

The background of the document is a photograph of a ship's deck. In the foreground, there is a large coil of thick, light-colored rope. To the left, a dark metal structure, possibly part of a winch or a railing, is visible. The background shows the sea and a bright sky, with a blue tint applied to the entire image.

# EdgeTech SSAHRS compass description

Electronics and the command system

Rev. 202303

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## Contents

1	Introduction .....	4
2	SSAHRs compass .....	5
2.1	Summary .....	5
2.2	Description of Calibration .....	6
3	Edge tech: Calibrating the Compass .....	8
3.1	Commands and procedure description .....	8
3.2	Changing the Angle of Declination (Earth magnetic field).....	10
4	SSAHRs commands description .....	11
4.1	stop .....	11
4.2	start .....	11
4.3	restart.....	11
4.4	resetDefaults.....	11
4.5	getVersion .....	11
4.6	setMode .....	11
4.7	getMode.....	11
4.8	getModeFormat.....	12
4.9	setOutputMode .....	12
4.10	getOutputMode .....	12
4.11	setBaudRate .....	12
4.12	getBaudRate.....	12
4.13	setHeadingReference.....	13
4.14	getHeadingReference .....	13
4.15	setGain .....	13
4.16	getGain.....	13
4.17	setSerialNumber .....	13
4.18	getSerialNumber .....	13
4.19	setOutputRate.....	13
4.20	getOutputRate .....	14
4.21	setFilterCutoff .....	14
4.22	getFilterCutoff.....	14
4.23	setAlgorithm .....	14
4.24	getAlgorithm .....	14
4.25	setInstallOrientation .....	14
4.26	getInstallOrientation.....	15
4.27	setMagnetometerFieldRange .....	15
4.28	getMagnetometerFieldRange .....	15

4.29	setGyroscopeFullScale .....	15
4.30	getGyroscopeFullScale .....	15
4.31	setAccelerometerRange .....	15
4.32	getAccelerometerRange .....	15
4.33	getAccelerometerSensitivity .....	16
4.34	getGyroscopeSensitivity.....	16
4.35	getMagnetometerSensitivity .....	16
4.36	setCoefficients .....	16
4.37	getCoefficients .....	16
4.38	getCurrentBias .....	16
4.39	getCurrentAlignment .....	17
4.40	getCurrentSensitivity .....	17
4.41	setAutoCompassCalibration.....	17
4.42	getAutoCompassCalibration .....	18
4.43	getCurrentCompassCalibration.....	18
4.44	setLevel2CompassCalibrationFromCurrent .....	18
4.45	setLevel2CompassCalibration .....	18
4.46	getLevel2CompassCalibration.....	18
4.47	setLevel3CompassCalibrationFromCurrent .....	19
4.48	setLevel3CompassCalibration .....	19
4.49	getLevel3CompassCalibration.....	19
4.50	setDeclination .....	19
4.51	getDeclination .....	20
4.52	setFitRange .....	20
4.53	getFitRange .....	20
4.54	setAttitudeBias.....	20
4.55	getAttitudeBias .....	20

## 1 Introduction

EdgeTech SSS-fishes use three types of compasses:

- Oldest one, the OceanServer precision 3-Axis Tilt Compensated compass (ET4200);
- From 2014 or 2015 year, SSAHRS compass (ET4200, ET4125);
- From 2019 or 2020 year, "MEMS-based, upgraded compass in 4205 towfish".

***OceanServer compass*** is described in the document Digital Compass User's Guide, OS5000-S & OS5000-US / REVISION 2.0 / 2007 OceanServer Technology, Inc, 151 Martine St, Fall River, MA 02723 USA:

"The OS5000 family of compasses uses high precision Anisotropic Magneto-resistive magnetic 3 axis sensors from Honeywell to measure the earth's magnet field. The Z-axis measurement allows the compass to calculate azimuth when the compass is tilted at an angle. These sensors are solid state and can survive being dropped from the sky. To increase the resolution and accuracy of measurements the designs utilize state of the art 24 bit differential AD converters and advanced digital filtering to provide the highest accuracy the sensors can provide.

The tilt measurement provides the roll and pitch information for attitude. The attitude is used to mathematically gimbal the compass for true azimuth measurements when the device is not level. The tilt measurement is made with three axis digital accelerometers from STM. These sensors measure the gravity vector in three axes allowing an accurate calculation of roll and pitch angle. These solid-state accelerometers replace the older electrolytic liquid level sensors providing much greater accuracy as well the ability to withstand 10,000 G shocks."

There is no documentation describing the ***SSAHRS compass***.

**This document has been prepared to describe the electronics of the SSAHRS compass and the command system.** It is based on information from the Internet and help-messages from the compass software. A calibrated SSAHRS compass gives good results for the SSS-heading (see SSS heading issues, Vol. 10-05).

MEMS-based, ***upgraded compass in 4205 towfish***, is shortly described in the document Technical Note: Compass in a Side Scan Sonar ©2020 EdgeTech (no other description found in the public domain):

"The introduction of the 4205, has given us an opportunity to improve the performance of the heading sensor, by fitting a MEMS-based inertial motion sensor unit that combines data from built-in gyroscope, accelerometer, and magnetic field sensors. The data inputs are combined in a Kalman filter, so whilst it still uses the magnetic field sensors to determine magnetic north, the use of the rate gyro inputs means that the resultant output does not suffer from the noise issues of a purely magnetic sensor system. So whilst the absolute heading is still reliant on magnetic field measurement, and as such subject to some of the limitations outlined above, the incorporation of other sensor data means that the relative heading is much more stable, and overall the sensor provides a more reliable output that is less susceptible to short term magnetic field variations."

In the latest versions of the ET4200 documentation (2023), EdgeTech does not recommend the use of previous types of compasses for SSS heading and has removed the text about SSAHRS compass calibration. However, the documentation for ET4125 does not contain such recommendations and the text with the SSAHRS compass calibration procedure is retained.

## 2 SSAHRS compass

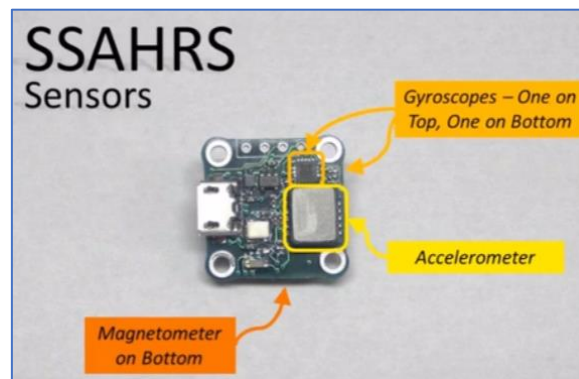
<https://www.kickstarter.com/projects/1978512181/solid-state-attitude-and-heading-reference-system/description>

### 2.1 Summary

The SSAHRS is a very small, highly accurate electronic device that produces pitch, roll and yaw (heading) measurements one hundred times per second. It contains precision sensors and advanced algorithms that produce high quality results even in moving systems. Factory calibration is sufficient to achieve this, but for the most discriminating applications we provide the tools to go even further.

The SSAHRS produces an overall accuracy of  $1^\circ$  (2sigma) in pitch and roll and nominal  $1^\circ$  (1sigma) in heading. Heading accuracy depends on the magnetic environment, however our built-in hard/soft iron magnetic calibration algorithms help minimize the effects.

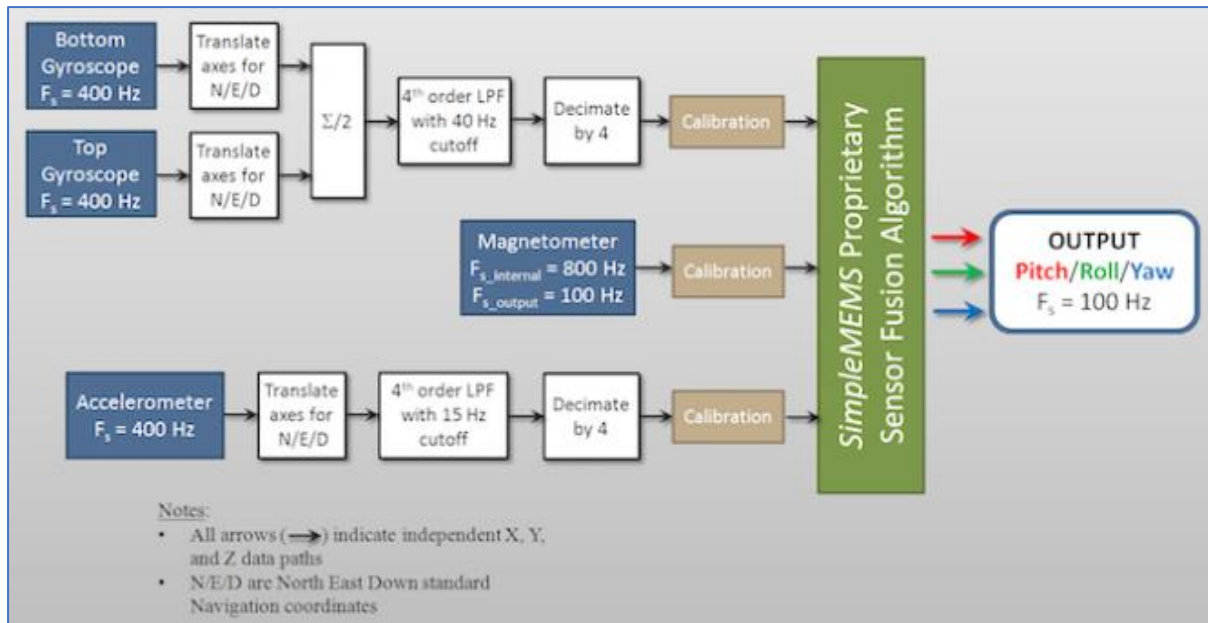
An Attitude Heading and Reference System (AHRS) is a device capable of measuring heading (yaw), pitch, and roll angles of an object moving through three-dimensional space. Data from three different sensors: a magnetometer, accelerometer, and gyroscope (Figure 1) are fused to calculate pitch, roll, and yaw of a moving body. In static conditions, where the system is stationary, pitch and roll can be completely and accurately determined using just a high-quality accelerometer. Heading comes from using the accelerometer to find the gravity vector (i.e. “down”), then translating the three-axis magnetometer to get heading in the horizontal axes.



Calculations under these conditions are fairly trivial. However, once the AHRS begins to move through space these calculations no longer apply. As an example, think of the three-axis accelerometer on an AHRS that is tossed into the air. Since it is in free flight, all axes on the accelerometer will read exactly zero. Thus, both pitch and roll are undefined, and the magnetometer output cannot be translated to the horizontal plane. Sensor fusion algorithms use these two sensors plus a three-axis gyroscope to form the solutions.

Our AHRS implementation, the SSAHRS, uses an advanced quaternion-based sensor fusion algorithm to continue the solution as the pitch reaches  $90^\circ$ . Platform motion is tracked without singularity. Quaternion processing is unnecessary in applications where the pitch is limited in range, such as marine vessels and non-aerobatic aircraft. In these cases, the simpler Euler Angles approach may be used.

Below is a flow chart showing the flow of the MEMS sensor signals used in ssAHRS. The design is optimized to reduce sensors noise to maximize performance. Note that two MEMS gyroscopes are used in the SSAHRS. The purpose of this is twofold: 1) improve the gyro's vibration immunity over that of a single gyro and 2) help remove biases that may present in any of the gyro's three axes.



## 2.2 Description of Calibration

The acceleration, magnetic field and rotation sensors in the SSAHRS are all microelectromechanical Systems (MEMS) devices. These consist of real mechanical systems and sensing electronics fabricated in silicon, similar to the manufacturing process for typical integrated circuits. While silicon manufacturing is quite precise, a number of different characteristics result in variations from one silicon wafer to the next or from one region of a silicon wafer to another. These result in differences in performance characteristics from one MEMS device to another. In addition, all mechanical systems and sensing electronics will exhibit some degree of temperature dependence, resulting in non-ideal behaviour.

All of these sources of error get added together and ultimately result in increased error mean (bias) and standard deviation (noise). The goal of calibration is to remove these effects and reduce the system bias and noise.

The figure below shows a commonly accepted way of describing coefficients that can help correct for the main sources of error in each of the three MEMS devices.

- **Bias:** This is the most significant source of error. In the presence of zero driving force (example: a gyroscope undergoing no rotation), sensors which are sampled many times will still produce a non-zero average result. The B parameters correct for this.
- **Gain:** Assuming that the sensor produces data that is linear with what it is sensing (which is a good approximation), there will be some error in the slope of the linear relationship. The S parameters correct for this.
- **Cross-axis:** In theory, the X, Y, and Z axes are perfectly orthogonal to each other. Another way of saying this is that the X axis is 90 degrees off from Y, and both X and Y are 90 degrees off from Z. In practice, there may be deviation from this. The M parameters are experimentally generated and correct for cross-axis error.

$$\begin{array}{c}
 \text{Calibrated Sensor} \\
 \text{Output} \\
 \left[ \begin{array}{c} O_x \\ O_y \\ O_z \end{array} \right] = \underbrace{\begin{bmatrix} 1 & M_{xy} & M_{xz} \\ M_{yx} & 1 & M_{yz} \\ M_{zx} & M_{zy} & 1 \end{bmatrix}}_{\text{Cross-Axis Correction Factors}} \underbrace{\begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & S_z \end{bmatrix}}_{\text{Gain Correction Factors}} * \underbrace{\left( \begin{bmatrix} I_x \\ I_y \\ I_z \end{bmatrix} - \begin{bmatrix} B_x \\ B_y \\ B_z \end{bmatrix} \right)}_{\text{Uncalibrated Sensor raw Output}} \\
 \text{Inherent Sensor Bias offset}
 \end{array}$$

In practice the majority of error can be removed by correcting for the inherent sensor bias. The SSAHRS is factory calibrated to remove these biases. Algorithms for generating the gain and cross-axis correction coefficients as well as instructions for uploading them will be provided with the SSAHRS documentation package.

Accelerometer calibration over temperature is accomplished with piecewise linear approximation of the sensor offset. Offset is measured in the factory at room temperature. Hot and Cold temperatures are then extrapolated to generate offset for each axis as a function of temperature.

Magnetometer calibration is accomplished upon installation in the target system (drone aircraft, camera stabilizer, etc.) by rotating around a circle to remove hard iron (ferrous metal) and soft iron (electromagnetic field) effects. The sensor collects magnetic field data and calculates calibration coefficients automatically.

#### Factory Calibration

Prior to deliver the SSAHRS will be calibrated for the most significant sources of error contributing to pitch, roll, and yaw inaccuracies: Accelerometer, magnetometer and gyroscope sensor bias offsets  $B_x$ ,  $B_y$ ,  $B_z$ . Appropriate values will be programmed into sensor non-volatile memory and provided with included calibration documentation.

#### User calibration

Accurate calibration of the magnetic sensor necessitates in-situ calibration. Geomagnetic fields are significantly disrupted by the presence of nearby ferrous metals and by any electromagnetic fields. A common source of error-inducing electromagnetic fields is electrical current traveling through unbalanced (non-coaxial) wire in the vicinity of the magnetometer. The factory calibration can remove any error in the sensor chip and SSAHRS, but it is up to the user to calibrate out effects of the system in which the SSAHRS is installed. The procedure for performing this calibration will be clearly provided in the SSAHRS documentation.

In addition to these error sources, the user may also calibrate each sensor in the SSAHRS for cross-axis error ( $M_x$ ,  $M_y$ ,  $M_z$ ) and gain factor ( $S_x$ ,  $S_y$ ,  $S_z$ ). Though these error sources are minor in comparison to the bias errors, they still do contribute to the overall system error.

The SSAHRS is also set up to be calibrated for temperature. A piecewise linear approximation is used at three temperatures: Hot, room temperature, and cold. The precise values of the hot and cold temperatures are not critical, but it is suggested that they be at or beyond the temperature extremes that the SSAHRS will see in your particular application.

### 3 Edge tech: Calibrating the Compass

[https://www.edgetech.com/wp-content/uploads/2019/07/0004823\\_Rev\\_H.pdf](https://www.edgetech.com/wp-content/uploads/2019/07/0004823_Rev_H.pdf)  
0004823\_REV\_H. 4125i/4125 SIDE SCAN SONAR SYSTEM USER HARDWARE MANUAL.  
January 7, 2021

#### 3.1 Commands and procedure description

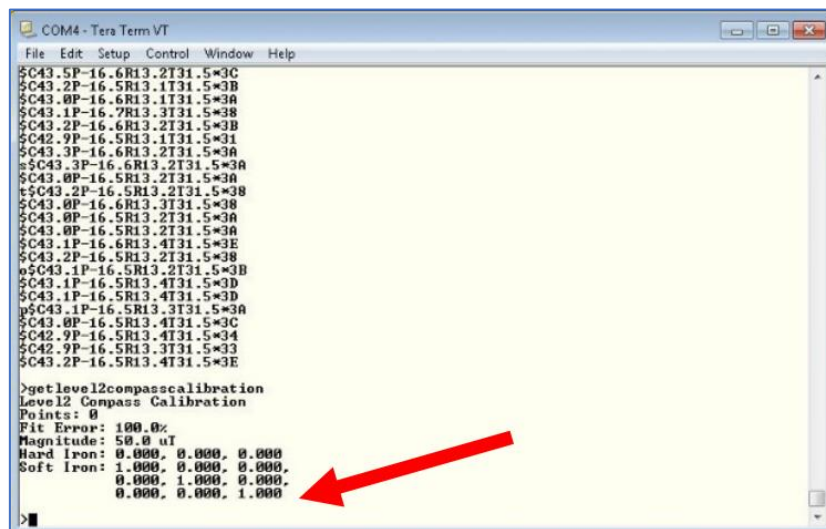
1. ... 6. Open Remote Desktop application and start Tera Term command console (COM 4).
7. Stop the device (SSAHRs) and retrieve the current level 2 (factory) calibration using the following two commands.

> stop <CR>

> getLevel2CompassCalibration <CR>

**Warning!!! Record (photograph or copy) the calibration coefficients. In case of a failed calibration, you will be able to restore them to their "current state".**

8. Ensure that the points are 0, the error percentage is 100.0%, the hard iron values are all 0.0, and that the soft iron values are an identity matrix.



```
COM4 - Tera Term VT
File Edit Setup Control Window Help
$C43.5P-16.6R13.2T31.5*3C
$C43.2P-16.5R13.1T31.5*3B
$C43.0P-16.6R13.1T31.5*3A
$C43.1P-16.7R13.3T31.5*38
$C43.2P-16.6R13.2T31.5*3B
$C42.9P-16.5R13.1T31.5*31
$C43.3P-16.6R13.2T31.5*3A
s$C43.3P-16.6R13.2T31.5*3A
$C43.0P-16.5R13.2T31.5*3A
t$C43.2P-16.5R13.2T31.5*38
$C43.0P-16.6R13.3T31.5*38
$C43.0P-16.5R13.2T31.5*3A
$C43.0P-16.5R13.2T31.5*3A
$C43.1P-16.6R13.4T31.5*3E
$C43.2P-16.5R13.2T31.5*38
o$C43.1P-16.5R13.2T31.5*3B
$C43.1P-16.5R13.4T31.5*3D
$C43.1P-16.5R13.4T31.5*3D
p$C43.1P-16.5R13.3T31.5*3A
$C43.0P-16.5R13.4T31.5*3C
$C42.9P-16.5R13.4T31.5*34
$C42.9P-16.5R13.3T31.5*33
$C43.2P-16.5R13.4T31.5*3E

>getLevel2CompassCalibration
Level2 Compass Calibration
Points: 0
Fit Error: 100.0%
Magnitude: 50.0 uT
Hard Iron: 0.000, 0.000, 0.000
Soft Iron: 1.000, 0.000, 0.000,
          0.000, 1.000, 0.000,
          0.000, 0.000, 1.000
```

If for some reason they are not; reset SSAHRs with the following command and **then cycle power.**

> setLevel2CompassCalibration,factory2015,0,100.0,50.0,0,0,0,1,0,0,0,1,0,0,0,1 <CR>

9. Restart the SSAHRs by issuing the following command, to start compass data:

> start <cr>

Heading, Pitch, Roll, and Temperature should begin to scroll.

10. Slowly move the vehicle around in such a fashion as to position the compass in as many possible orientations as possible for pitch, roll, and heading directions.

- a. UUT in a neutral position: Pitch/Roll  $\sim 0$  degrees, rotate device thru 360 degrees of heading (10 times)
- b. UUT in Pitch/Roll  $\sim -90$  degrees rotate device thru 360 degrees of heading (10 times)
- c. UUT in Pitch/Roll  $\sim +90$  degrees rotate device thru 360 degrees of heading (10 times)





11. At the serial console, execute the following commands:

> stop <CR>

> getCurrentCompassCalibration <CR>

12. The compass solution will be displayed to the user, as well as the number of points, magnitude of the magnetic field at this location, and the fit error. If the solution is not viable, the device should be returned to streaming with the start <CR> command, and steps 8 through 10 should be repeated until the fit error is  $\leq 1.0\%$  and Points is  $> 100$ .

a. Valid solution:

```
>getlevel2compasscalibration
Level2 Compass Calibration
Points: 152
Fit Error: 0.9%
Magnitude: 47.6 uT
Hard Iron: -3.398, -2.457, -0.513
Soft Iron: 0.975, 0.000, 0.000,
           0.000, 1.016, 0.000,
           0.000, 0.000, 1.009
>
```

b. If the solution was acceptable, Fit Error  $\leq 1.0\%$  record and provided product engineer along with the vehicle type. Finally, save the data into the factory calibration (level2) portion of the device with the following command, then cycle power:

> setLevel2CompassCalibrationFromCurrent, factory2015 <CR>

c. Verify Factory Compass Calibration has been set by issuing the following commands:

> Stop <CR>

> getLevel2CompassCalibration

13. At this point, the SSAHRS calibration is complete. Close the Remote Desktop application.

### 3.2 Changing the Angle of Declination (Earth magnetic field)

The compass angle of declination is set to true north at the EdgeTech facility. However, to provide a more accurate target location, it is necessary to enter the known magnetic declination for the survey location into the compass as follows:

1. Repeat steps 1 through 6 in the Calibration procedure in the CALIBRATING THE COMPASS section.
2. Verify current Declination Angle of Deviation using the following command:

```
> getDeclination <CR>
```

3. Enter the set declination command to get help for command:

```
> setDeclination, [D]
```

Where [D] is Declination angle (degrees), which is the correction between magnetic north and true north. This value depends on geographic location.

For example, enter the Declination Angle using the command:

```
> setDeclination, 14.47 <CR>
```

4. Verify entry of declination Angle using the command:

```
> getDeclination <CR>
```

## 4 SSAHRS commands description

Help for Software version 2.02.

An uncalibrated compass was used to obtain examples of "answers".

### 4.1 stop

stop

Description: stop measurements

### 4.2 start

start

Description: start measurements

### 4.3 restart

restart

Description: restart measurements (???)

### 4.4 resetDefaults

resetDefaults, [SN]

Description: resets device settings to default (from fabric???)

>resetDefaults

resetDefaults, [SN]

[SN]: Serial number of the device

### 4.5 getVersion

getVersion

Description: get hardware and software version.

>getVersion

Solid State Attitude and Heading Reference System (SSAHRS)

Hardware Revision: C

Software Version: 2.02

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### 4.6 setMode

setMode, [RAW|SENSOR|LEVEL1|LEVEL2|LEVEL3|LEVEL4|QUATERN|EULER]

Description: ---

>setMode

setMode, [MODE]

[MODE]: Sensor level data, level1 calibrated data, level2 calibrated data, level3 calibrated data, or fused euler angles(RAW|SENSOR|LEVEL1|LEVEL2|LEVEL3|LEVEL4|QUATERN|EULER)

### 4.7 getMode

getMode

Description: ---

>getMode

Mode, EULER

#### 4.8 getModeFormat

getModeFormat, [RAW|SENSOR|LEVEL1|LEVEL2|LEVEL3|LEVEL4|QUATERN|EULER]

Description: ---

>getModeFormat, [MODE]

[MODE]: Sensor level data, level1 calibrated data, level2 calibrated data, level3 calibrated data, or fused euler angles(RAW|SENSOR|LEVEL1|LEVEL2|LEVEL3|LEVEL4|QUATERN|EULER)

#### 4.9 setOutputMode

setOutputMode, [LEGACY|MODERN]

Description: ---

>setOutputMode

setOutputMode, [M]

[M]: Legacy or modern output mode (LEGACY|MODERN)

> setOutputMode, MODERN

\$PRY,+00.8,-000.5,+158.5

\$PRY,+00.8,-000.5,+159.2

\$PRY,+00.8,-000.5,+158.7

\$PRY,+00.8,-000.5,+159.4

> setOutputMode, LEGACY

\$C147.6P0.9R-0.6T16.0\*04

\$C147.8P0.9R-0.6T16.0\*0A

\$C147.5P0.9R-0.6T16.0\*07

\$C148.2P0.9R-0.7T16.0\*0E

#### 4.10 getOutputMode

getOutputMode

Description: ---

>getOutputMode

OutputMode, MODERN

>getOutputMode

OutputMode, LEGACY

#### 4.11 setBaudRate

setBaudRate, [B]

Description: ---

>setBaudRate

setBaudRate, [B]

[B]: Baud rate (bps) between 4800 and 921600

#### 4.12 getBaudRate

getBaudRate

Description: ---

>getBaudRate

baudRate, 115200

#### 4.13 setHeadingReference

setHeadingReference, [MN|TN]

Description: ---

>setHeadingReference

setHeadingReference, [HR]

[HR]: Whether the heading is in reference to magnetic north or true north (MN|TN)

#### 4.14 getHeadingReference

getHeadingReference

Description: ---

>getHeadingReference

HeadingMode, TRUE\_NORTH

#### 4.15 setGain

setGain, [GAIN]

Description: ---

>setGain

setGain, [GAIN]

[GAIN]: Gain value between 0.01 and 0.50

#### 4.16 getGain

getGain

Description: ---

>getGain

Gain, 0.12

#### 4.17 setSerialNumber

setSerialNumber, [PWD], [SN]

Description: ---

>setSerialNumber

setSerialNumber, [PWD], [SN]

[PWD]: Password

[SN]: Serial number between 0 and 99999999

#### 4.18 getSerialNumber

getSerialNumber

Description: ---

>getSerialNumber

SerialNumber, 00000544

#### 4.19 setOutputRate

setOutputRate, [OR]

Description: ---

>setOutputRate

setOutputRate, [OR]

[OR]: Values evenly divisible into 400 between 1 and 400 Hz. The maximum value is a function of the baud rate

#### 4.20 `getOutputRate`

`getOutputRate`

Description: ---

`>getOutputRate`

OutputRate, 10

#### 4.21 `setFilterCutoff`

`setFilterCutoff`, [FC]

Description: ---

`>setFilterCutoff`

`setFilterCutoff`, [FC]

[FC]: Value between 1.0Hz and 50.0Hz

#### 4.22 `getFilterCutoff`

`getFilterCutoff`

Description: ---

`>getFilterCutoff`

Filter Cutoff, 4.166700 Hz

#### 4.23 `setAlgorithm`

`setAlgorithm`, [AHRS|IMU|AHRSDC]

Description: ---

`>setAlgorithm`

`setAlgorithm`, [ALG]

[ALG]: Attitude and heading reference system, Inertial measurement unit, or Attitude and heading reference system de-coupled (AHRS|IMU|AHRSDC)

#### 4.24 `getAlgorithm`

`getAlgorithm`

Description: ---

`>getAlgorithm`

Algorithm, AHRSDC

#### 4.25 `setInstallOrientation`

`setInstallOrientation` [0|1|2|3|4|5]

Description: ---

`>setInstallOrientation`

`setInstallOrientation`, [0|1|2|3|4|5]

[0]: (Default) A pitch and roll of 0 are achieved by installing the board with the USB connector up and aft

[1]: The default state then rolled -90 degrees

[2]: The default state then rolled +90 degrees

[3]: The default state pitched -90 degrees

[4]: The default state then pitched +90 degrees  
[5]: The default state then rolled either +/-180 degrees

#### 4.26 `getInstallOrientation`

`getInstallOrientation`

Description: ---

`>getInstallOrientation`

Install Orientation, 0

#### 4.27 `setMagnetometerFieldRange`

`setMagnetometerFieldRange, [FR]`

Description: ---

`>setMagnetometerFieldRange`

`setMagnetometerFieldRange, [FR]`

[FR]: Anticipated field range in uTesla (88|130|190|250|400|470|560|810)

#### 4.28 `getMagnetometerFieldRange`

`getMagnetometerFieldRange`

Description: ---

`>getMagnetometerFieldRange`

MagnetometerFieldRange, 130 UTesla

#### 4.29 `setGyroscopeFullScale`

`setGyroscopeFullScale, [FS]`

Description: ---

`>setGyroscopeFullScale`

`setGyroscopeFullScale, [FS]`

[FS]: Full scale degrees per second (125|250|500|1000|2000)

#### 4.30 `getGyroscopeFullScale`

`getGyroscopeFullScale`

Description: ---

`>getGyroscopeFullScale`

GyroscopeFullScale, 2000.00 DPS

#### 4.31 `setAccelerometerRange`

`setAccelerometerRange, [R]`

Description: ---

`>setAccelerometerRange`

`setAccelerometerRange, [R]`

[R]: Range in G's (2|4)

#### 4.32 `getAccelerometerRange`

`getAccelerometerRange`

Description: ---

`>getAccelerometerRange`

AccelerometerRange, 2.0 G's

#### 4.33 getAccelerometerSensitivity

getAccelerometerSensitivity

Description: ---

>getAccelerometerSensitivity

Accelerometer Sensitivity, 1024.0000 LSB/G

#### 4.34 getGyroscopeSensitivity

getGyroscopeSensitivity

Description: ---

>getGyroscopeSensitivity

Gyroscope Sensitivity, 2.0000 LSB/Deg. C,  
16.4000 LSB/DPS,  
939.6508, LSB/RPS

#### 4.35 getMagnetometerSensitivity

getMagnetometerSensitivity

Description: ---

>getMagnetometerSensitivity

Magnetometer Sensitivity, 10.9000 LSB/uTesla,  
128.0000 LSB/Deg.C

#### 4.36 setCoefficients

setCoefficients, [ACC|GYRO|MAG], [BIAS|SENS|ALIGN], [ROW], [COL], [A7:A0]

Description: ---

>setCoefficients

setCoefficients, [S], [T], [R], [C], [A7:A0]

[S]: Sensor (ACC|GYRO|MAG)

[T]: Type (BIAS|SENS|ALIGN)

[R]: Row

[C]: Column

[A7:A0]: Polynomial coefficients

#### 4.37 getCoefficients

getCoefficients, [ACC|GYRO|MAG], [BIAS|SENS|ALIGN], [ROW], [COL]

Description: ---

>getCoefficients

getCoefficients, [S], [T], [R], [C]

[S]: Sensor (ACC|GYRO|MAG)

[T]: Type (BIAS|SENS|ALIGN)

[R]: Row

[C]: Column

#### 4.38 getCurrentBias

getCurrentBias, [ACC|GYRO|MAG]



Description: ---

>getCurrentBias

getCurrentBias, [S]

[S]: Sensor (ACC|GYRO|MAG)

>getCurrentBias,ACC

CurrentBias, ACC, 15.0, 0.000, 0.000, 0.000

>getCurrentBias,GYRO

CurrentBias, GYRO, 15.0, 0.000, 0.000, 0.000

>getCurrentBias,MAG

CurrentBias, MAG, 15.0, 0.000, 0.000, 0.000

#### 4.39 getCurrentAlignment

getCurrentAlignment, [ACC|GYRO|MAG]

Description: ---

>getCurrentAlignment

getCurrentAlignment, [S]

[S]: Sensor (ACC|GYRO|MAG)

>getCurrentAlignment,ACC

CurrentAlignment, ACC, 15.5,

1.000, 0.000, 0.000,

0.000, 1.000, 0.000,

0.000, 0.000, 1.000

>getCurrentAlignment,GYRO

CurrentAlignment, GYRO, 15.5,

1.000, 0.000, 0.000,

0.000, 1.000, 0.000,

0.000, 0.000, 1.000

>getCurrentAlignment,MAG

CurrentAlignment, MAG, 15.5,

1.000, 0.000, 0.000,

0.000, 1.000, 0.000,

0.000, 0.000, 1.000

#### 4.40 getCurrentSensitivity

getCurrentSensitivity, [ACC|GYRO|MAG]

Description: ---

>getCurrentSensitivity

getCurrentSensitivity, [S]

[S]: Sensor (ACC|GYRO|MAG)

#### 4.41 setAutoCompassCalibration

setAutoCompassCalibration, [ON|OFF]

Description: ---

>setAutoCompassCalibration

setAutoCompassCalibration, [STATUS]

[STATUS]: Whether automatic (runtime) compass calibration is on or off [ON|OFF].

#### 4.42 getAutoCompassCalibration

getAutoCompassCalibration

Description: ---

>getAutoCompassCalibration

AutoCompassCalibration, ON

#### 4.43 getCurrentCompassCalibration

getCurrentCompassCalibration

Description: ---

>getCurrentCompassCalibration

Current Compass Calibration

Points: 0

Fit Error: 100.0%

Magnitude: 50.0 uT

Hard Iron: 0.000, 0.000, 0.000

Soft Iron: 1.000, 0.000, 0.000,

0.000, 1.000, 0.000,

0.000, 0.000, 1.000

#### 4.44 setLevel2CompassCalibrationFromCurrent

setLevel2CompassCalibrationFromCurrent, [PWD]

Description: ---

>setLevel2CompassCalibrationFromCurrent

setLevel2CompassCalibrationFromCurrent, [PWD]

[PWD]: Factory password.

#### 4.45 setLevel2CompassCalibration

setLevel2CompassCalibration, [PWD], [P], [FE], [M], [HX:Z], [S11:S33]

Description: ---

>setLevel2CompassCalibration

setLevel2CompassCalibration, [PWD], [P], [FE], [M], [HX], [HY], [HZ], [HZ], [S11], [S12], [S13], [S21],

[S22], [S23], [S31], [S32], [S33]

[PWD]: Factory password.

[P]: Solution points.

[FE]: Fit error percentage.

[M]: Magnitude of magnetic field in uTesla.

[HX:HZ]: Hard iron values in uTesla.

[S11:S33]: Soft iron correction matrix.

>setLevel2CompassCalibration,factory2015,0,100.0,50.0,0,0,0,1,0,0,0,1,0,0,0,1

#### 4.46 getLevel2CompassCalibration

getLevel2CompassCalibration

Description: ---

```
>getLevel2CompassCalibration
Level2 Compass Calibration
Points: 0
Fit Error: 100.0%
Magnitude: 50.0 uT
Hard Iron: 0.000, 0.000, 0.000
Soft Iron: 1.000, 0.000, 0.000,
           0.000, 1.000, 0.000,
           0.000, 0.000, 1.000
```

#### 4.47 setLevel3CompassCalibrationFromCurrent

```
setLevel3CompassCalibrationFromCurrent
Description: ---
>setLevel3CompassCalibrationFromCurrent
setLevel3CompassCalibrationFromCurrent
```

#### 4.48 setLevel3CompassCalibration

```
setLevel3CompassCalibration, [P], [FE], [M], [HX:Z], [S11:S33]
Description: ---
>setLevel3CompassCalibration
setLevel2CompassCalibration, [P], [FE], [M], [HX], [HY], [HZ], [HZ], [S11], [S12], [S13], [S21], [S22],
[S23], [S31], [S32], [S33]
[P]: Solution points.
[FE]: Fit error percentage.
[M]: Magnitude of magnetic field in uTesla.
[HX:HZ]: Hard iron values in uTesla.
[S11:S33]: Soft iron correction matrix.
```

#### 4.49 getLevel3CompassCalibration

```
getLevel3CompassCalibration
Description: ---
>getLevel3CompassCalibration
Level3 Compass Calibration
Points: 0
Fit Error: 100.0%
Magnitude: 50.0 uT
Hard Iron: 0.000, 0.000, 0.000
Soft Iron: 1.000, 0.000, 0.000,
           0.000, 1.000, 0.000,
           0.000, 0.000, 1.000
```

#### 4.50 setDeclination

```
setDeclination, [D]
Description: ---
>setDeclination
setDeclination, [D]
```

[D]: Declination angle (degrees) which is the correction between magnetic north and true north. This value depends on geographic location.

#### 4.51 getDeclination

getDeclination

Description: ---

>getDeclination

Declination, 0.00 Degrees

#### 4.52 setFitRange

setFitRange, [MIN], [MAX]

Description: ---

>setFitRange

setFitRange, [MIN], [MAX]

[MIN]: Minimum acceptable magnetic field strength in uTesla to accept a compass calibration solution.

[MAX]: Maximum acceptable magnetic field strength in uTesla to accept a compass calibration solution.

#### 4.53 getFitRange

getFitRange

Description: ---

>getFitRange

FitRange, 45.00, 75.00 uTesla

#### 4.54 setAttitudeBias

setAttitudeBias, [PB], [RB]

Description: ---

>setAttitudeBias

setAttitudeBias, [PB], [RB]

[PB]: Pitch bias (degrees) between -3.0 and +3.0.

[RB]: Roll bias (degrees) between -3.0 and +3.0.

#### 4.55 getAttitudeBias

getAttitudeBias

Description: ---

>getAttitudeBias

AttitudeBias, 0.00, 0.00 Degrees