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Modelling and mitigation of quench risk for a NI HTS MRI brain magnet

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A no-insulation (NI), cryogen free HTS MRI magnet is currently being developed at the Robinson Research Institute. Consisting of 23 double pancake coils of varying size, width and REBCO material, the magnet is designed to image the human brain (1.5T of moderate uniformity, +/- 150 ppm over a 200 x 150 ellipsoidal imaging volume).

Risk of a quench arises from several sources, such as defects in the HTS tape; placement of HTS tape in a location with an unfavorable magnetic field and/or field angle; or variability of the critical current along a length of HTS tape. It is important to understand how the magnet would behave if a quench does occur, to ensure that the magnet is sufficiently protected from the thermal and mechanical forces that could destroy the device.

This study used transport current measurements of the critical current at 77.5 K self-field to determine the localised Ic at every position in the magnet geometry, for both YgdBCO and EuBCO conductor. Then, a lumped circuit model was used to predict the behavior of the magnet over a variety of different failure modes, such as simulating a localised quench event iteratively over a large number of different positions in the magnet geometry.

This study revealed that the magnet is broadly resilient to damage during a quench event. The ability to tune the turn-to-turn resistivity, in addition to the relatively small inductive coupling between coils, resulted in a negligible amount of the simulations exceeding damage thresholds.

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