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Electromagnetic FEM studies of disruptions and engineering consequences for the power supply and coils design of planned upper divertor at ASDEX Upgrade

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There is proposed a new upper divertor for the ASDEX Upgrade tokamak experiment [1]. It is planned to be equipped with internal coils for investigation of advanced magnetic configurations like e.g. „snowflake“. Due to the close vicinity of the coils to the plasma, high induced and very stiff voltages are expected during disruption events. Because only very vague analytical estimates of voltages, forces and coupling factors were available, an improvement by the help of finite element method (FEM) was envisaged. Therefore, recorded measurements of currents, plasma position, plasma profile and the geometry were integrated into the electromagnetic simulation as boundary conditions to calculate resulting field distributions during selected AUG disruption events. The time resolution can be better than 100 microseconds and the required computing resources are comparable small due to utilization of 2D axis-symmetry. The results were compared with magnetic probe measurements integrated into the tokamak. They are in good agreement. After this, the simulated geometry was modified to the target geometry including the new divertor to calculate all relevant parameters. The output of these calculations has strong implications for the coil and power supply design: (1) The power supply will be protected with a new kind of crowbar to avoid uncontrolled current and force rise of the coils and power supply damage due to overvoltage. The concept of this so called “ripping crowbar” will be introduced, which is under development, now. (2) The coil cable should be coaxial shaped to monitor isolation faults and to become inherently safe against single-turn shortcuts, identified as a destructive fault scenario.

[1] A. Herrmann, et al., Fusion Engineering and Design 123 (2017) 508-512.

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