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M3Or1A-03: Simulations of a modified CLIQ System using Split MgB2 Coils and Simultaneous Joule Heating Using a Lumped Parameter Model

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In this work, we performed numerical studies of a quench protection system relevant to MgB2 based 3T conduction cooled magnetic resonance imaging (MRI) machines using a lumped parameter model in Open Modelica. Our initial approach was similar to the CLIQ scheme, which we modelled for one coil (OD 901 mm, winding pack 44 mm thick×50.6 mm high, conduction-cooled, react-and-wind, with 1.7 km of MgB2 strand). In previous simulations, the required capacitor, other component sizes and ratings are determined. However, a large maximum voltage was required for this system. There is a breakdown voltage, and a high voltage could burn the coil. By splitting the coils, the voltage could be reduced, but not sufficient. We found we could split the coil in such a way to reduce further the inductance of the combined set and the resultant maximum voltage. We then explored a method that would allow further voltage reductions while still generating sufficient heating in the coil for protection. A lumped parameter model was built in Open Modelica to describe the resistance of the coil for operating current larger than critical current (I > Ic), and we explored directly driving the coil into overcurrent for protective heating to AC loss induced heating. This mixed approach using split coils and Joule heating in the matrix might be possible. This model in Open Modelica, including both thermal and electrical components, describes the interface between the superconducting wire and its environment. In this case, liquid helium (4.2 K) surrounds the wire, and a thermal conductor has G = 0.4 W/K as interfacial liquid-solid thermal conductance. The heat capacitor describes the heat capacitance (4e4 J/K) of the superconducting wire itself, how much heat it can store. The results are testing under different cases with different superconducting wire parameters, voltage supplies, and inductors conditions.

Author: ZHANG, Xianhao

Co-authors: SUMPTION, Michael; MAJOROS, Milan

Presenter: ZHANG, Xianhao

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