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Thu-Af-Or20-04: Quench protection of the 16 T Nb3Sn ERMC and RMM magnets

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CERN launched a high-field magnet R&D program aimed at demonstrating 16 T class superconducting magnets for future circular colliders. The program includes designing, manufacturing, and testing two Nb3Sn magnet models, namely the Enhanced Racetrack Model Coil (ERMC) and the Racetrack Model Magnet (RMM). Both magnets target a magnetic field of 16 T with 10% margin on the load line at 4.2 K. The ERMC magnet is composed of two flat racetrack coils with no bore, whereas the RMM is composed of two ERMC coils and a middle coil, with a 50 mm bore.

The quench protection of a full-scale, high-field, Nb3Sn magnet is very challenging due to the high stored energy-density and relatively high margin to quench. Thus, an active protection system that quickly detects the quench onset and transfers the winding pack to the normal state is required to avoid damage due to overheating of the hot-spot where the quench started.

The protection of the ERMC and RMM magnets is based on conventional quench heaters glued to the coil and on CLIQ (Coupling-Loss Induced Quench), an innovative technology recently developed at CERN. CLIQ is composed of a charged capacitor bank, connected to the magnet via dedicated current leads. Upon quench detection, the capacitor bank is discharged into the magnet, resulting in fast oscillations of the currents in the coil sections. Thus, a high magnetic-field change is introduced, and hence high coupling loss is generated in the superconductor, which is quickly heated above its critical temperature. This method was successfully applied to 12 T Nb3Sn magnets.

The baseline quench protection system is demonstrated on the 1-meter-long ERMC model magnet. The test parameters are selected to be representative of a 15-meter-long magnet with a cross-section identical to RMM. Furthermore, a more optimized CLIQ design, featuring leads between the two layers of each pancake coil, is discussed. This design is more challenging to implement in the magnet design, but offers a significant improvement of the magnet quench-protection.

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