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Design of in-vessel saddle coils at ASDEX Upgrade for ELM suppression and Resistive Wall Mode stabilisation

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A set of 24 saddle coils for ASDEX Upgrade has been designed to study the suppression of Edge Localised Modes by resonant magnetic perturbation, to produce rotating error fields for locked-mode prevention, and, together with a passive wall structure, sensor coils and fast independent power supplies for each coil, to investigate feed-back controlled stabilisation of the resistive wall mode (RWM) in advanced tokamak scenarios. The coils are mounted inside the vacuum vessel of ASDEX Upgrade on the low-field side and allow for a maximum DC current of 3 kA$\times$turns per coil, and AC capability up to a frequency of 3 kHz, consistent with calculated RWM growth rates.

Resonant magnetic perturbations for ELM suppression can be created in different configurations. Eight toroidally distributed coils allow for a fundamental toroidal mode number up to $n = 4$, which in combination with the narrow radial distance of the coils to the plasma helps to minimize parasitic core perturbations. Vacuum field calculations indicate that significant stochastisation in the pedestal region can be obtained at a coil current of 500 A$\times$turns while at this current the core island width remains below $3-4$ mm ($< 1\%$ of the minor radius). A DC $n = 4$ perturbation can be produced with only one power supply (existing at ASDEX Upgrade) if all coils are connected in series. The three poloidally separated toroidal sets of eight coils can be operated in phase (0^0, even phasing) or anti-phase (180^0, odd phasing) with respect to each other, which yields four possible combinations (even-even, odd-even, even-odd, odd-odd) with different poloidal mode number (m) spectrum and therefore different resonant safety factor profiles. Alternatively, for $n = 3$ perturbations the phase between poloidally separated coil sets can be varied quasi-continuously (i.e. almost independently of amplitude), allowing to produce (or avoid) a poloidal mode spectrum resonant with an arbitrary edge safety factor.

In this contribution, we describe the design of the coil systems, the power supply concept, and the calculated (m, n) spectra for the various coil current configurations. Based on radial field-line excursions calculated with the GOURDON code, the Chirikov parameter and Lyapunov exponent around islands and stochastic regions are calculated as a basis for the discussion of the appropriateness of the various configurations for ELM control.