M2PoB-03[M9]

Effect of Discontinuities and Penetrations on the Shielding Efficacy of High Temperature Superconducting Magnetic Shields

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Introduction

- Effect of discontinuities (holes) in the superconducting magnetic shields studied along with methods to mitigate these effects
- Shielding factor measured at variable amplitudes and frequencies of external magnetic field for different sizes of holes (0-12 mm)
- Masking layer placed in front of the hole at 2 mm, 4 mm and the shielding factor measurements repeated
- Magnetic field was perpendicular to sheet axis and wide tape face
- Measurements were performed at 77 K in liquid nitrogen bath

Motivation

- Various cables and pipes often need to go thorough magnetic shields that cause deterioration in shielding performance
- Aging and mechanical stresses also lead to local discontinuities of degraded superconducting properties
- It is important to quantify effect of discontinuities on shielding efficacy of HTS magnetic shields and look for solutions

Goals

- Set up experimental facility to measure magnetic field inside an experimental shield as a function of amplitude and frequency
- Prepare shields with various hole diameters and masks over the hole (12 mm) at a distance of 2 mm and 4 mm from the hole
- Measure shielding properties in the range 20– 400 Hz at 77 K

Experimental

Tape

2G – YBCO on Ni-W substrate, dimensions: 46 mm x 0.2 mm, ~400 A/cm-width at 77 K

Shields

2G – Sheets on fiberglass epoxy former, 10 cm x 6 cm,

Instrumentation

Hall Probe – HHP-MP 100 µm x 100 µm, sensitivity 73.2 mV/T at 10 mA, IEE, SAS, Bratislava Lock-in amplifier SR 830, DC current source Lake Shore C120, double helix dipole magnet, B was _|_ to the axis of the sheets

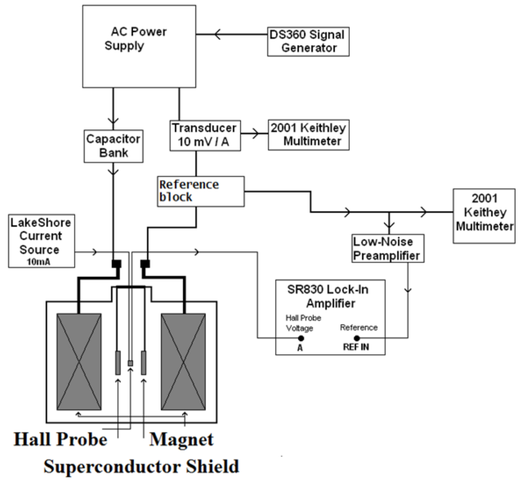
Shielding factor

The shielding factor is defined as the percentage of external field that is shielded:

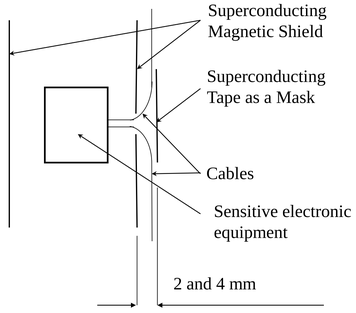
$$\text{Shielding factor} = (B_{ext} - B_{int})/B_{ext} * 100\ [\%]$$

B_{ext} - external magnetic field

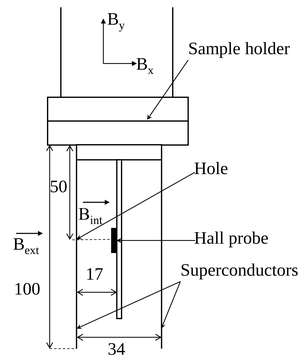
B_{int} - magnetic field in the center of the shield



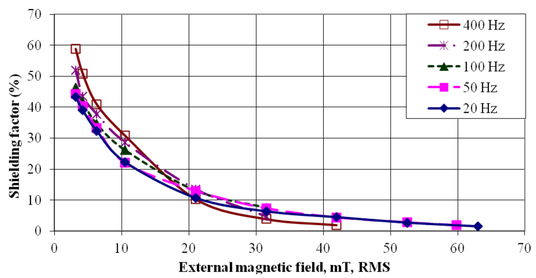
Block diagram of the instrumentation used in measurements of shielding properties



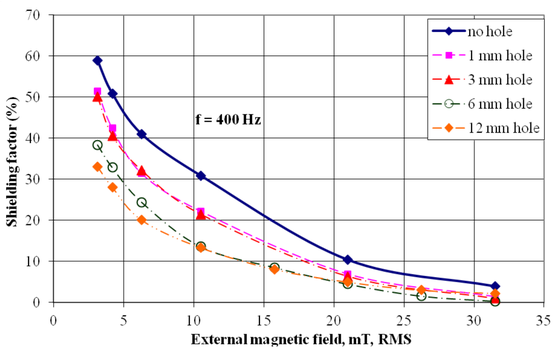
Use of masking layer to mitigate the effect of a hole in the magnetic shield



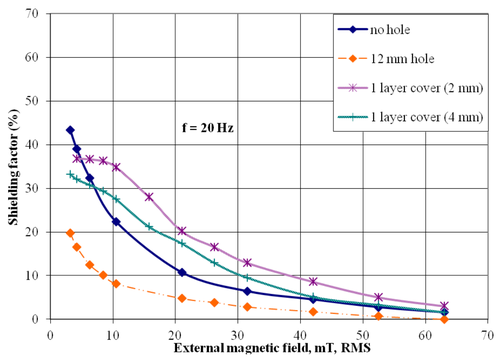
A schematic of the experimental set-up for AC shielding with flat superconducting sheets. All dimensions are in mm



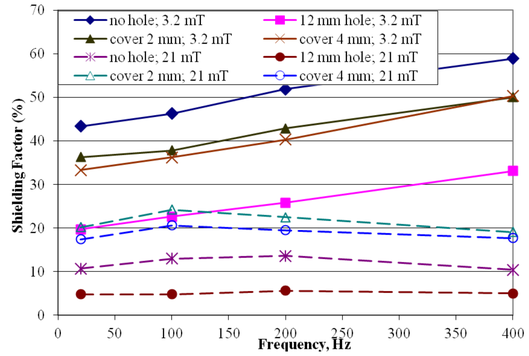
Variation of shielding factor with external magnetic field for 3 layer shield with no holes



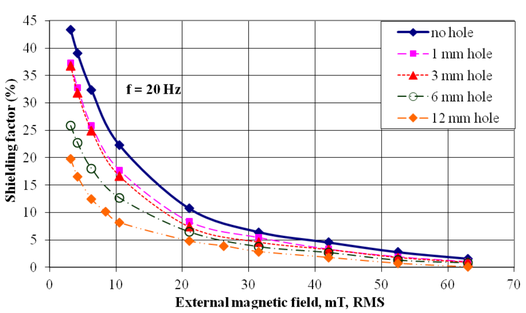
Variation of shielding factor with external magnetic field at 400 Hz for different sizes of holes



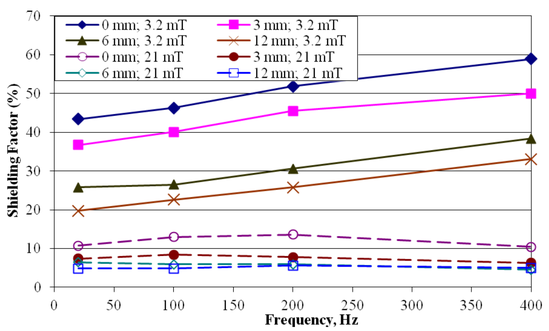
Effect of mask placed at a distance of 2 mm and 4 mm from the 12 mm hole at 20 Hz



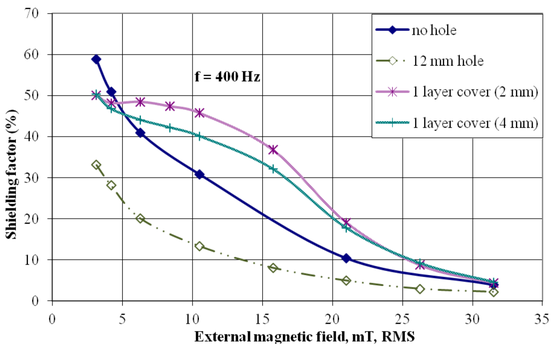
Effect of the mask placed at a distance of 2 mm and 4 mm from the 12 mm hole for 3.2 mT and 21 mT of applied external magnetic fields



Variation of shielding factor with external magnetic field at 20 Hz for different sizes of holes



Shielding factor vs frequency for 3 layer-shield. Hole diameter is the parameter and external magnetic field is 3.2 mT and 21 mT



Effect of the mask placed at a distance of 2 mm and 4 mm from the 12 mm hole at 400 Hz

Summary

- Superconducting magnetic shields were fabricated from 2G HTS tapes
- The effect of discontinuities in shields on the shielding efficacy is studied
- Shielding factor decreases with increasing external magnetic field and increases with increasing frequency
- Considerable drop occur in the shielding factor due to the presence of holes and the drop increases with increasing size of holes
- A superconducting mask on the 12 mm hole, at a distance of 2 and 4 mm, completely mitigates the negative effect of hole
- Future work can be done to optimize the dimension and location of the mask layer

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