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Conceptual design and first test results on the high current Nb-Ti/Cu-Ni thermal switches

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High-current superconducting switches can simplify the energy extraction in large magnet systems. For example, they can replace mechanical and vacuum breakers in the conventional electrical circuit of TF coils for fusion magnets, thus mitigate the risk of arcing. Vast majority of current leads to room temperature can be eliminated, and the cryogenic power consumption can be substantially reduced. When used in a chain of HTS accelerator magnets, the quench protection is improved because of much lower energy needed to initiate the fast discharge. Aiming at the experimental study, Nb-Ti wires in a highly resistive Cu-Ni matrix are procured both as a single strand and in a 6-around-1 cabling configuration. An Ayrton–Perry winding, essentially a layer-wound solenoid with reversed currents in neighboring layers, is proposed for this application because of its simplicity and increased distance between the switch terminals, thus reducing the electrical stresses. Multiple parallel strands or 6-around-1 cables can be considered within each individual winding layer, maintaining the full transposition feature. However, the strands in the entire winding are not transposed. Therefore, in order to assess the parameters influencing the current distribution among the strands, an electromagnetic model is developed. The outcome of the modelling is compared with the test results obtained on the first 1 kA/2 Ohm thermally-activated switch made of the two single strands. In addition to the co-wound heater, low inductance of the switch allows to turn it off by applying AC current of low amplitude (˜10 A) and high frequency (˜kHz range), thus triggering the transition into the normal state by coupling loss. Thanks to the model, the current distribution among the strands can also be extracted based on the measured total transport current and produced magnetic fields. The next steps are focused on using the 6-around-1 cables in the switch samples rated up to 10 kA (1 cable per layer in 2 layers) and 30 kA (2 cables per layer in 4 layers).

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