Tri-Axial Square Helmholtz Coils System to Generate Uniform Magnetic Field Volume

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Abstract

This poster presents analysis and validation of a tri-axial square Helmholtz coils system (see Figure 1), commonly used to generate highly uniform magnetic field on a specific volume. The analysis of square Helmholtz coil is based on the Bio-Savart law [1] for which it performs a Taylor series approximation for the magnetic field at a point on the axis of symmetry, finding an approximate expression of the homogeneity with respect to the parameter length [2]. In order to validate the distribution and uniformity of each magnetic field component Bz, By, and Bx on the volume of interest, the computational model was designed in COMSOL Multiphysics® software and this consists of three pairs of Helmholtz coils and a sufficiently large square cube which is assigned zero potential for electromagnetic analysis [3] (see Figure 2). Once constructed the geometry and electrical properties assigned, the characterization of load conditions and meshing was performed for the electromagnetic analysis (COMSOL uses the finite element method for solving Maxwell's equations). Each pair of Helmholtz coils (considered the source elements) was characterized as a solid conductive material powered by voltage without considering the effects of eddy currents. The model is implemented using the AC/DC Module of COMSOL for the analysis of static magnetic fields and low frequency. The simulation results show a homogeneous distribution of the magnetic field on an approximate area of 12 cm x 12 cm in each symmetry plane of the system, obtaining a uniform magnetic field volume around the center (see Figure 3). These results were verified with experimental and theoretical results [4]. The simulation process allows obtaining a broader solution of the magnetic field behavior in the coils system and considering different operating conditions in order to predict the real behavior of the system.

Reference

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2. Restrepo-Alvarez, A. F., Franco-Mejia, E. y Pinedo-Jaramillo, C. R., Study and analysis of magnetic field homogeneity of square and circular Helmholtz coil pairs: A Taylor series approximation, ANDESCON 2012 IEEE, 1-4, Cuenca, Ecuador, 7-9 Nov. (2012).
3. Olivares-Galvan, J. C., Campero-Littlewood, E., Escarela-Perez, R., Magdaleno-Adame, S. y Blanco-Brisset, E., Coil Systems to Generate Uniform Magnetic Field Volumes, COMSOL Conference 2010, 1-7, Boston, United States, 7-9 Oct. (2010).
4. Restrepo, A. F., Franco, E., Pinedo, C. R., Metodología de diseño e implementación de un sistema para generación de campos magnéticos uniformes con bobinas Helmholtz Cuadrada Tri-Axial. Información Tecnológica, 25(2), 3-14 (2014).

Figures used in the abstract

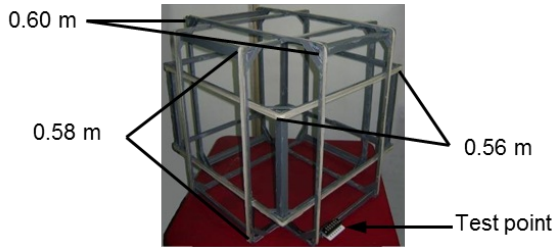

Figure 1: Tri-axial square Helmholtz coils system.

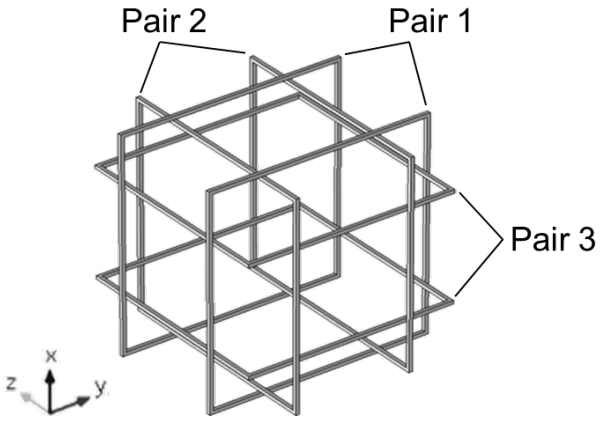

Figure 2: Computational model of the coils system.

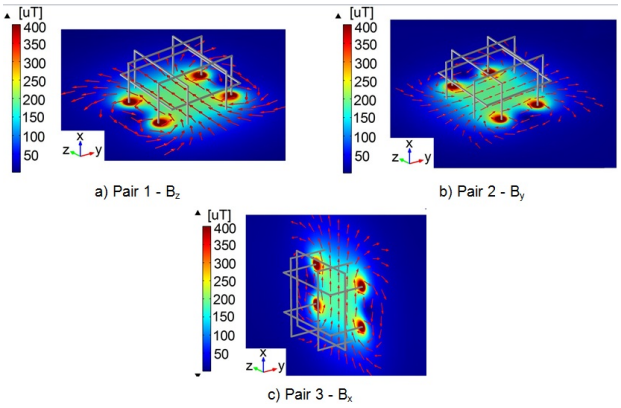

Figure 3: Simulation of magnetic field lines and uniform area of the coils system.