Model-based Control of the Resistive Wall Mode in DIII-D: A Comparison Study

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One of the major non-axisymmetric instabilities under study in the DIII-D tokamak is the resistive wall mode (RWM), a form of plasma kink instability whose growth rate is moderated by the influence of a resistive wall. One of the approaches for RWM stabilization, referred to as *magnetic control*, uses feedback control to produce magnetic fields opposing the moving field that accompanies the growth of the mode. These fields are generated by coils arranged around the tokamak. One problem with RWM control methods used in present experiments is that they predominantly use simple non-model-based proportional-derivative (PD) controllers requiring substantial derivative gain for stabilization, which implies a large response to noise, leading to a requirement for high peak voltages and coil currents, usually leading to actuation saturation. Motivated by this limitation, current efforts in DIII-D include the development of model-based RWM controllers. The General Atomics/Far-Tech DIII-D RWM model represents the plasma surface as a toroidal current sheet and represents the wall using an eigenmode approach [1]. Although the plasma surface deformation cannot be directly measured in real time, the magnitude and phase of the deformation can be diagnosed from measurements by a set of 22 magnetic field sensors composed of poloidal probes and saddle loops. An array of 12 control I-coils can then be used to return the plasma to its original axisymmetric shape. Using an estimator for the two orthogonal components of the assumed n=1 mode pattern, the resultant plant can be constructed into a reduced form from the original 12 input, 22 output. In particular, using a typical quartet configuration for the I-coils and matched filter, the plant can be simplified to a 3-input/2-output system. Optimal and robust controllers have been designed exploiting the availability of the RWM dynamic model. The controllers are tested through simulations, and results are compared to present non-model-based PD controllers. Advantages and disadvantages associated with the different control approaches, including implications for experimental implementation and use, are discussed.

[1] Y. In, et al, "Model-based dynamic resistive wall mode identification and feedback control in the DIII-D tokamak," Phys. Plasmas 13 (2006) 062512.