STATUS OF THE DIAMOND FAST ORBIT FEEDBACK SYSTEM

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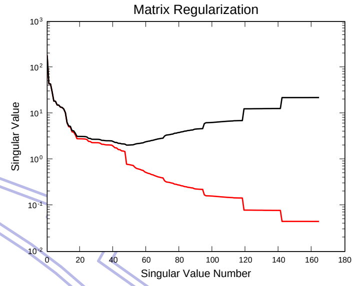
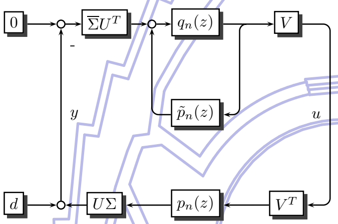
Introduction

The requirements on RMS beam stability at Diamond are less than 10% of beam size at the insertion device, which is particularly tight vertically due to the low emittance, $\Delta Y < 0.6\ \mu$m. The fast orbit feedback system (FOFB) performs global corrections, distributing positions from 168 Libera EBPMs over a dedicated 2D torus fibre network to a PowerPC processor in each of 24 cells. The full response matrix is ill-conditioned and must be regularized by scaling singular values so that the solution is robust in the presence of noise, the black curve shows the singular values after Tikhonov regularization.


Matrix Regularization

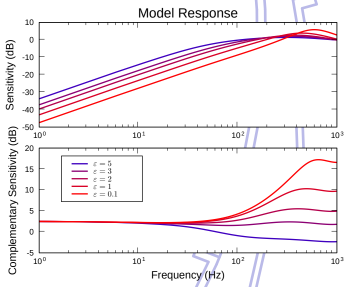


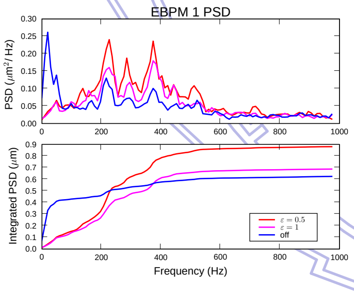
Controller

FOFB a cross-directional control problem where each sensor and actuator has the same dynamics. The response of the power supply controller can be approximated as a first-order filter plus delay, and the optimal solution is the internal model controller (IMC). This improves on the PI controller by handling model uncertainty in a systematic way and explicitly compensating for delay. The diagram shows the structure of the feedback loop in SVD mode space, the implementation is optimized by performing the dynamics calculations in corrector space which can be distributed between the cells.

Model

The sensitivity function is the response from noise d to output y, the FOFB time constant ε changes the controller bandwidth giving a tradeoff between low-frequency suppression and high-frequency amplification of noise. The complementary sensitivity function is the response from noise d to actuators u which limits the maximum performance due to the unattainably large demand currents at high bandwidth.


Model Response

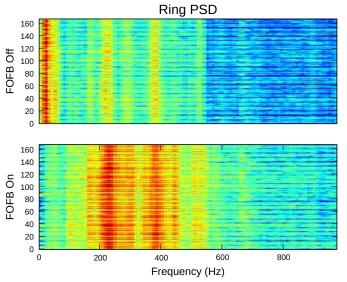

EBPM 1 PSD

Measurements

The curves show vertical noise up to 1 KHz at the first EBPM with the FOFB on and off. The main disturbance on the beam is at 24 Hz and is suppressed effectively giving $\Delta Y < 0.2\ \mu$m, which will be less at the source point. The peaks around 200 and 400 Hz are amplified as is clear from the model response so further improvements will require increasing the FOFB bandwidth. At time constants less than $\varepsilon = 0.5$ the controller introduces noise at low frequencies due to power supply nonlinearities.

Conclusion

The PSD with and without FOFB at all EBPMs is shown, the noise scales with beta function and is therefore present on the beam and not due to sensor movements. Further invesigations will consider a weighting scheme for EBPMs and reducing the power supply nonlinearity introduced by a rate limiter, which may allow reduction of the noise at 200 Hz. It is unlikely that the noise peak around 400 Hz can be addressed with the current power supply electronics so work continues to identify and passively reduce vibrations due to girder resonances in the machine. FOFB is now in continuous operation at Diamond.


Ring PSD

diamond