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Strategies to reduce the voltage to ground in the FCC main dipole circuits

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Within the FCC project, the EuroCirCol Work Package 5 is dedicated to the study of the high-field, high-current superconducting dipole magnets. The target performance of these magnets, together with the unprecedented size of the accelerator, poses a number of challenges as, among others, machine integration and protection.
As for the LHC, dipole magnets have to be powered in long strings, resulting in large stored energy in the circuits. In case of a quench or equipment failure, a safe extraction of the circuit energy in a short amount of time is very challenging due to the development of high voltages to ground.
The voltage to ground in the coils of a magnet is composed by two contributions: the voltage drop over the string from the grounding point to the magnet input and its internal voltage distribution. The higher the unbalance between resistive and inductive voltage during the current discharge, the higher the resulting voltage to ground.
In this paper, we discuss dedicated strategies to reduce the voltage to ground both at the circuit level and at the level of the powering layout of single magnets. Numerical simulations support the results, considering electrical transients at the circuit level together with magneto-thermal transients occurring at the magnet level during a quench. In this context, we also present the effect of the Coupling-Loss Induced Quench (CLIQ) system, a magnet protection technology recently developed at CERN, on the voltage to ground distribution.

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