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Mon-Af-Po1.16-01 [44]: Design of a quench detection system by implementing an optimization procedure

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ENEA is currently working on the design of an experimental fusion reactor named DTT (Divertor Test Tokamak).
DTT magnetic system will be realized using superconductor materials thus implying the need for specific protection strategies. In particular, in case of magnet quench, detection and protection devices are needed and they represent a significant cost. The design of quench protection circuits should take into account reliability requirements and also possible protection circuit failures.
To the aim of design purposes, it is fundamental to evaluate all possible failure scenarios in order to identify the most critical conditions. Failure scenarios analysis is a typical problem involving the detection of an extreme condition which is suitable to be solved using parametric optimization algorithms.
From the point of view of magnetic couplings, the quench protection system may be thought as composed of two subsystems: 1) the Central Solenoid (CS), Poloidal Field coils (PF) and Plasma; 2) Toroidal Field coils (TF).
Both the magnetic subsystems include the possibility of timely Fast Discharge Units (FDU) in order to discharge the energy stored into the superconducting coil in case of quench detection. Each unit includes proper breaker circuit with discharge resistor banks in parallel. When the quench is detected, the current carried out by the circuit breaker is commutated into the discharge resistor, and the superconducting coil energy is dissipated with the circuit time constant. Therefore, these resistor banks are designed to fulfill the requirements in terms of discharge time constants. After the mentioned discharge time constants, failure occur in superconductors.

Voltages and currents in each single coil and each single FDU component, both in design and quench conditions, are estimated developing a suitable electrical model and implementing it in the ANSYS software.

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