ITER CS MAGNET:
SELECTION OF A QUENCH DETECTION SYSTEM

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With a clear difference with respect to most of the existing superconducting systems operating in the world, the ITER Central Solenoid (CS) magnet is a fast pulsed system. This creates a specific situation regarding the quench detection system as a small resistive signal associated with a quench has to be discriminated from the high inductive signals imposed by the plasma scenario. This is particularly true in the plasma initiation phase (PIP) where current variations in the 6 modules of the CS are in the range of 3000 A/s corresponding to magnetic field variations of about 1 T/s. The total voltage across the modules during this phase can reach up to10 kV and the initial stored energy is 4 GJ.

The quench detection is based on an inductive compensation built from three adjacent double pancakes. The ITER protection rules for a superconducting magnet impose to respect the so-called hot spot criterion, which means that a maximum temperature of 250 K must not be exceeded in the superconductor when assumed adiabatic conditions during a phase including the propagation of the quench, the detection and the fast safety discharge.

For this reason, a particular attention has been paid to the understanding of the quench propagation phase and to the estimation of the time elapsed to reach the voltage threshold retained for the detection. The results provided by the Gandalf code as a function of the current and location in the modules are compared to a simple analytical model. This model turns out to be valid in the earliest time of the quench, which is relevant for the detection.

A careful analysis of the residual inductive signals in the detection voltage shows that a blanking of the quench detection cannot be avoided during the first time of the plasma run (i.e. within 3.5 s). This corresponds to the PIP where the magnetic field variations are particularly steep. It is demonstrated that this blanking is however acceptable while fulfilling the hot spot criterion because the PIP is very similar to a fast safety discharge and corresponds to a fast decrease of the current modules, which is favourable for the magnet protection.

The voltage threshold of the detection signal is eventually selected through a careful check of the theoretical residual detection voltage of each of the double pancakes during a reference scenario. This voltage can be predicted thanks to a code specifically developed for this study. Last, the holding time needed for a quench confirmation is selected through a detailed analysis of two reference magnetic situations which are the plateau just before the PIP and the blanking corresponding to the PIP, both in relation with the respect of the hot spot criterion.