Exploring Robustness of Magnetic Feedback Using Current-Driven Resistive Wall Mode Stabilization *

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The pursuit of a steady-state production of thermonuclear fusion energy in tokamaks has led to research on the stabilization of the external kink and the resistive wall mode. Advances in theory, together with improvements in diagnostics, heating and feedback methods, have led to substantial and steady progress in this interesting area of research in high beta plasmas. One challenge of exploring resistive wall mode (RWM) stabilization in high beta plasmas is the non-reproducibility of mode excitation since the RWMs are often excited near the operational limit. In this regard, the robustness of RWM feedback stabilization has not been systematically explored. To meet this challenge, reproducible current driven-RWMs at very low beta have been extremely useful to investigate the feedback logic and to understand RWM feedback physics. The current-driven RWM is excited at edge safety factor q_{95}~4 by a rapid plasma current ramp, whose helical mode structure is observed to be very similar to that of the pressure-driven RWM in high beta plasmas. The magnetic feedback applied to modes that appear above the no-wall q_{95}~4 current-kink limit successfully reduced the plasma response to a few Gauss level by compensating the component of intrinsic n=1 error field resonant to the RWM. This also avoids the formation of a magnetic island at the q~2 surface. Higher feedback gain sustained plasma stability up to very close to the q_{95}~4 ideal-wall limit. The additional application of time derivative gain was very effective in expanding the stable feedback range. Toroidal phase shift of the feedback field relative to the mode toroidal direction observed by sensors also improved the stability. These results indicate the feedback process acted as a fast direct feedback on the mode itself in addition to compensating on a slower time scale the component of uncorrected error field resonant to the RWM.

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*Work supported by the US Department of Energy under DE-AC02-76CH03073, DE-FG02-03ER83657, DE-FC02-04ER54698 and DE-FG02-89ER53297.