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Active Feedback Stabilization of Resistive Wall Mode on DIII-D[1]

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The resistive wall mode (RWM) is a prominent cause of global MHD events limiting high performance in toroidal devices. The RWM is an ideal MHD kink excited on the slow resistive time scale (L/R) of the vacuum vessel and strongly destabilized when the toroidal rotation velocity is reduced to a fraction of sound velocity. Experimental results consistent with these theoretical predictions have led to the next step: suppression of the RWM guided by up-to-date theory. Here, we report a proof-of-principle experiment on DIII-D for magnetic feedback stabilization in high beta discharges. Various feedback logic schemes, including smart shell, fake rotating shell, and explicit mode control were examined using a rapid I_p ramp, which excites strong RWMs at modest beta. The explicit mode control logic with time-derivative gain, where the feedback signal is enhanced by subtracting the contribution of the active coil, reduced the RWM from 20 G to 1 G and maintained toroidal rotation with <30% loss. This low level RWM period was sustained for more than 200 ms until the configuration drifted to a severely unstable equilibrium, leading to a sudden 40 G RWM event. With a quasi-steady state advanced tokamak discharge ($\beta \sim 4\,\mathrm{I/aB}$), the feedback suppressed several RWM events and maintained the beta above the no-wall limit. Full toroidal models for RWM feedback simulation have been developed to study beyond cylindrical model. The VALEN code indicates that with improved sensor locations, beta 30% above the no-wall limit should be achievable.

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