DESIGNING, CONSTRUCTING AND USING PLASMA CONTROL SYSTEM ALGORITHMS ON DIII-D

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The DIII-D Plasma Control System (PCS [1]), initially deployed in the early 1990's, now controls nearly all aspects of the tokamak and plasma environment. Versions of this PCS, supported by General Atomics, are presently used to control several tokamaks around the world, including the superconducting tokamaks EAST and KSTAR. The experimental challenges posed by the advanced tokamak mission of DIII-D and the variety of devices supported by the PCS have driven the development of a rich array of control algorithms, along with a powerful set of tools for algorithm design and testing. Broadly speaking, the PCS mission is to utilize all available sensors, measurements and actuators to safely produce a plasma state trajectory leading to and then maintaining the desired experimental conditions. Often new physics understanding leads to new or modified control requirements that use existing actuators in new ways.

We describe several important DIII-D PCS design and test tools that support implementation and optimization of algorithms. We describe selected algorithms and the ways they fit within the PCS architecture, which in turn allows great flexibility in designing, constructing and using the algorithms to reliably produce a desired complex experimental environment. Control algorithms, PCS interfaces, and design and testing tools are described from the perspective of the physics operator (PO), who must operate the PCS to achieve experimental goals and maximize physics productivity of the tokamak. For example, from a PO's (and experimental team leader's) standpoint, a PCS algorithm interface that offers maximum actuator, algorithmic and measurement configuration flexibility is most likely to produce a successful experimental outcome. However, proper constraints that limit flexibility in use of the PCS can also help to maximize effectiveness. For example, device limits and safety must be built into the PCS, sometimes at the algorithm level. We show how the D3D PCS toolset enables rapid offline testing of a new or modified algorithm in a simulated tokamak environment. Finally, we illustrate usage of PCS-based checklists and procedures that enhance experimental productivity and we describe an asynchronous condition detector system within the PCS that enhances device safety and enables complex experiment design.

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