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Feedback Suppression of Rotating External Kink Modes in the Presence of Noise[1]

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We report on the first experimental demonstration of active feedback suppression of rotating external kink modes near the ideal wall limit in a tokamak using Kalman filtering to discriminate the $n = 1$ kink mode from background noise. In order to achieve the highest plasma pressure limits in ITER, resistive wall mode stabilization is required,[2] and feedback algorithms will need to distinguish the mode from noise due to other magnetohydrodynamic activity. The Kalman filter contains an internal model that captures the dynamics of a rotating, growing $n = 1$ mode. This model is actively compared with real-time measurements to produce an optimal estimate for the mode's amplitude and phase. On the HBT-EP experiment, the Kalman filter algorithm is implemented using a set of digital, field-programmable gate array controllers with 10 microsecond latencies. Signals from an array of 20 poloidal sensor coils are used to measure the $n = 1$ mode, and the feedback control is applied using 40 poloidally and toroidally localized control coils. The feedback system with the Kalman filter is able to suppress the external kink mode over a broad range of phase angles between the sensed mode and applied control field, and performance is robust at noise levels that render proportional gain feedback ineffective. Suppression of the kink mode is accomplished without excitation of higher frequencies as was observed in previous experiments using simple lead-lag loop compensation.[3]

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[2]T. C. Hender, J. C. Wesley, J. Bialek, *et al.*, *Nuclear Fusion* **47**, S128 (2007).

[3]A. J. Klein, D. A. Maurer, T. S. Pedersen, M. E. Mauel, *et al.*, *Phys. Plasmas* **12**, 040703 (2005).