Effects of control voltage saturation and sensor noise on the RWM feedback in ITER

S. Wang¹, Y. Q. Liu²,1, G. Y. Zheng¹, X. M. Song¹, G. Z. Hao¹, G. L. Xia¹,³ and L. Li⁴,

¹ Southwestern Institute of Physics, P.O. Box 432 Chengdu 610041, China
² General Atomics, PO Box 85608, San Diego, CA 92186-5608, USA
³ CCFE, Culham Science Centre, Abingdon, OX14 3DB, UK
⁴ Donghua University, College of Science, Shanghai 201620, China

Active control of the $n = 1$ ($n$ is the toroidal mode number) resistive wall mode (RWM) is numerically studied, taking into account (i) recent design of the plasma equilibrium for the ITER 9 MA steady state scenario, and (ii) two important control aspects towards realistic modeling of the RWM feedback for ITER, namely the control power saturation issue and the presence of sensor signal noise. This is the first such attempt where both the aforementioned factors are included into investigation. The large L/R response time of the active coils in ITER results in a significant reduction of the open-loop RWM growth rate, when the active coils act as passive conductors. For a typical RWM, the linear flux-to-voltage control scheme yields complex closed loop eigenvalue (in the absence of plasma flow and drift kinetic effects), before the mode is fully stabilized by feedback. Without sensor signal noise, the RWM feedback system can tolerate a low level of control voltage saturation, typically in the order of 1 V in ITER. The presence of high-frequency sensor signal noise, however, can significantly increase the tolerable level of control power saturation. For a plasma close to the ITER target, and with the feedback gain well beyond the critical value for the linear closed loop stability, the tolerable voltage saturation level is predicted to be about 4 V at the sensor signal noise level (standard deviation) of 0.25 Gauss, and about 40 V at noise level of 1 Gauss.