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Mon-Af-Po1.13-06 [26]:A Novel and Fast Method for Inductance and Force Calculation of Multi-Coaxial Coils for NMR Magnet Design

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In the ultra-high field NMR (nuclear magnetic resonance) and MRI (magnetic resonance imaging) application with using high-temperature superconducting (HTS) materials, the elaborate analysis of multiple coaxial solenoid coils is essential for the magnet design. The inductance and force were calculated by some authors using analytical and semi-analytical expressions based on double integrations or elliptical integrals of the first and second kinds, Heuman's Lambda function. In this study, we present new and fast procedures for calculating inductance and force exerted between coaxial coils. The combination of Biot-Savart law and Numerical method are used to calculate magnetic field at the interesting area, the inductance is the flux linkage surface integral over the cross section and the force is the Lorentz force volume integral over the solenoid in the cylindrical coordinate system. The derived inductance and force formula based on double integral can be implemented respectively by MATLAB programming with no concern of singularity. Compared with the traditional method, in the MIT 1-GHz NMR magnet design, the inductance and force calculation results respectively differ by less than 8 ‰ and 1 ‰ when the coil distance is 0.26mm. With the increase of the distance, the minimum differences are 7.0×10-3 ‰ and 4.8×10-3 ‰. The suggested method calculation time is 2 times faster in the meantime. The presented approach is more general for calculating the inductance and force of coaxial coils and more applicable to get highly accurate results caused by a relatively simple procedure and shows low computational time.

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Authors: Mr LIU, Quanyue (Uiduk University, Gyeongju, Republic of Korea); Prof. LEE, Sangjin (Uiduk University, Gyeongju, Republic of Korea); Dr CHOI, Yoonhyuck (Francis Bitter Magnet Laboratory / Plasma Science and Fusion Center, Massachusetts Institute of Technology); Dr PARK, Dongkeun (Francis Bitter Magnet Laboratory / Plasma Science and Fusion Center, Massachusetts Institute of Technology)

Presenter: Mr LIU, Quanyue (Uiduk University, Gyeongju, Republic of Korea)

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