Real-time plasma boundary reconstruction in RFX-mod tokamak discharges

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The RFX-mod machine, originally designed as a Reversed Field Pinch, has also been operated as a tokamak with a low security factor at the edge. In the circular shape discharges, the active control of \( m=2, n=1 \) MHD mode by means of saddle coils has been achieved. An experimental program on double-null and single null discharges is in progress with the aim of both controlling the same MHD mode in shaped plasma discharges and accessing improved confinement regimes. Preliminary data have been collected in discharges obtained preprogramming the poloidal field coil currents. A special effort is now focused on designing a reliable feedback control system of plasma centroid and shape. In the frame of this activity, a new diagnostic method for real time plasma boundary measurement was developed to make available real time measures of plasma-wall distances along fixed directions (gaps). This method is based on the calculation of the vacuum magnetic potential and, subsequently, the magnetic field components as a Fourier series whose coefficients are derived from signals of magnetic sensors – 8 flux loops and 8 pick-up coils. A real time applicable numerical scheme for X-point position and separatrix flux evaluation was proposed and tested on both experimental and simulation data, obtained by means of the MHD equilibrium code MAXFEA. The X-point position was estimated by imposing the condition to be null on both radial and poloidal component of the magnetic field. In developing this algorithm, provisions were also made to reduce the aliasing errors caused by limited number of sensors. This method is based on the separation of plasma and poloidal field coil currents contribution to the magnetic potential. Since higher order harmonic components are generated mostly by the 16 poloidal field shaping coils, the corresponding coefficients could be calculated and were included in the algorithm. The real time evaluation of the coil current contribution to the magnetic potential was sped up by using precalculated function values associated to fixed set of points. As a further step, a real time method for computation of the separatrix position at any poloidal position was developed and tested. The future work will contain the implementation of the above mentioned methods into the MARTe framework. The possibility of applying this method to other modern tokamak devices is also being studied.