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ITR/P5-02: Quench Detection in ITER Superconducting Magnet Systems

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The quench of one of the ITER magnet systems is an irreversible transition of the conductor from superconducting to normal resistive state. The normal zone propagates along the cable in conduit conductor, dissipating a large power. The detection has to be fast enough (2 - 3 s) to initiate the dumping of the magnetic energy and avoid irreversible damage of the systems.
The experience of CEA is based on the operation of the superconducting tokamak TORE SUPRA for more than 20 years. In support to ITER, CEA was also very involved during these last 3 years in quench detection investigations, in the framework of ITER contracts.
The primary quench detection in ITER is based on voltage detection, which is the most rapid detection. The very magnetically disturbed environment during plasma scenario makes the voltage detection particularly difficult, inducing large inductive components across the pulsed coils (10 kV) or coil subcomponents. Voltage compensations have therefore to be designed to discriminate the resistive voltage associated with the quench.
A conceptual design of the quench detection based on voltage measurements is discussed for the main ITER magnet systems and a clear methodology is developed. It includes the analysis of the main phases of the quench detection, given below with typical orders of magnitude:
- the propagation phase characterized by the time tau_p (about 1 s)
- the filtering time characterized by the time tau_h (about 1 s)
- the opening time of the current breakers tau_cb about 0.5 s)
- the total allowable detection and action time (hot spot criterion) tau_da (about 3 s)

Based on this analysis it is possible to propose for each ITER magnet system the two main parameters of the quench detection which are V_t and tau_h. V_t (0.1-0.5 V) is the voltage triggering the current breaker opening after the filtering time tau_h.
A secondary detection based on thermohydraulic signals system has also to be investigated to protect the environment in case of a non detected quench, especially for the largest ITER system which is the TF system with a stored energy of 40 GJ.

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