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Fault analysis and overvoltage estimation in the DEMO Toroidal Field coil circuit

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In the European DEMOnstration nuclear fusion power plant (DEMO), the desired toroidal magnetic field is produced by a magnet system composed of 16 Toroidal Field (TF) coils, according to the last 2017 reference baseline. The total stored energy of about 140 GJ, more than three times that of ITER TF coils, has to be quickly dissipated in case of quench by a suitable Quench Protection (QP) system. The energy, the current and the required discharge time constant define the voltage to be applied to the coils; however, the peak value at the coil terminals during the fast transient phase at the beginning of the discharge or in case of faults can be much higher.

This paper deals with first studies addressed to estimate maximum voltage stresses for TF coils in various operating conditions and for different TF circuit topologies to evaluate their relative merit and to provide inputs for the definition of the number of toroidal sectors as a compromise between requirements for the coil insulation and cost and size of protection system, busbars and current leads.

The studies were firstly done with 18 TF coils (2015 reference baseline); since three different winding pack options are under study, we selected the one characterized by the highest inductance, thus by the related highest voltage across the coils at the discharge.

Numerical simulations were carried out to reproduce the voltage waveforms at the coil terminals, across the coils and to calculate the i2t in the coils for the cases analyzed for the different TF QP circuit topologies, operating conditions, and number of sectors (18 / 9). Then, the analyses have been updated for the case of 16 / 8 sectors of the last reference baseline; all the main results are reported and discussed.

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