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Toroidal modelling of RWM feedback in the presence of control voltage saturation and sensor noise

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Systematic, multiple initial value simulations are performed for a toroidal plasma, using the recently updated MARS-F code, in order to understand how the resistive wall mode (RWM) can be feedback controlled in the presence of the control coil voltage saturation and/or the sensor noise. In the absence of any noise, our initial value simulations show that the RWM is feedback stabilized, provided that (i) the feedback gain exceeds the threshold value as predicted by the corresponding eigenvalue computations, and (ii) the control coil voltage saturation limit is above a certain critical value. This critical, minimal voltage requirement, together with the maximal voltage reached by the closed loop in the absence of any voltage constraints, form a band within which the control becomes non-linear but the mode can still be suppressed. Above the upper bound for the control voltage, the feedback is linear, where the initial value problem is essentially the same as the corresponding closed loop eigenvalue problem, except for a special case to be discussed later. Below the lower bound of the control voltage, the power saturation eventually leads to loss of the RWM control. Interestingly, our numerical simulations also reveal that the lower bound (i.e. the minimal voltage limit) is independent of the feedback gain (as long as the gain the above the threshold value for the linear stability of the closed loop system), confirming the analytic finding from the analytical results (Li et al 2012 Phys. Plasmas 19 012502). Moreover, simulation results reveal a linear trend between the maximum tolerable sensor noise level and the degree of relaxing the control coil voltage saturation requirement, up to a certain level of noise, corresponding to the noise-to-signal ratio of about 25%. Beyond this level, further relaxing the control voltage saturation limit does not lead to increased sensor noise tolerance for the RWM stabilization.