=0 (no skipping) and the number of readings to take is 850 (default value), then the capture sequence will complete in a little over a minute. During this time, the compass carrier must be maneuvered through at least one rotation to collect a complete set of magnetic data. If the maneuvering will take longer, either n or the total number of readings to take can be increased.

The software will record three files in the LogFiles subfolder:

1. a data file containing the data that was collected, CalData
2. a results file containing the results of the calibration, CalResults
3. an intermediate file containing progress data, CalProgress

These files contain information that can help to diagnose calibration issues.

3D (Figure 10)

To collect continuous 3D data where sample points are not coplanar, select the “Capture every [n] readings” option, begin rotating, pivoting, and rolling the unit, and click the Start button. Three histogram style graphs show the X, Y, and Z data distribution as it is being captured. During data collection, use the Pause/Resume button to suspend/resume taking readings. Once you have collected the specified number of readings, data collection will stop and results will be calculated. The Finish button is enabled after ten readings have been collected, but it may be necessary to collect many more than this minimum number to produce accurate results.

To manually collect 3D data, select the “Multi-step samples triggered manually” option and specify the number of readings to average for each captured sample. After clicking the Start button, position the eCompass at different fixed positions and click the Sample button to take each sample. Three histogram style graphs show X, Y, and Z data distribution as it is being captured. The Finish button is enabled after ten samples have been collected, but it may be necessary to collect many more than this minimum number to produce accurate results.

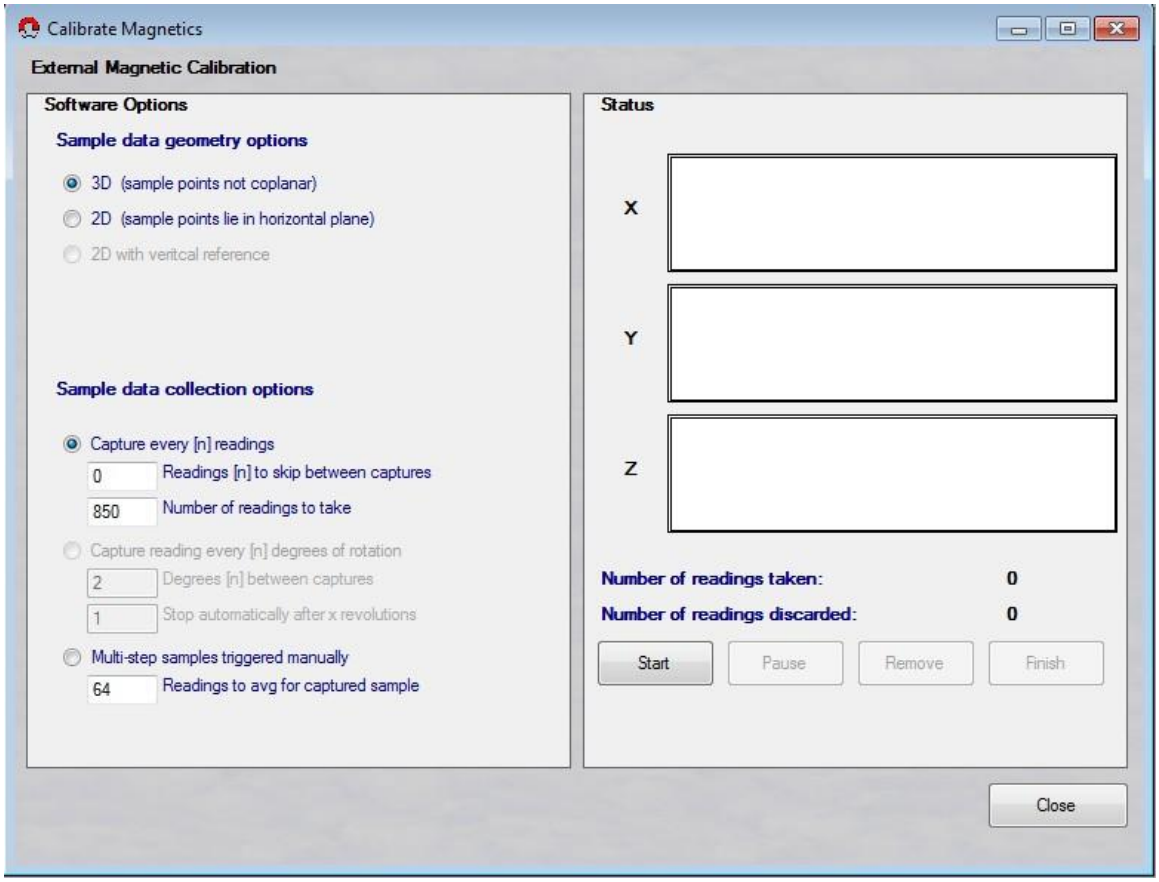


Figure 10

2D or 2D With Vertical Reference (Figure 11)

To collect 2D data continuously in a circle, select the “Capture every [n] readings” option and specify the number of readings to take and the number of readings to skip between captures. Begin rotating the eCompass and click the Start button. A series of blue dots will be drawn on the circular graph to plot the data points. During data collection, use the Pause/Resume button to suspend/resume taking readings. Once you have collected the specified number of readings, data collection will stop and results will be calculated. The Finish button is enabled after six readings have been collected, but it may be necessary to collect many more than this minimum number to produce accurate results.

To collect 2D data based on angle, select the “Capture reading every [n] degrees of rotation” option and specify the number of degrees between captures and the maximum number of rotations. Begin rotating the eCompass and click the Start button. A series of blue dots will be drawn on the circular graph to plot the data points. Once you have completed the specified number of rotations, data collection will stop and results will be calculated. The Finish button is enabled after six readings have been collected, but it may be necessary to collect many more than this minimum number to produce accurate results.

To manually collect 2D data, select the “Multi-step samples triggered manually” option and specify the number of readings to average for each captured sample. After clicking the Start button, position the eCompass at different fixed positions and click the Sample button to take each sample. On the circular graph, discarded readings will appear as gray dots, and each collected sample is drawn as a blue X. The Finish button is enabled after six samples have been collected, but it may be necessary to collect many more than this minimum number to produce accurate results.

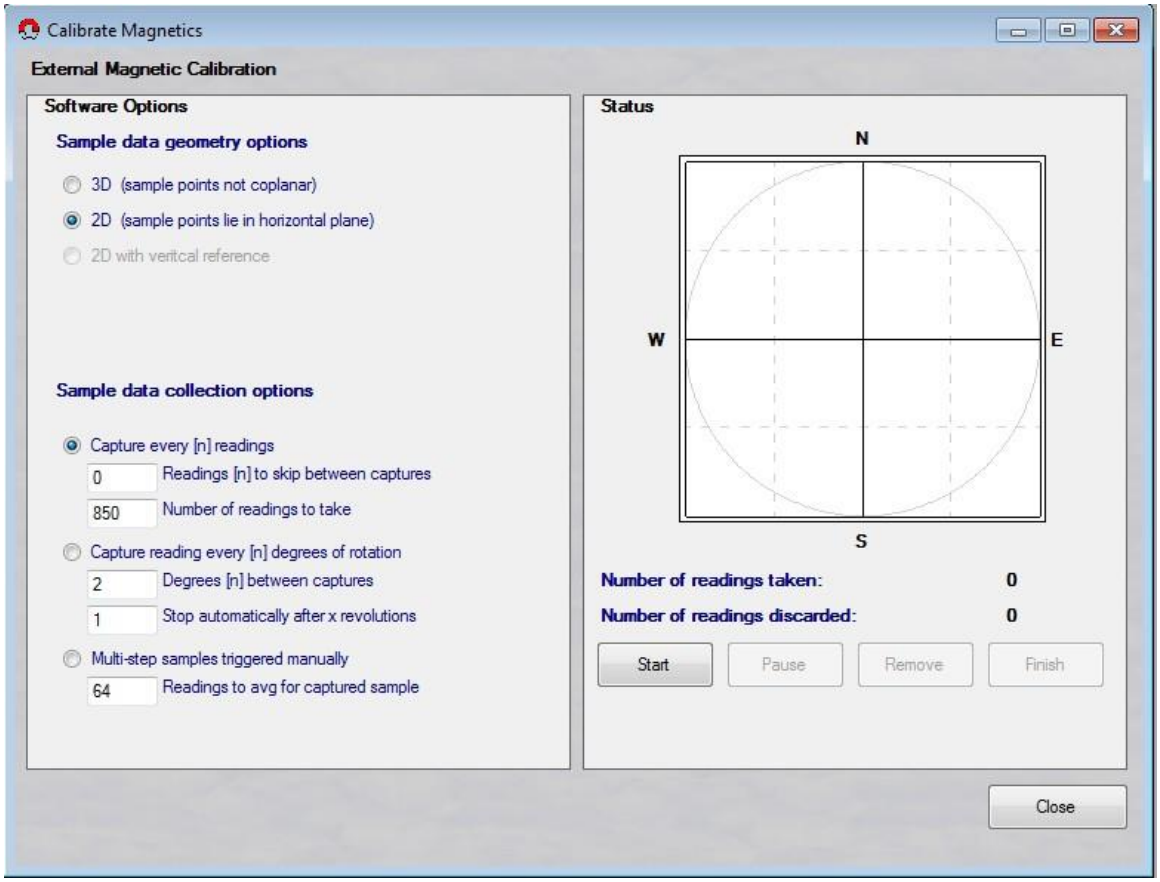


Figure 11

If you have trouble performing a magnetic calibration on the eCompass, this may mean that the magnetic settings have been corrupted. In this case, you can Reset the Magnetic Calibration to restore the factory default magnetic settings. You will then need to successfully perform a magnetic calibration. Use this option with caution!

External Magnetic Calibration Results

If the new results produce less variation in total magnetic field strength than the old, then the new offsets will be shown in boldface, and the Use New button will be highlighted similar to Figure 12. Likewise, if the application of soft-iron gains produces the least variation, the Use Soft Iron Gains checkbox is checked. Either or both of these can be overridden. You can toggle between using the old and new values by clicking the Use Old and Use New buttons, respectively.

The value labeled Mag Total 3 Sigma in the dialog is a percentage that means that 97% of the calculated total field magnitudes fell within a range centered on the average, plus or minus the indicated percent of average. It indicates the calculated variation with and without soft-iron, depending on whether the Use Soft Iron Gains checkbox is checked.

The value labeled Ellipticity is the percentage difference between the major and minor axes of the calculated ellipse that best fits the data. The value shown is 100 times the ratio of the major axis divided by the minor axis. For 3D soft iron, the ratio is between the longest and shortest of the three axes. Using soft-iron compensation will not be suggested if the two axes differ by less than 0.5%.

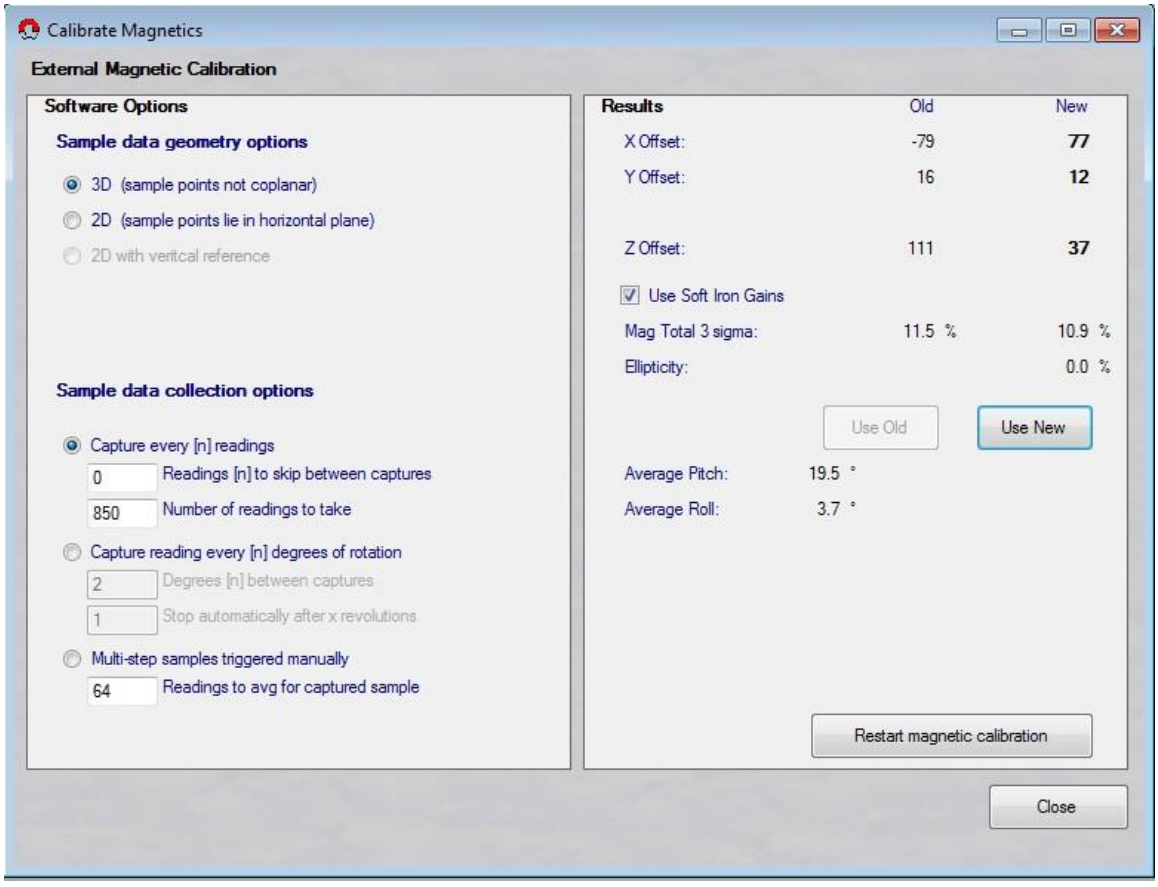


Figure 12

External Magnetic Calibration Settings

The CalMag section of the eCompassTest.INI file contains various settings that affect external magnetic calibration. Most of these settings correspond to the data geometry and data collection options on the external magnetic calibration screen. However, the following settings are configurable only in the INI file:

CalMagTC

Smoothing time constant for calculated magH

CalNumAvg2DTilt

Number of tilt readings to average on both sides of each data point

CalSoft3DMaxIter

Number of iterations before aborting soft-iron algorithm

CalBeforePauseIgnoreCount

Number of CCD sentences to discard before pausing data collection

CalIgnoreCount

Number of CCD sentences to ignore when data collection starts initially or resumes after being paused

CalTimeoutCount

Number of CCD sentences to capture before terminating automatically

CalVrefMaxTilt

Maximum tilt angle for averaging calculated vertical magnetic component to determine Z hard iron