Advanced Quench Protection for the Nb_3Sn Quadrupoles for the High Luminosity LHC

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Abstract — The goal of the High Luminosity LHC project is upgrading the LHC in order to increase its luminosity by a factor five. To achieve this, twenty-four 150 mm aperture, 12 T, Nb3Sn quadrupole magnets are to be installed close to the two interaction regions at ATLAS and CMS. This new generation of high-field magnets poses a significant challenge concerning the protection of the coils in the case of a quench. The very high stored energy per unit volume requires a fast and effective quench heating system in order to limit the hot-spot temperature and hence avoid damage due to overheating. Conventional protection systems based on quench heaters have a limited response time due to the thermal insulation between the heater and the coil. An advanced solution for the protection of high-field magnets is the CLIQ (Coupling-Loss Induced Quench) system, recently developed at CERN. Due to its fast intra-wire energy-deposition mechanism, CLIQ is a very effective, yet electrically robust, quench protection system. Various protection scenarios including quench heaters, CLIQ, or combinations of the two methods are analyzed and discussed, with the aim of minimizing the coil's hot-spot temperature and thermal gradients during the discharge. The proposed design assures a fully redundant system.

Keywords (Index Terms) — Accelerator magnet, circuit modeling, CLIQ, quench protection, superconducting coil.