RXF-mod is a medium size (R=2m, a=0.459m) device capable of confining plasmas in both Tokamak and Reversed Field Pinch magnetic configurations. It is equipped with an advanced feedback system for field error and MHD control [1]. 192 active saddle coils (independently fed) entirely cover the outer surface of the resistive shell and play as actuators with 192 sensors.

In order to improve the effectiveness of the active control system and assess the external action on a given plasma, optimization of the produced magnetic fields is sought. This work shows examples of simple techniques that can be applied real time for performance improvement.

Improving the performance of the control system is a task that can be tackled by using the coupling terms between actuators and sensors. Given the presence of passive structures in between, these coupling terms are frequency dependent.

Mutual coupling matrices have been calculated from experimental data (currents and magnetic fluxes) for a given set of frequencies, during dedicated vacuum shots

\[ \Phi(\omega) = I(\omega) M(\omega) \]

Decoupling matrices are obtained from coupling terms and used in experiments and simulations to recombine input currents as to achieve an optimized output.

A dynamical simulator [3] has been implemented based on an input current plant model obtained through the CarMa code [4]. Decoupling matrices are also obtained from model transfer function:

\[ K(\omega) = [C(\omega) - D(\omega)^{-1} D(\omega)] \]

A decoupling matrix calculated from the CarMa model for \( \omega = 0 \) Hz has been applied in both simulations and dedicated experiments, in which a sample magnetic perturbation is requested to the system.

The open-loop generation of a step-like \((1,-6)\) perturbation has been tested with and without decoupling. The reduction of the \(m=0\) component can be noticed, leading to the sought improvement of the harmonic content.

The same has been seen with different frequencies and matrices, the best results being obtained normalizing each matrix to its maximum value.

A closed-loop application example allows to appreciate the same result as in the open-loop case, with the applied matrix being calculated from experimental data.

Furthermore, the very good superposition of the requested \(n=6\) component in the two cases leads to the conclusion that the implementation of a decoupling matrix has a negligible effect on the applied gains.

The vacuum model has been tested and validated against experimental data.

Real vacuum experimental setup is reliably reproduced by the simulation tools, that can be therefore applied in a predictive way.

### References

2. M. Baruzzo et al., Nucl. Fusion 52, 103001 (2012)

Conclusions

A range of simple and real-time applicable strategies for the assessment and optimization of the RXF-mod active system output magnetic field has been developed and tested. Starting from the acknowledgement that such a field contains spurious components given by geometrical characteristics and discreetness of the active system. Full dynamic simulations and vacuum experiments have been presented to show the effects of such simple optimization methods, which have been implemented and used during routine experimental sessions.