A new approach for the development of Disruption Protection-Avoidance Tools for JET

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Studies based on a first-principles physics approach have produced a wider understanding of JET disruptions. The next step is to explore the implementation of a disruption protection system to integrate the physics knowledge on each type of disruption with the machine experience and the technical constraints posed by the actual real-time JET plasma protection and control systems.

The paper focuses on a particular class of disruption: the mode lock. The physical mechanism responsible for the mode locking is the rotation braking effect of error fields or MHD modes (such as resistive wall modes) in slowing and ultimately stopping the rotation of the plasma column. In a mode lock disruption the amplitude of the perturbation causing the rotation braking grows as the plasma rotation decreases.

At JET the protection against the mode lock disruptions uses the mode amplitude as the disruption precursor. The present algorithm suffers from an offset in the magnetic signal used as to monitor the growth of the perturbation. This offset has a non linear dependence on the poloidal field circuit currents, very difficult to compensate for reliably. Hence, to avoid the effect of spurious trips in this signal, the trigger level used to request the pulse termination is set to a high value. This procedure has the drawback of delaying the termination request to the very last phase of the disruption even if, by monitoring the signal, the presence of a mode lock could have been predicted earlier.

The study analyses the mode lock algorithm to understand what can be done to minimise the effect of this offset, starting from its physical and engineering basis, to anticipate the current mode lock protection system. The paper presents different approaches used to tackle this problem, focusing on the discrete Fourier transform, which presents the best performance. This method readily allows eliminating the dominant DC and low frequency components of such signal offset. Using this technique combined with the present protection system, the performance increases from 63.2% of pulses correctly predicted to 89.7%, where a database of 106 disruptions has been considered. Moreover this technique anticipates the alarm for 76.9% of the considered pulses.

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