Magnetometer

0.1 What it is used for?

1. It is primary attitude sensors specially for nano-satellites.
2. In situations, where high pointing accuracy is not required, as emergency, standby, or during satellite orbital maneuvers, one often uses magnetometers which is simpler and more reliable than more accurate instruments.

0.2 Why we need to calibrate it?

Implementation of magnetometers on board the satellite results with numerous disadvantages because of the sensor errors and these errors limit the overall achievable attitude determination accuracy.So, calibration is needed

0.3 Errors

The errors for magnetometer measurements can be mainly covered in two categories:

- **Inherent sensor errors** are related to the processes of sensor manufacturing and installation onto the satellite
- Errors caused **by the internal and external disturbances** are dependent to the variations in the magnetic fields affecting the sensors
- Items inside the satellite such as magnetic torquers may generate unwanted magnetic fields that are **time-varying**
- Any unwanted magnetic field, generated by materials with permanent magnetic field (**hard irons**), impose bias on the magnetometer measurements.
- **Soft irons** imposes error on the magnetometer measurements depending on the generated magnetic field.
- **Scaling**- sensitivity of each magnetometer is different and to represent this difference(output of three sensors of magnetometer triad are different even when they are subjected to identical magnetic field) the output of each sensor must be multiplied with a scale factor.
- **Misalignment**- As a result of different factors like mounting errors or vibrations during the launch misalignments exist between the ideal and real sensor frames.

0.4 How calibration is done?

- **Hard iron biases** Response curve center is shifted from origin

  Correction Subtract the average of min and max of the magnetic value data obtained from the obtained values to recenter the response surface on the origin.

- **Soft iron biases** Response curve is ellipsoidal instead of spherical.

  Correction A **scale factor** is calculated by taking the ratio of the average max - min along each axis and the average of all three axes. This means that an axis where the max - min is large has its magnetic field reduced and an axis that under-measures the field with respect to the other axes has its magnetic field values increased. This is just a simple orthogonal rescaling, equivalent to a diagonalized 3 x 3 calibration matrix but it allows some additional correction for scale bias

0.5 Constraints

1. Magnetometer can't be placed near ferromagnetic materials.
2. Magnetometers can't be in contact with magnetic torquers.

0.6 Drawback

Main drawback is not considering ferromagnetic materials as one of the disturbance sources causing errors in sensor measurements.