Dipole Sensitive, Homogeneous-field Compensated High-T_c dc SQUID

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Abstract — Magnetic nanoparticles (MNP) are of great interest for industrial and medical applications. Therefore, the properties of the particles must be well known. In order to determine parameters such as particle size and particle size distribution, several magnetic measurement schemes have been developed. For the measurement of small amounts of particles, a sensor design with high dipole sensitivity is required while homogenous excitation fields must be shielded or compensated. The spatial dimensions need to be tuned to the sample size in order to maximize the coupling efficiency. In this paper, we present a new sensor design employing a high-T_c $YBa_2Cu_3O_7$ (YBCO) superconducting quantum interference device (SQUID) which is inductively coupled to a surrounding superconducting compensation loop. The design offers a tunable coupling inductance in order to achieve a compensation of the flux coupled into the SQUID by an external magnetic field. We choose a square SQUID design which is positioned in the axis of symmetry of the compensation loop in order to compensate spatial homogenous and first order gradient magnetic fields. The SQUID is operated in a flux locked loop (FLL) with bias reversal. We investigate the dependence of the performance on the compensation loop layout. Design limitations are demonstrated and the SQUID noise is characterized with and without applied magnetic field.

Keywords (Index Terms) — High-T_c SQUID, SQUID noise, dipole sensitivity, magnetic shielding, magnetic nanoparticles