Piezoelectric actuators for fine dynamic tuning of Superconducting RF cavities fundamental mode frequency

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Abstract

Superconducting RF (SRF) cavities, resonating at frequencies f_0 ranging from 88 MHz to 1300MHz, are used as accelerating structures (at large scale) in particle accelerators. These accelerators are applied for fundamental research studies in a broad range of science (nuclear and high energy physics: Spiral2, LHC, FEL: XFEL and high brightness light sources: SOLEIL, neutrons sources: ESS for condensed matter and advanced material R&D). To lower both investment and operation costs of these accelerators, SRF cavities are operated at high accelerating field E_{acc} (E_{acc}= 20-35MV/m) with high quality factors Q_0 (Q_0>10^{10}). However, at high electromagnetic surface fields, Lorentz force induces small deformations (e.g. ~0.1-10 μm) of the SRF cavity wall leading to a frequency shift or cavity detuning Δf_0. Piezoelectric actuators, which are integrated into Fast Active Cold Tuning System are used for dynamic tuning of the cavity in order to keep Δf_0 below the resonator bandwidth. This paper addresses the following items: 1) Basics properties of Piezoelectric Actuators and some applications of PA, 2) Fundamental properties of SRF cavities for accelerators, 3) State of the art of high performance SRF cavities, 4) Use of Piezo-Actuators for Fast Active Cold Tuning System (FACTS) of SRF resonators. The fourth section is devoted to full characterization of piezoelectric actuators at cryogenic temperatures including radiation hardness test with fast neutrons at fluences in excess of 10^{14} n/cm^2.