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Fri-Mo-Po.03-06: Low-AC-Loss Nb3Sn Validation Model Coil in Solid Nitrogen for a Fast-Switching-Field MRI Magnet Prototype

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In this paper, we present the design and test results of a low-AC-loss Nb3Sn model coil developed to validate key enabling technologies for a fast-switching-field magnetic resonance imaging (MRI) magnet concept that can change the magnetic field very quickly in time, within 1 second, between significantly different field strengths: a high field (3 T) for relaxometry and prepolarization and a low field (0.5 T) for spectroscopy and imaging. While conventional MRI magnets require a static magnetic field, we expect that our proposed superconducting magnet with rapidly changing fields can provide opportunities for novel contrast mechanisms, which include level-crossing between spin-1/2 and quadrupolar nuclei, accelerated spin-lattice relaxation, and adiabatic demagnetization/remagnetization, by permitting differential relaxometry enabled by a large field strength difference, and ratiometric molecular/superthermal imaging. We have developed and demonstrated an innovative magnet design that uses a very low-AC-loss Nb3Sn coil and a novel cooling technology featuring highly heat-conductive thermal links between the coil and solid nitrogen surrounding the coil. These thermal links in solid nitrogen are anchored at one end to the cryocooler cold head. This design enables rapid switching between two magnetic fields in the superconducting magnet without inducing quench. The paper provides details on the construction, test results, and an in-depth analysis of AC losses and the maximum temperature rise in the coil of the small-scale fast-switching-field magnet system.

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