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Conductors for Fast Ramping Accelerator Magnets

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Fast ramping magnets are important accelerator components in several areas. In High Energy Physics they are needed in an accelerator ring for a Muon Collider, in booster accelerators for other colliders, and for production of high-intensity proton beams for high intensity targets. In the Basic Energy Sciences and the Department of Defense there is considerable need for intense levels of irradiation for material science and single-event effects component testing, which is critical for establishing hardware reliability in satellites. For applications such as accelerator driven modular nuclear reactors in Fusion Energy Sciences, a compact accelerator technology would enable either or both multiple accelerators and multiple beam ports into the core mitigating the difficult ultra-reliability requirement. A fast-cycling superconducting compact accelerator technology is also a critical and disruptive technology for commercial and medical applications. In this paper the performance of hyperconductors and high purity aluminum Litz cables is compared with those of fine filament LTS and HTS superconductors based on AC loss calculations. Suitability of each conductor is established on the basis of fast ramping magnet specifications for different accelerator applications. As an example, we consider concepts for muon beam acceleration to TeV-scale beam energies, which utilize fast ramping magnets in hybrid rapid cycling synchrotrons and recirculating linac designs. These concepts utilize lattices with fast-ramping normal conducting iron or superferric HTS-based dipoles interleaved with high field superconducting dipoles1,2,3. To minimize muon decays during the ramping cycle, these magnets would ideally provide peak ramp rates >1000 T/s with roughly ± 2T peak-to-peak magnetic field excursions. Finally, for suitable conductors, cable design for various accelerator magnet applications is explored.

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