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Modeling stabilizer and superconducting inhomogeneities of commercial REBCO tapes with a 1-D electro-thermal model

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Commercial REBCO tapes are a promising technology for power and magnet engineering. Due to their complex manufacturing, they present inhomogeneities of the critical current distribution and silver stabilizer thickness along their length. It is therefore paramount to investigate the impact of inhomogeneities when designing superconducting devices based on such tapes.
This kind of study requires extensive use of Finite Element Analysis (FEA) since such inhomogeneities are not known a priori, and various scenarios (degree of inhomogeneity, statistical distributions, etc...) need to be investigated. However, due to the very large number of degrees of freedom present in modeling large 2-D or 3-D systems, the computational cost can be very high.
In this work, we present a 1-D electro-thermal model implemented in COMSOL with MatLab, aiming to reduce the computational efforts while simulating many inhomogeneous case scenarios. The electric part is homogenized (0-D) and assumes that the thickness of the REBCO tape is negligible; the thermal part is one-dimensional (1-D) and accounts for heat propagation along the conductor length. The model accounts for both the nonlinear electrical and thermal dependence of the materials and the heat exchange with the liquid nitrogen. The resistivity models considered are the widely used power-law model and the more recently developed overcritical current (eta-beta) model. Finally, it is possible to select a statistical distribution (uniform, normal or Weibull) and its parameters to simulate the degree of inhomogeneities of the superconducting properties and/or that one of the stabilizer along the length of the tape. The FEM model is verified by comparing the simulations with DC fault measurements performed on a commercial REBCO tape.

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