DIII-D Integrated Plasma Control Tools Applied to Next Generation Tokamaks*

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Current and next generation fusion experiments are increasingly expected to operate in advanced tokamak (AT) regimes and require highly integrated, complex plasma control. The DIII-D program is dedicated to the AT mission and has developed an extensive set of modeling, simulation, and design tools for real-time control development to enable integrated high performance regulation of plasma shape, internal profiles, fueling, pumping, current drive and heating [1]. The highly flexible DIII-D machine allows validation of this software suite over a wide range of plasma parameters and configurations. The system is tightly integrated with our state-of-the-art digital Plasma Control System (PCS) [2] enabling rapid development and testing of algorithms prior to device implementation. This paper provides an overview of this software suite and its application to next generation tokamaks. Modeling environment elements have been used to design controllers for devices that use, or plan to use, the DIII-D PCS, including NSTX, MAST, KSTAR and EAST. DIII-D integrated plasma control tools have been applied to analysis and control simulation of ITER-FEAT using a demonstration PCS. Results of applications to these devices will be presented.

The software suite consists of detailed linear/non-linear models of plasma and system components, simulators, control design tools, and PCS interface/testing modules. Both rigid and non-rigid linear equilibrium models of the plasma shape are used in device simulation and controller development. A nonlinear plasma model based on DINA [3] is used to simulate coupled plasma shape and profile evolution. System simulation is performed using a plant model including power supplies, PF coils, passive elements, plasma models, diagnostics and data filtering/conditioning. The simulator connects to the actual PCS hardware (or a software version of the PCS) to perform hardware-in-the-loop tokamak/PCS simulation. The integrated plasma control suite provides a comprehensive environment for development and testing of complex plasma control algorithms. Applications of the suite have identified power supply characteristics and gains required to satisfy machine design constraints.

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*Work supported by U.S. Dept of Energy under DE-FC02-04ER54698 & DE-AC02-76CH03073.