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# Mon-Af-Po1.13-02 [22]: Reaching Field Uniformity of One Part Per Billion and Below

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High magnetic field uniformity is important for various applications, including NMR, MRI and quantum computing. A novel scheme has been developed to significantly improve magnetic field uniformity in a good field region, defined by (Bmax-Bmin)/Bmin, to levels well below 1X10-6 limit achievable in modern NMR and MRI magnets with shimming. This novel scheme can achieve theoretical field uniformity of 1x10-11 in a good-field-region as proven by semi-analytic calculations. The proposed scheme has a main coil that generates a high-uniformity main field, correction coils and permanent magnet arrays a two-step correction procedure to successively reduce field errors. The main coil is a discretized wire-wound spherical coil with optimized winding pitch between adjacent conductors. Assuming conservative manufacturing tolerances a field uniformity of parts per million (1X10-6) is feasible without shimming ofthe main coil. The two-step correction procedure uses a novel field decomposition technique, based on 3D cylindrical multipole description of measured magnetic field along two orthogonal axes, which allows identification and systematic correction of field errors. The first correction step uses correction coils of appropriate multipole order and with high field uniformity to correct the main field error by one or two orders of magnitude. Persistent mode superconducting magnets are needed for the main coil and correction coils to achieve sufficient temporal stability. In the second step further improvements in field uniformity are achieved using permanent magnet arrays that constitute crude Halbach arrays of given multipole order. State-of-the-art NMR field mappers with accuracy of 1X10-9 can be used for shimming of magnets with flux densities in the Tesla range. Additionally, another variation of this novel scheme is presented that enables shimming of parts per billion with peak field levels of mTesla and below.

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