Contribution ID: **631** Type: **Contributed Oral**

Sat-Mo-Or5-06: Radio-frequency quench sensing integrated with flexible round HTS cables

Saturday 5 July 2025 12:30 (15 minutes)

Quench detection is a crucial technology that enables using HTS conductors in high-field magnets for high-energy physics and fusion applications. At the same time, hot spot localization capability provides valuable insights to magnet developers and operators. Distributed temperature sensing along the conductor path can achieve both goals and is especially suitable for fast-ramping magnets or current-shared cable conductors, where voltage signals due to a slowly propagating normal zone may be ambiguous or unreliable. Various temperature sensing approaches for HTS magnets using optical fibers, radio-frequency (RF), and ultrasonic methods have recently been reported. Among those, RF sensors stand out as the most robust and less expensive than optical fibers while showing a superior thermal sensitivity. The present work discusses quench sensing enabled by the temperature-induced permittivity variations in RF transmission lines made with custom insulation materials. Two distinct measurement techniques are reported. One is an RF interferometry, which is entirely based on coherent software-defined radio (SDR), and the other is a classic time-domain reflectometry using picosecond-level pulsing and a 25 GHZ sampling oscilloscope. To demonstrate our approach in practice, we have custom-wound round flexible multi-conductor ReBCO cables and embedded distributed RF temperature sensors into them. Using the above-described measurement techniques, we validate quench detection and localization capabilities in such a cable at 77 K and cross-calibrate voltage and thermal responses. The next development steps will be discussed, including measurements of the thermal runaway margin and cable-level integration of active quench protection.

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Session Classification: Sat-Mo-Or5 - Quench Detection Modelling