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Abstract

Spherical magnetic flux density sensor array

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In the field of medical imaging, particularly magnetic particle imaging, the accurate measurement of magnetic fields in field generators is of significant importance for the assessment of implementation quality and the detection of deviations by the used material and manufacturing tolerances. The data is used to enhance image quality through shimming or physics-informed reconstruction algorithms. However, conventional measurement with a 3-axis Hall probe mounted on a robotic system is time-consuming, presents challenges in terms of reproducibility and is safety-critical due to moving parts. A spherical measuring device is being developed with the objective of enabling fast, accurate and easily reproducible measurements of quasi-static magnetic fields, based on field calculations explanting a solid spherical harmonics expansion [1]. The magnetic field calculation is based on a limited number of support points defined by a spherical t-design. To implement these representations in a measuring instrument, a device comprising 36 three-axis integrated circuit Hall sensors (IC) was developed (representing an 8-design with N = 36) [cf. 2]. Most of its electronic and mechanical elements were produced using additive rapid prototyping techniques. First, the sensor boards (PCB) were rapidly prototyped with a polyjet printer that is specially designed for the additive manufacturing of electronic components. This printer offers a resolution of below 40 µm, while simultaneously printing and sintering a conducting and a dielectric material (Dragonfly IV, Nanodimension, USA, AgCite and Dielectric Ink 1092). A series of design and functionality tests were conducted to verify the readout of sensor values and communication of the IC. Additionally, various mounting concepts for the PCB were implemented and evaluated. Secondly, a holder to mount the 36 sensor boards in corresponding recesses was developed and manufactured utilizing an industrial 3D printer (J850, Stratasys Ltd., USA), which is capable of maintaining an accuracy of ±0.2 mm in any spatial direction. This ensures that the active area of the Hall sensors remains no more than 0.6 mm from the calculated point of the t-design, due to the inherent tolerances of the additive manufacturing processes. The sensor mount is composed of a series of interconnected platforms, which feature a multitude of undercuts and cut-outs, facilitating the simultaneous implementation of functional assembly and cable routing. The intricate geometry of this design would render conventional manufacturing methods technically very complex and costly. Consequently, additive manufacturing with support material represents an optimal choice for this initial prototype. The results of this prototype serve as a basis for further development, with the aim of developing a user-friendly, stable and modular measuring instrument, with additive manufacturing supporting a fast iterative development.

AUTHOR'S STATEMENT

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