Application Note: Boundary Field Measurement

OVERVIEW

In a number of experiments, the magnetic field in a region of interest must be known accurately and sometimes controlled. Whilst sometimes it is possible to have magnetometers within the volume of interest, it is not always the case.

In these circumstances, it is possible to use, assuming that certain conditions are met with regards to the presence of dipole sources within the volume for example, the measurements from an array of sensors located immediately outside of the volume of interest.

Magnetic Field Evaluation Based on Boundary Field Measurements

We will use here the example of the Neutron Electric Dipole Moment (nEDM) experiment which is being setup at the Spallation Neutron Source (SNS) at Oak Ridge National Lab (ORNL).

Details of the magnetic field monitoring setup is detailed in A. Aleksandrova's Thesis (https://uknowledge.uky.edu/physastron_etds/68/).

The aim of the experiment is to improve the reliability of the measurement of the nEDM by a factor 100 compared to previous work. In order to achieve this improvement, one of the factors that needs to be precisely constrained is the knowledge of the magnetic field at the neutron's location.

Assuming that there are no sources of currents or magnetization within the volume of interest, the field inside the volume can be inferred. The accuracy of the field reconstructions is directly dependent upon the number of measurement points around the volume of interest.

Carefully selected measurements points will help with a greater accuracy of the reconstruction, helping to understand the contribution of each factor in the polynomial defining the magnetic field.

In a first iteration of the setup, using 12 single axis probes assisted in characterizing one component of the field in a particular direction but yielded poor results in different direction of the setup.

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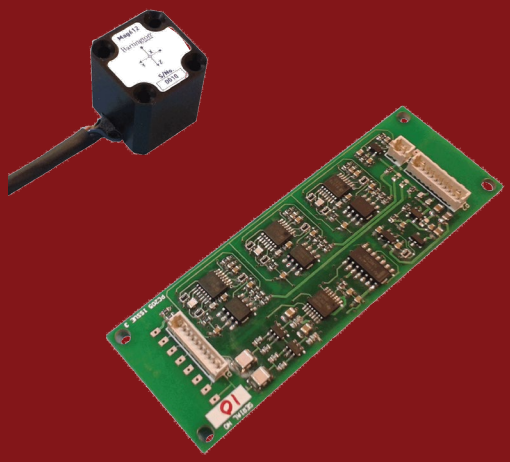
Equipment

- Three-axis Fluxgate Magnetometer



Applications

- Determining the field at a location inaccessible for a magnetometer based on measurement from an array surrounding the location of interest.

The sensor array was updated to 39 sensors and provided much better results in reconstructing the field and gradient within the volume of interest to within a few percent of the measured field, thus validating the array design.

In this particular case, the sensor used are the Bartington Mag F probes due to the requirement for the equipment to be placed at cryogenic temperature.

https://gmw.com/product/mag-01h/

However, other sensors may be used. The electron EDM experiment at JILA uses an array of room temperature fluxgate sensors for determining the field within their trap (Cairncross, 2019). The method is not only reserved for low field measurements but could be applied to a number of problematics in higher field settings.

https://gmw.com/product/other-probes/

Aleksandrova, Alina, "Magnetic Field Monitoring in the SNS Neutron EDM Experiment" (2019). Theses and Dissertations--Physics and Astronomy. 68.
https://uknowledge.uky.edu/physastron_etds/68

Cairncross, William, "Searching for time-reversal symmetry violation with molecular ions: Quantum state control and photofragment imaging" (2019). Thesis.
https://jila.colorado.edu/bec/CornellGroup/theses/cairncross_thesis.pdf