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TRANSP-based closed-loop simulations of current profile optimal regulation in NSTX-Upgrade

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Active control of the toroidal current density profile is one of the plasma control milestones that the National Spherical Tokamak eXperiment - Upgrade (NSTX-U) program must achieve to realize and sustain high-performance, MHD-stable plasma operation. As a first step towards the realization of this goal, a nonlinear, control-oriented, physics-based model describing the temporal evolution of the current profile has been obtained by combining the magnetic diffusion equation with empirical correlations obtained for the electron density, electron temperature, and non-inductive current drives in NSTX-U [Fusion Eng. Des., 123 (2017) 564–568]. The proposed model has then been embedded into the control design process to synthesize a time-invariant, linear-quadratic-integral, optimal controller capable of regulating the rotational transform profile around a desired target profile while rejecting disturbances. Neutral beam injectors, electron density, and the total plasma current are used as actuators to shape the current profile. The effectiveness of the proposed controller in regulating the rotational transform profile in NSTX-U is demonstrated in this work in closed-loop nonlinear simulations based on the physics-oriented code TRANSP. These high-fidelity closed-loop simulations, which are a critical step before experimental implementation and testing, are enabled by a flexible framework recently developed to perform feedback control design and simulation in TRANSP [Nucl. Fusion 55 (2015) 053033 (15pp)].

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Topic

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Preferred presentation

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