Magnetic field compensation coil design for magnetoencephalography

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Introduction

Optically pumped magnetometers (OPMs) are sensitive magnetic field sensors, even applicable to magnetoencephalography (MEG). OPMs can be attached to participants heads, which allows certain head movements and minimizes the distance to the brain. However, since the dynamic range of commercially available (QuSpin) OPMs is about ±5nT, movements in the remnant magnetic field disable the OPMs. Active suppression of the remnant field by compensation coils is therefore essential.

Methods

High quality compensation coils for OPM-labs have previously been designed as bi-planar coils by optimizing spatial harmonics of a stream function . Shielding effects of the magnetically shielding room (MSR) were not considered in these optimizations.
We define a stream function on a five-sided mesh of a cuboid with side-lengths of approximately 2m and the front face removed. The target volume for compensation is a sphere of diameter 60cm in the center of the cuboid. The shielding effects are taken into account by virtually mirroring the mesh on the walls of the MSR. Optimization is computed by a regularized least squares regression of the stream function for a specified target field at points in the target volume. Coil wiring paths are computed as contour lines of the optimized stream function.

Results

The literature on bi-planar coil design reports simulated errors below 5% in field homogeneity and linearity without taking shielding effects into account. In practice, they report increased errors between 10% and 26% due to shielding effects. In our design, shielding effects are taken into account during optimization and simulated errors stay below 5% with shielding effects.

Conclusion

We propose a compensation coil design which achieves higher accuracy compared to reported results, when shielding effects are taken into account. The validation of our simulations via test measurements is planned for the near future.

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Digital process chains for patient specific medical devices

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As part of digitization, customers are increasingly being involved in designing their desired product. For example, customers can configure their chosen vehicle, plan their own kitchen or design an individual T-shirt. To meet healthcare needs, health workers cooperate with manufacturers to develop innovative, patient-specific medical devices. For patient-specific medical devices, healthcare professionals are involved, via online services, in the design of patient matched and custom-made products. Digital process chains are the key.
The requirements for digital process chains of standardized products in medical technology are described in the quality management (see DIN EN ISO 13485) and software systems (see IEC 62304) standards. In addition, requirements from the General Data Protection Regulation must be observed. From the point of view of quality management, the development of digital processes must be attached to the development file. In the case of custom-made products, it is also necessary for the treating healthcare professional to specify the custom-made product. Digitalization makes it possible to integrate the medical expertise of the health worker and thus his specification for the design and modeling of patient specific products into the process workflows.
The Medical Technology Advisory Committee of the VDI Society for Technologies of Life Sciences is currently developing a guideline on digital process chains in industrial medical technology (VDI-5705). In the first step, four patient-specific medical devices, from different medical areas, were used to analyze the processes, starting with the patient examination and ending with market observation. Subsequently, four process areas were identified, a digital process chain was described and assistance for implementation was developed, as well as references to regulations given.