Performance Assessment of a Dynamic Current Allocator for the JET eXtreme Shape Controller

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The need for achieving increasingly better performance in present and future tokamak devices is pushing plasma control to gain increasing importance in tokamak engineering. High performance in tokamaks is achieved by plasmas with elongated poloidal cross-section. A strong motivation to improve plasma control is the need of maximize the plasma volume within the available space. In particular, the ability to control the plasma shape while ensuring good clearance between the plasma and the facing components is an essential feature of any plasma position and shape control system. The eXtreme Shape Controller (XSC, [1, Ch. 9]) allows to accurately control highly elongated plasmas at the JET tokamak [2] by driving the current in the Poloidal Field (PF) coils. The XSC enables high accuracy control of the overall plasma boundary, specified in terms of a certain number of gaps. In its present implementation, the XSC does not handle current saturations in the PF coils. Indeed, each operating scenario is carefully designed [3] so as to avoid that the currents reach the saturation limits in the presence of the envisaged disturbances (i.e. plasma current, poloidal beta and internal inductance variations). A dynamic coil current allocator based on the technique originally proposed in [4] has been recently proposed to manage current limit avoidance with the XSC [5]. The allocator exploits the redundancy of the PF coil system to obtain "almost the same plasma reference shape" with different combinations of coil currents. Hence, in the presence of disturbances, it aims at avoiding the current saturations by "relaxing" the plasma shape constraints. Furthermore, the allocator guarantees an optimal trade-off, at the steady-state, between shape loss and distance of the coil currents from their saturation limits. In order to assess the performance of the proposed limit avoidance system, the allocator control logic has been integrated within the XSC Tools [3]. As an example, pulse #66566 at the flat top has been considered, corresponding to an high elongated configuration with nominal plasma current of 1.9 MA. In this setting, the maximum tolerable disturbance for the control system in the (betap,li) plane, before reaching a unacceptable shape deformation and/or a current saturation limit, is more than doubled when using the dynamic allocator with the XSC, as compared to the bare use of the XSC. It should be also emphasized that these results are obtained using a linear plasma model, hence they are significant within the range of validity of the linearity assumption. This paper reports on the results attained during this preliminary analysis and illustrates the advantage arising from the use of the dynamic allocator, versus the bare use of the XSC, in terms of size of the region of the maximum tolerable disturbances.

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