Toward Active Current Density Profile Control in NSTX-U: Performance Assessment via Predictive TRANSP Simulations*

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Active control of the toroidal current density profile is among those plasma-control milestones that the NSTX-U program must achieve to realize its operational goals. An overview of current efforts toward current-profile control in NSTX-U will be provided. A two-component control design approach is followed for the regulation of the current profile by actuating the total plasma current and the powers of the individual neutral beam injectors. First, nonlinear optimization techniques are used to compute offline actuator trajectories that achieve specific plasma scenarios. Given a desired operating state, the optimizer produces the actuator trajectories that steer the plasma to such state. The objective of the feedforward control design stage is to provide a systematic approach to scenario planning. Secondly, a feedback control algorithm is developed to track a desired current density profile evolution by modifying online the previously computed feedforward trajectories. The objective of the feedback control design stage is to add robustness against model uncertainties and disturbances to the overall current-profile control scheme. Both the actuator-trajectory optimizer and the real-time feedback controller are designed based on a first-principles-driven, control-oriented model that predicts the evolution of the current density profile by combining the poloidal magnetic flux diffusion equation with empirical correlations obtained at NSTX-U for the electron density, electron temperature, and non-inductive current drives. The proposed control scheme is being tested in TRANSP simulations through the recently developed Expert routine, which provides a framework to perform closed-loop predictive simulations within the TRANSP source code. Simulation results assessing the effectiveness of the proposed control scheme will be presented.

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