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Development of tools for advanced quench diagnostics at LBNL Magnet Test Facility

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Testing of high-field superconducting accelerator magnets aims at identifying potential causes of quenching, localizing quench origins and measuring quench propagation velocity along the coil winding. This information is essential for establishing protection limits and providing useful feedback to the magnet designers. Traditionally, quench studies are conducted using voltage taps. However, for the long or complex magnets this approach becomes impractical due to large number of taps required to track quench propagation and difficulty of incorporating them without jeopardizing magnet integrity. At LBNL, we develop and implement alternative methods of quench diagnostics based on time-correlated multi-point sensing of magnetic and mechanical disturbances. We have built a novel inductive quench antenna comprising a pc-board array of dipole-bucked coils interfaced to a cryogenic 16:1 multiplexed amplifier, capable of input scanning at rates up to 1 MHz. Spatial resolution of the antenna for quench localization is approx. 1 cm, and multiple pc-board arrays can be stacked together to cover full length of the magnet. A six-channel cryogenic acoustic detection system is implemented and operated simultaneously with the quench antenna. Such combined acquisition setup allows for a high-accuracy quench localization. In addition, it enables separation of mechanical and electromagnetic events, spatial mapping of mechanically-unstable areas in the magnet, and estimation of an instantly released mechanical energy during magnet ramping. Quench diagnostics examples derived from recent testing of high-field block-type Nb3Sn dipole HD3b and Canted Cosine Theta NbTi dipole will be shown. A future upgrade path for the MTF diagnostic capabilities will be presented.

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