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Flex-PCB quench antenna developments at FNAL

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Fermilab has been developing flexible printed circuit board (flex-PCB) based quench antenna (QA) probes since 2017, and these have seen a variety of improvements and customization for different applications over the years. The flex-QA have proven to be low-noise, low-cost, non-invasive, and highly sensitive sensors for quench characterization in superconducting magnets, with potential to extend to being used for quench detection as well. Recently we have been exploring applications in several directions: 1) small area sensors and feasibility for operations at high pressure; 2) sensor geometry and relative orientations to increase sensitivity and spatial resolution while rejecting noise; 3) multi-channel quench antenna arrays covering the complete area of the conductor (of the innermost magnet layer). Moving beyond refinements in warm and cold bore QA, we have also progressed to antennas which can be attached to conductor surfaces within accelerator magnets. Multiple programs and projects at FNAL and collaborating institutions have benefited from this work already, and our plans target further extensions of capabilities and applicability of these devices. In this paper, we present the reasoning behind the development steps taken so far, results from testing at various stages, and direction of near-term research on flex-QA at Fermilab.

Primary authors: STOYNEV, Stoyan (FNAL (US)); DIMARCO, Joseph (Fermilab (US))

Presenter: STOYNEV, Stoyan (FNAL (US))

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