3D vacuum magnetic field modeling of the ITER ELM control coil during standard operating scenarios

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Abstract. In-vessel, non-axisymmetric, control coils have proven to be an important option for mitigating and suppressing edge-localized modes (ELMs) in high performance operating regimes on a growing number of tokamaks. Additionally, an in-vessel non-axisymmetric ELM control coil is being considered in the ITER baseline design. In preparing for the initial operation of this coil set, a comprehensive study was carried out to characterize the linear superposition of the 3D vacuum magnetic field, produced by the ELM coil, on a series of equilibria representing nine standard ITER operating scenarios. Here, the spatial phase angle of toroidally distributed currents, specified with a cosine waveform, in the upper and lower rows of the ITER ELM coil (IEC) set is varied in 2º steps while holding the current in the equatorial row of coils constant. The peak current in each of the three toroidal rows of window-frame coils making up the IEC is scanned between 5 kAt and 90 kAt in 5 kAt steps and the width of the edge region covered by overlapping vacuum field magnetic islands is calculated. This width is compared to a vacuum field ELM suppression correlation criterion found in DIII-D. A minimum coil current satisfying the DIII-D criterion, along with an associated set of phase angles, is identified for each ITER operating scenario. These currents range from 20 kAt to 75 kAt depending on the operating scenario being used and the toroidal mode number (n) of the cosine waveform. Comparisons between the scaling of the divertor footprint area in cases with $n = 3$ perturbation fields versus those with $n = 4$ show significant advantages when using $n = 3$. In addition, it is found that the DIII-D correlation criterion can be satisfied in the event that various combinations of individual IEC window-frame coils need to be turned off due to malfunctioning components located inside the vacuum vessel. Details of these results for both the full set of 27 window-frame coils and various reduced sets, using either $n = 3$ and $n = 4$ perturbation fields, are discussed.

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