Systematic design and demonstration of a MIMO gas injection controller for the N-II emission front and line averaged electron density in TCV

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Unmitigated, the expected power fluxes impacting the divertor targets during reactor relevant operation will exceed present-day engineering limits. Real-time feedback control of *plasma detachment*, a regime characterized by a large reduction in plasma temperature and pressure at the divertor targets, is considered mandatory to achieve acceptable power fluxes. Controlling the divertor plasma in future reactors is inherently a multi-input multi-output (MIMO) control problem. Injection of multiple different gas species like deuterium, nitrogen and neon is envisioned for ITER. Each of these species will affect multiple output performance parameters, for example divertor radiation, neutral pressure and electron density. In control terminology, this is called *interaction*, and must be specifically dealt with in controller design [1].

In this contribution we show a systematic design of a MIMO controller that accounts for this interaction. We aim to individually control the N-II emission front position L_{pol} and the line averaged electron density $\bar{n}_e$ using a combination of D_2 and N_2 gas injection in TCV [2]. The designed MIMO controller uses a decoupling matrix as a pre-compensator to reduce interaction around the control loop bandwidth. The pre-compensator is based on an apt transfer function structure for gas injection response in TCV [3], and its parameters are identified using system identification experiments. The generalized Nyquist theorem is used to test the controller stability, which accounts for interaction. The N-II emission front position is tracked using a real-time image processing algorithm [4] applied to spectrally filtered images from the multi-spectral imaging diagnostic MANTIS [5]. We demonstrate the controllers ability to keep the N-II emission front at a desired position, and then keep it there while changing the line-averaged density.

References

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