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Current distribution modeling in the open-source OPENSC2 tool for the multi-physics analysis of HTS and LTS superconducting cables

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Within the framework of Open Science, set as a priority by the European Commission in Horizon Europe, the OPEN Super Conducting Cable (OPENSC²) code has been recently developed and released to grant the entire research community the possibility to analyse thermal-hydraulic (TH) transients in forced-flow superconducting (SC) cables for fusion and power applications. The code is flexibility in the reference cable topology, level of discretization, and capability of dealing with different fluids as coolants.
In this paper we present the current distribution model recently implemented in OPENSC², based on the discretization of the different cable regions with flexible 1D elements with arbitrary orientation in 3D space. This choice allows studying superconductive cables with different levels of approximation, from superconductive tapes to wound twisted cables, from region level discretization to single strand representation. The integral formulation of the magneto quasi-static approximation of Maxwell's equations is used, accounting for the inductive coupling among the elements, the local nonlinear behaviour of the SC material and possible element-to-element cross interaction due to electric contact. The flexibility of the formulation allows the user to introduce possible statistical effects on the strand distribution along the cable. While the electromagnetic (EM) and TH equations share the same discretization in space, the simulation of EM phenomena can occur on a faster time scale than the thermal response of the cable. Different coupling schemes, allowing simultaneous (implicit) or separate (explicit) time marching are then adopted according to kind of transient under investigation.
In the paper we show how the code, developed following an object-oriented approach, is currently capable to simulate EM-TH transients in both LTS and HTS cable-in-conduit conductors for fusion applications, as well as in HTS cables for power transmission.

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