Plasma magnetic control scenarios for the ITER PFPO-1 phase

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The first ITER non-active (H or He fuel) Pre-Fusion Power Operation phase (PFPO-1) will also be the first in which the full blanket first wall and divertor will be installed and in which the ITER Research Plan foresees the achievement of diverted plasma scenarios potentially up to plasma currents of I_p = 10 MA in L-mode and 5 MA in Type I ELMing H-mode. This in turn requires that the Plasma Control System (PCS), in particular for plasma current, position and shape control, be developed with the full required functionality well in advance of the campaign. This PCS PFPO-1 design activity is now underway, with completion expected in 2025. Scenario simulations with specific focus on plasma magnetic control and taking into account the engineering limits of the ITER machine, are a key input to this PCS design. As will be described in this paper, they are being performed with the DINA code, which incorporates a 2D free boundary equilibrium solver, and is now fully integrated into the ITER Integrated Modelling Analysis Suite. The various controllers used in DINA for the scenario development are also being ported into the PCS Simulation Platform (PCSSP). To perform sensitivity studies of the impact of plasma internal inductance on magnetic control, the DINA transport module has recently been updated.

Magnetic control on ITER is complicated as a result of long settling times caused by the thick vacuum vessel walls, the high inductance of the poloidal field coils and the relatively low voltage limits allowed by the superconducting magnets. There are also many additional requirements which impose detailed optimization of magnetic control scenarios (for example the generation of oscillations in power consumed from the electric grid). Plasma density waveforms are optimized to be high enough to reduce the possibility of locked modes, but not too high as to exceed the Greenwald limit. The achievable stable plasma elongation is estimated respecting the minimum allowed distance between the inner and outer separatrices, and vertical stability with the presence of noise in the vertical position control. In the low I_p PFPO-1 scenarios, the initial charge of the Central Solenoid (CS) is reduced to save lifetime. Even for a half-charged CS, I_p flattop durations of ~100 s are found to be possible.