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Quench detection and protection of high-temperature superconducting magnets: The case of a Bi-2212 Rutherford cable canted-cosine-theta dipole magnet

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High temperature superconducting magnets have the potential to generate magnetic field of greater than 20 T for compact fusion reactors, particle physics colliders and nuclear magnetic resonance. A key remaining technology challenge is the quench detection and protection; the difficulty is mostly due to the low normal zone propagation velocity, on the order of cm/s. In this presentation, we report 4.2 K experimental data of a dozen of thermal runaway quenches of a prototype 1.64 T canted-cosine-theta dipole magnet constructed from a high temperature superconducting Bi-2212 Rutherford cable. We provided an analysis of the hot spot temperature reached, the size of normal zone, and how they vary with experimental parameters such as current ramping rate. An important question we try to answer is how large a safety margin we have with the quench protection scheme used (active energy extraction with a quench detection voltage of 100 mV and a dump resistor). We then discuss how a popular conventional quench protection analysis method widely applied for selection quench protection parameters for low temperature superconducting magnets, the MIITS method, should be modified for high-temperature superconducting magnets. We arrive at several recommendations of operation schemes, and a recommendation of a set of strategies for operating high-temperature superconducting magnets.

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