Building an Affordable Helmholtz Magnetic Simulator for CubeSat Satellites

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Analysis

Numerical analysis of square Helmholtz coils
The task of numerical analysis was to obtain magnetic flux density vectors for a system of square Helmholtz coils. Coils dimensions: 20 turns, side length a = 0.54 m, spacing b = 0.30 m (ratio between a and b is 0.55). Each coil represented with 400 current elements, Biot-Savart law used to determine field strength of each element. Magnetic flux density was evaluated in 3-D polar coordinates by principle of superposition of all coils and elements. Resulting magnetic flux density in the center of the coil pairs is 305 µT at 100 A (~10 % lower than with circular coils).

Control

Digital temperature sensors integrated into the cage frame to directly observe coil temperatures.

Interface

Big alphanumeric LCD on front panel of the driver with an encoder knob
- Display of coil currents, magnetic flux densities (references and measurements)
- Display of coil and driver temperatures
- Encoder used to move between different menus, change parameters
- Coil currents or reference magnetic flux densities can be altered manually
- Easily-accessible on/off switch on the front

Built-in galvanically isolated USB connection or Ethernet
- Cross-platform library for use in Windows, Linux (including embedded systems)
- Interface example for C and Matlab (Simulink S-Function)
- Remote access for monitoring and control

Construction

Lightweight wooden coils cage
The cage is made of wood parts, then painted in matte black. Professional, clean look of the device.

Coils wound using 1 mm copper wire
Coils are wound to achieve +/- 200 µT of magnetic flux density.

Heavy-duty connector
Hassle-free connection between the driver and the coils.

Driver case suitable for use in 19'' rack

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3-D representation of current elements
(3-D representation of current elements (in total of 2400))

Homogeneity border (1 %) in one axis

Homogeneus field volume
approx. 10 cm x 10 cm x 10 cm
less than 1 % field discrepancy

Homogeneous volume boundaries visualization
Boundary of the 1 % homogeneity region was searched for in 3-D. Arbitrary shaped homogeneous volume was determined.

Volume boundary parameterized in polar coordinates

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LABORATORY OF MODELLING, SIMULATION AND CONTROL
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Device testing in the laboratory

Device testing in the laboratory

Developed for SPACE-SI in cooperation with BDM-Tech

Check video demo