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Integrated current profile, normalized beta and NTM control in DIII-D

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There is an increasing need for integrating individual plasma-control algorithms with the ultimate goal of simultaneously regulating more than one plasma property. Some of these integrated-control solutions should have the capability of arbitrating the authority of the individual plasma-control algorithms over the available actuators within the tokamak. Such decision-making process must run in real time since its outcome depends on the plasma state. Therefore, control architectures including supervisory and/or exception-handling algorithms will play an essential role in future fusion reactors like ITER. However, most plasma-control experiments in present devices have focused so far on demonstrating control solutions for isolated objectives. In this work, initial experimental results are reported for simultaneous current-profile control, normalized-beta control, and NTM suppression in DIII-D. Neutral beam injection (NBI), electron-cyclotron (EC) heating & current drive (H&CD), and plasma current modulation are the actuation methods. The NBI power and plasma current are always modulated by the Profile Control category within the DIII-D Plasma Control System (PCS) in order to control both the current profile and the normalized beta. Electron-cyclotron H&CD is utilized by either the Profile Control or the Gyrotron categories within the DIII-D PCS as dictated by the Off-Normal and Fault Response (ONFR) system, which monitors the occurrence of a Neoclassical Tearing Mode (NTM) and regulates the authority over the gyrotrons. The total EC power and poloidal mirror angles are the gyrotron-related actuation variables. When no NTM suppression is required, the gyrotrons are used by the Profile Control category, but when NTM suppression is required, the ONFR transfers the authority over the gyrotrons to the NTM stabilization algorithm located in the Gyrotron category. Initial experimental results show the potential of the ONFR system to successfully integrate competing control algorithms.

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