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# Design of the ITER Plasma Control System for Disruption Prevention and Mitigation

The ITER Plasma Control System (PCS) is responsible for real-time regulation of plasma state and stability in order to satisfy the ITER physics mission and respond to fault conditions while minimizing the frequency of plasma-terminating disruptions [1]. Each of the control functions of the PCS work together to continuously prevent, asynchronously avoid, or mitigate (unavoidable) disruptions. This work describes selected architectural and algorithmic features of the PCS to enable the achievement of extremely low disruptivity, and to trigger the ITER Disruption Mitigation System (DMS) in a timely way to effectively mitigate adverse disruption effects.

Satisfying the ITER physics mission requires a multi-layered control architecture, each layer of which reduces the likelihood of loss of control that can lead to disruption. The first layer, continuous control functions that provide the nominal discharge scenario such as plasma equilibrium control, vertical stability, and current profile control, are designed to be robust to expected disturbances. A second control layer will continuously prevent disruptions by maintaining safe distance from key controllability boundaries, such as those corresponding to vertical instability, tearing mode, and divertor and core radiation limits. This layer will share equilibrium, kinetic, and profile control actuators to balance disruption prevention goals with scenario goals. Specific "exception handling"(EH) algorithms will respond asynchronously to faults, such as power supply failures or large impurity influxes, in order to explicitly avoid disruptions that might otherwise occur. EH functions will be aided by Faster-than-Real-Time-Simulation (FRTS) [2] and physics or data-driven predictors [3], which will monitor and project plasma and system behavior into the future to identify exceptions before they occur. Approaches to controllability boundaries will provide the earliest warnings enabling EH avoidance of disruptions. If a sufficiently high risk of unavoidable disruption is predicted, the Central Interlock System (CIS) will trigger the ITER Disruption Mitigation System to inject large impurity quantities to mitigate potentially damaging effects.

Operational features of the ITER PCS augment the architecture to enhance disruption prevention. The use of "compact controllers,"pre-validated modules accessible from a library, will maximize reliability when algorithms can draw from them. The ITER PCS will also be connectable to a control-level simulation in order to validate performance and robustness of control scenarios, as well as EH responses to a standard set of test faults and potentially-disruptive exceptions.

The layered architecture and algorithmic structure of the ITER PCS will provide unique capability to minimize disruptivity in ITER, enabling high reliability control of the physics scenario, maximizing sustained plasma operation time in a given discharge, and protecting the investment in the device itself. The present work will summarize the PCS design approach and place it in broad context with selected ongoing research [4].

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[1] Snipes, J.A., et al, Nucl. Fus. 57 (2017) 125001
[2] Humphreys, D.A., et al, Phys. Pl. 22 (2015) 021806
[3] Rea, C., et al, Nucl. Fusion 59 (2019) 096016
[4] Strait, E.J., et al, Nucl. Fus. 59 (2019) 112012

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