# nIMU - $\mu$IMU
# Bias and Sensitivity Corrections of Magnetometers
# Revision 1

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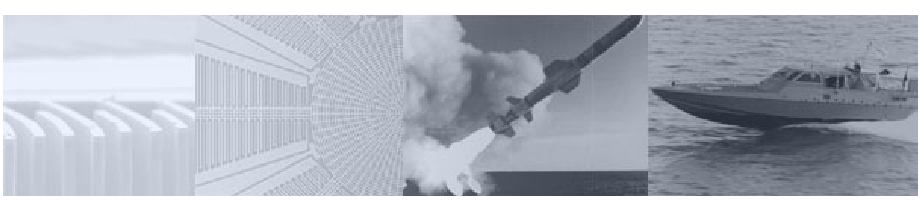


## Utilization of Magnetometers

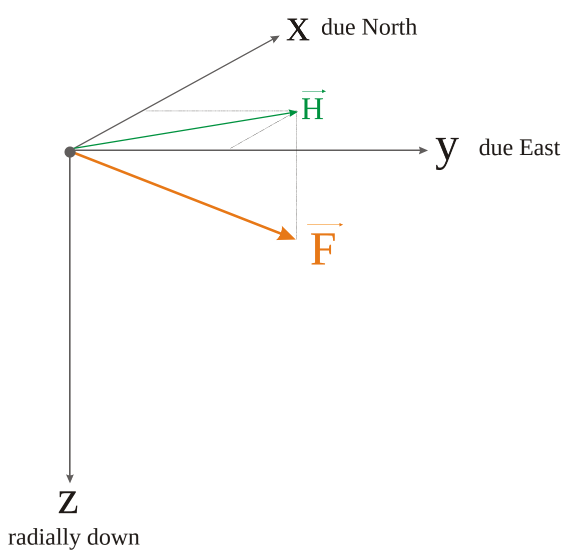
### Introduction

The magnetoresistive sensors within the nIMU and μIMU units have been calibrated under a controlled magnetic environment to determine temperature corrections to their bias and sensitivity. Additional corrections will be necessary to the magnetometer output if these devices will be operated in an environment containing additional local magnetic fields.

### Calibration of the Magnetic Sensors

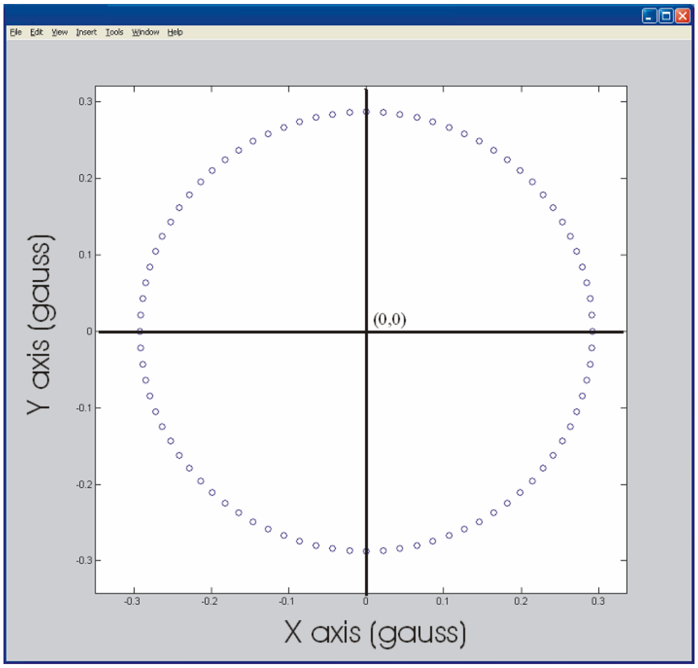
The Earth field is variable in both space and time. At a particular latitude, longitude, elevation, and time the field points in one direction. The entire field may be of interest or only the horizontal plane as is the case with the traditional eight-point compass. Figure 1.0 shows the field components read by a triaxial magnetometer positions congruently with the main compass directions. The traditional component of interest in eight-point compass systems is labeled here as H.

Figure 1.0 Field components of the earth field




### Magnetometer Output

If the magnetometers are used to read the earth field, and they are not under the influence of any local magnetic fields, then output such as in Figure 2.0 may be produced by rotating the device 360° in a plane. In this case the device was rotated 360° about the $Z$ axis with the $X$ and $Y$ axis reading the horizontal earth field component ($\left|\vec{H}_{\max}\right| \cong 0.28 gauss$ ).

<table>
<tr><td>Figure 2.0: Rotating in the horizontal plane with constant field</td><td>Figure 3.0: Rotating in the horizontal plane</td></tr>
<tr><td>


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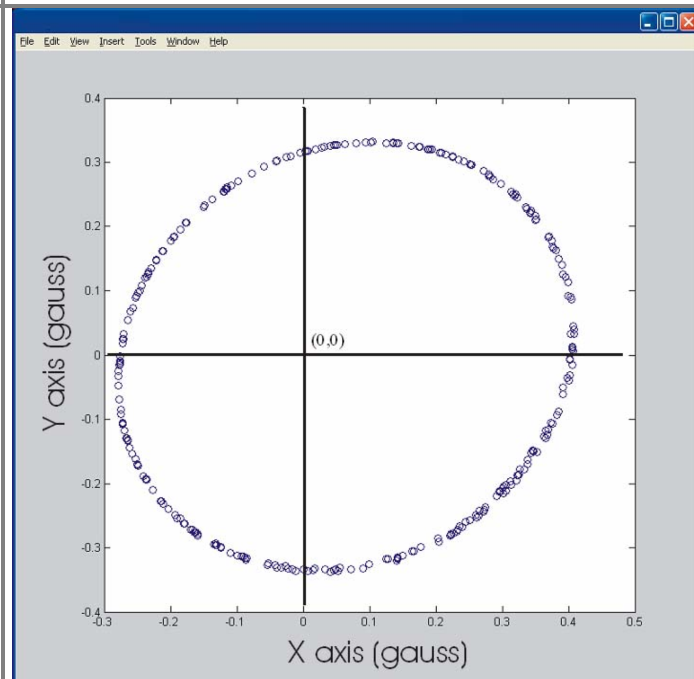

</td></tr>
<tr><td>No noise present</td><td>Without Corrections</td></tr>
</table>

Figure 2.0 shows a trial without any magnetic noise.

Figure 3.0 shows a similar trial where a local magnetic field was introduced.

## Correction to the Magnetometer Output

Corrections to the output may be calculated according to the following method:

1) Data is collected as the device is rotated 360° under the conditions that produce the magnetic interference.
2) The data is analyzed to produce bias offset and sensitivity scale factors to compensate for the interference.

An example:

The device is mounted to a steel bicycle being used for a new electronic athletic feedback system. A series of data sets are collected while the bike is ridden in a large circle multiple times.

The maximum output of the X and Y magnetometers is found from the data,

$$X_{\min} = -0.284\,gauss \qquad X_{\max} = +0.402\,gauss$$
$$Y_{\min} = -0.322\,gauss \qquad Y_{\max} = 0.246\,gauss$$

Choose one device to be scaled as one. It is beneficial to choose the device with the greater response for additional sensitivity. Since $X$ has the greater response we set its scale factor to one

$$X_s = 1.$$

For $Y$ we find the scale factor

$$Y_s = \frac{(X_{\max} - X_{\min})}{(Y_{\max} - Y_{\min})}.$$

For the bias offsets we use the following

$$X_b = X_s\left[\tfrac{1}{2}(X_{\max} - X_{\min}) - X_{\max}\right]$$

$$Y_b = Y_s\left[\tfrac{1}{2}(Y_{\max} - Y_{\min}) - Y_{\max}\right].$$

These values are found for the bicycle:

$$X_b = -0.059 \qquad X_s = 1.000$$

$$Y_b = +0.046 \qquad Y_s = 1.208.$$

The corrected output is then

$$X_{out} = X_{in} - 0.059$$

$$Y_{out} = 1.208 Y_{in} + 0.046$$

## Transient fields

Transient fields introduce many more complexities into the correction process. The presence of electric motors or servos cycling up to speed or slowing down will bring challenges to the correction of the magnetometers. It is best to increase the distance between the magnetometers and any source of transient fields to the maximum possible.

## Summary

Most applications using a magnetic sensor for determining the earth field must account for local magnetic interference. The output of the magnetic sensors in the presence of the magnetic noise can be used to correct for the deviations from the earth field using the demonstrated methods.