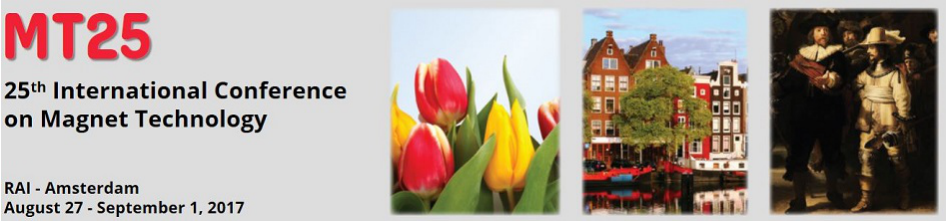

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E3SPreSSO: A Quench Protection System for High-Field High-Temperature Superconducting Magnets

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For reaching very high magnetic fields in fully superconducting magnets beyond 20T the use of High-Temperature Superconductors (HTS) is unavoidable. Due to the high Minimum Quench Energy in HTS, when operating in the temperature range of 4-20K, these coils are not very likely to quench. A nice twist of fate is, however, that it is the same stability that makes these coils much more difficult to protect against quenches using conventional methods such as quench heaters or Coupling Loss Induced Quench (CLIQ). Although it is possible to use a dump resistor on a short HTS magnet, extracting the energy externally, this does not provide a solution for longer magnets or magnets operated in a string, because the extraction voltage becomes unacceptably high. Here a method named E3SPreSSO is proposed that allows for fast energy extraction in HTS magnets. The \espr comprises units with a near-zero self-inductance superconducting circuit, connected in series with the main magnet. When the protection is triggered, these devices are turned resistive, using quench heaters, over-current or CLIQ, causing them to absorb the energy of the system. The units can be located outside the main magnet and do not generate magnetic field. Therefore it is possible to use relatively cost-efficient and robust Nb-Ti or possibly MgB_2. However, when a resistor is added in parallel, also non-stabilized HTS tapes can be considered. Multiple E3SPreSSO units can be used between magnets operated in a string or between the layers of a large coil in order to avoid high inductive voltages. This causes the operating current of the magnet to no longer depend on the protection system, reducing cost and complexity of testing and operation. This paper introduces the concept and provides an analytical analysis weighing the different options for designing the E3SPreSSO units themselves.
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