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Test of heat load smoothing strategies for the ITER Toroidal Field coils by means of Artificial Neural Networks

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Tokamak-type nuclear fusion reactors like ITER, under construction in France, use superconducting (SC) magnets cooled by supercritical helium (SHe) to confine the plasma. The small temperature margin available between operation and quench of the magnet requires a careful design of the magnet operating scenarios to guarantee adequate cooling in all phases. Sophisticated thermal-fluid dynamic models are available for that, e.g. the 4C code [L. Savoldi Richard, et al., Cryogenics 2010], but they are computationally very expensive. Therefore cheaper alternatives are needed, if real-time control has to be achieved.
Soft computing techniques, like Artificial Neural Networks (ANNs), were recently applied for the first time by our group to the problem of the cooling of the ITER SC magnets in the absence of controls [L. Savoldi Richard, et al., Cryogenics 2014] to predict the global evolution of the heat load to the cryoplant during plasma operation.
Here we concentrate on the ITER Toroidal Field (TF) coils, and we show how an ANN-based model of the coil, suitably inserted in the 4C TF circuit models and capable to cope with control/regulation of the cooling circuits , can be used to investigate and test control strategies for mitigation of the heat load from the coils to the cryoplant. The strategies are based on the opening of the bypass valve or on the variation of the cold circulator speed in the casing cooling loop. The results obtained using the ANN model are compared with those fully based on the 4C model in order to assess the accuracy of the model, and the computational time needed is checked to guarantee the applicability to real-time control.

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