Vector Based Magnetic Axis Determination of Solenoids for Gyro-Devices

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ABSTRACT

High-power vacuum electronic devices (VEDs), especially gyro-devices, rely on precise alignment with the magnetic field of the superconducting solenoids in which they operate. Accurate knowledge of the magnetic axis relative to the device axis is therefore essential, with required tolerances on the order of a few tens of micrometers.

This presentation introduces a novel vector-based method for determining the magnetic axis of superconducting solenoids with fields up to 11 T. The approach uses measurements from a 3D Hall probe and reconstructs the magnetic axis by evaluating the intersections of projected magnetic field vectors. In contrast to conventional methods, the proposed algorithm enables simultaneous determination of axis tilt and lateral shift from a single circular measurement layer, reducing measurement effort while maintaining high precision.

The method was developed and validated through detailed simulations incorporating realistic measurement noise and positioning uncertainties. The results demonstrate that the algorithm can reconstruct axis tilt with an accuracy better than 0.01 deg. and lateral displacement within 60 µm. Based on these investigations, quantitative requirements for the measurement and positioning accuracy were derived, providing practical guidelines for implementation in high-field measurement environments.

The presented work establishes an efficient and precise approach for magnetic axis characterization of superconducting solenoids used in gyro-device applications and provides the basis for improved alignment procedures in high-power RF systems.