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Magnet quench protection of the FCC-hh 16 T block-type dipole magnet by means of quench absorption coils

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For future particle colliders at the energy frontier such as the future circular collider for hadron-hadron collisions (FCC-hh), 16 T dipole magnets are needed to maintain the high-energy particle beams on their trajectories. This type of magnet features a very high stored energy density resulting in a challenge from a magnet quench protection perspective. A possible method for improving magnet quench protection involves using secondary normal conducting coils, so-called quench absorption coils, placed in close proximity to the primary superconducting coils. As the primary coil quenches, current is inductively transferred into the secondary coils and a substantial fraction of the stored energy is dissipated there. The secondary coils comprise insulated copper windings which are placed in series with a blocking diode, so that during regular ramping undesirable heating and field errors are avoided. In a previous numerical analysis of the R&D Nb3Sn dipole 'HD2', it was found that by adding the quench absorption coils to the heater-based magnet protection system (without an external dump resistor), the hotspot temperature was reduced by 100 K and the peak resistive voltage by 50%. We explore the feasibility of this concept for the FCC-hh block coil design, with an emphasis on magnet cost reduction. Firstly, a study is done to determine how much the size of the superconducting coil can be reduced while maintaining the specified hotspot and peak turn-to-turn voltage and voltage-to-ground. Secondly, the inductive interaction between the secondary coils and the coupling-loss-induced quench system (CLIQ) is studied. Thirdly, a mechanical analysis is performed to see if and how the presence of the secondary coils affects the overall mechanical behaviour. Based on the results of these investigations, the costs and benefits of this concept are weighed to see whether this magnet quench protection concept may prove useful for this type of magnet.

Submitters Country

Switzerland

Author: MENTINK, Matthias (CERN)

Co-authors: SALMI, Tiina-Mari (Tampere University of Technology, Finland); PRIOLI, Marco (CERN); Mr ZHAO, Junjie (Tampere University of Technology, Finland); LORIN, Clement (CEA/IRFU,Centre d'etude de Saclay Gif-sur-Yvette (FR))

Presenter: MENTINK, Matthias (CERN)

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