Feedback Stabilization of the Resistive Wall Mode in General Geometry

M.S. Chu
General Atomics

M.S. Chance, M. Okabayashi
Princeton Plasma Physics Laboratory

Many magnetic confinement configurations require the presence of an external perfect conducting wall for their stabilization against the external kink mode. When the resistivity of the external wall is taken into account, long term stability of the plasma then depends on its being stable with respect to the resistive wall mode (RWM). At the present moment, the most promising method for stabilization of the RWM is feedback stabilization with external sensor loops and feedback coils. In this work, we present a general formulation for modeling of feedback stabilization of the RWM for an ideal plasma. We show that the stability of the plasma satisfies a generalized inhomogeneous energy functional. It is a generalization of the usual ideal MHD functional with the inclusion of the resistivity of the external wall and the currents from the external coils; the currents in the external coils provide the inhomogeneous source term. The eigenmodes of the system without the inclusion of the source terms corresponds to the observed RWM without feedback. The sensing of these modes by the sensor loops and the subsequent excitation of them by the external coils form a complete equivalent circuit description of the system during feedback. This set of equations is, in general, non-self-adjoint. However, various quantities, such as the transfer function [1], can be easily derived. In a special case, when the sensor loops and feedback coils are closely coupled to the wall and to each other, the system remains self-adjoint, and can be solved with a flux conserving constraint [2]. The general formulation of the problem have been implemented numerically and applied to the DIII–D tokamak. We found that installing the sensor loops inside of the resistive wall is superior to installing them outside. Numerical examples, which show the effectiveness of the feedback on stabilizing the RWM, are also presented.

This is a report of work supported by U.S. DOE Grant DE-FG03-95ER54309 and Contract

References

[1] Y.Q. Liu and A. Bondeson, Phys. Rev. Lett. **84**, 907 (2000).
[2] M.S. Chance, M.S. Chu, and M. Okabayashi, IAEA, (2000).