SYSTEM IDENTIFICATION AND CONTROL FOR THE SIRIUS HIGH-DYNAMIC DCM

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LNLS sirius Brazilian Synchrotron Light Laboratory

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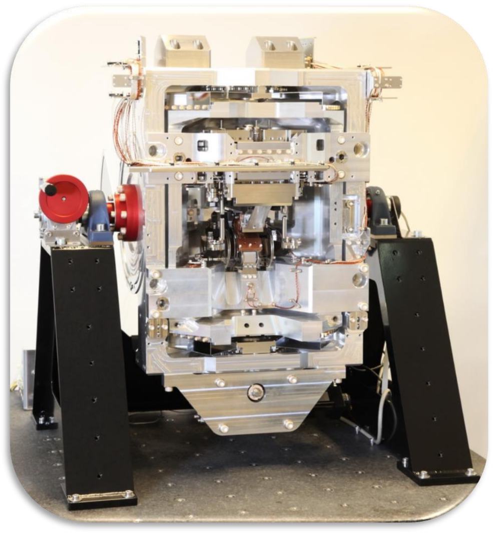
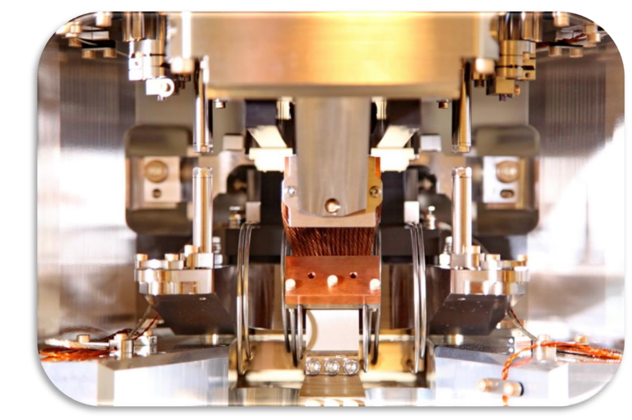
CNPEM Brazilian Center for Research in Energy and Materials



Abstract

The monochromator is known to be one of the most critical optical elements of a synchrotron beamline. It directly affects the beam quality with respect to energy and position, demanding high stability performance and fine positioning control. The new high-dynamic double-crystal monochromator (HD-DCM), prototyped at the Brazilian Synchrotron Light Laboratory (LNLS), was designed for the future X-ray undulator and superbend beamlines of Sirius, the new Brazilian 4th generation synchrotron. The next generation machines demand higher stability performance than at the previous ones, both at the accelerator and at the beamlines, requiring improved solutions to deal with factors such as high-power loads, power load variations, and vibration sources. This paper describes the system identification work carried out for enabling the motion control of the mechatronic parts composing the HD-DCM. The tests were performed in MATLAB/Simulink Real-Time (RT) environment, using a Speedgoat RT Performance Machine as a RT target. Sub-nanometric resolution and nanometric stability at 250 Hz closed loop bandwidth in a MIMO system were the main design targets. Frequency domain identification tools, control techniques and the first partial results are presented in this paper.



PCT/BR2017/050262, Patent Application.

Dynamic concept

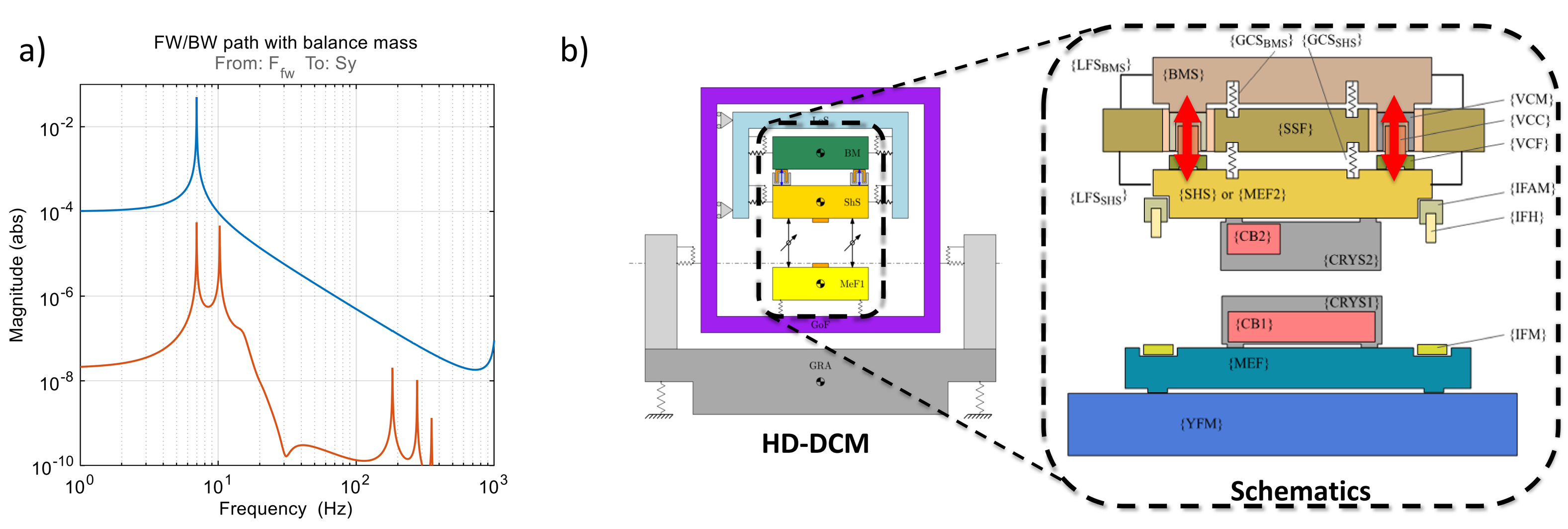


Figure 1: a) FRF showing forward and backward path with balance mass dynamic filtering concept.
b) HD-DCM core assembly schematic, with high-dynamic core in detail.

System identification

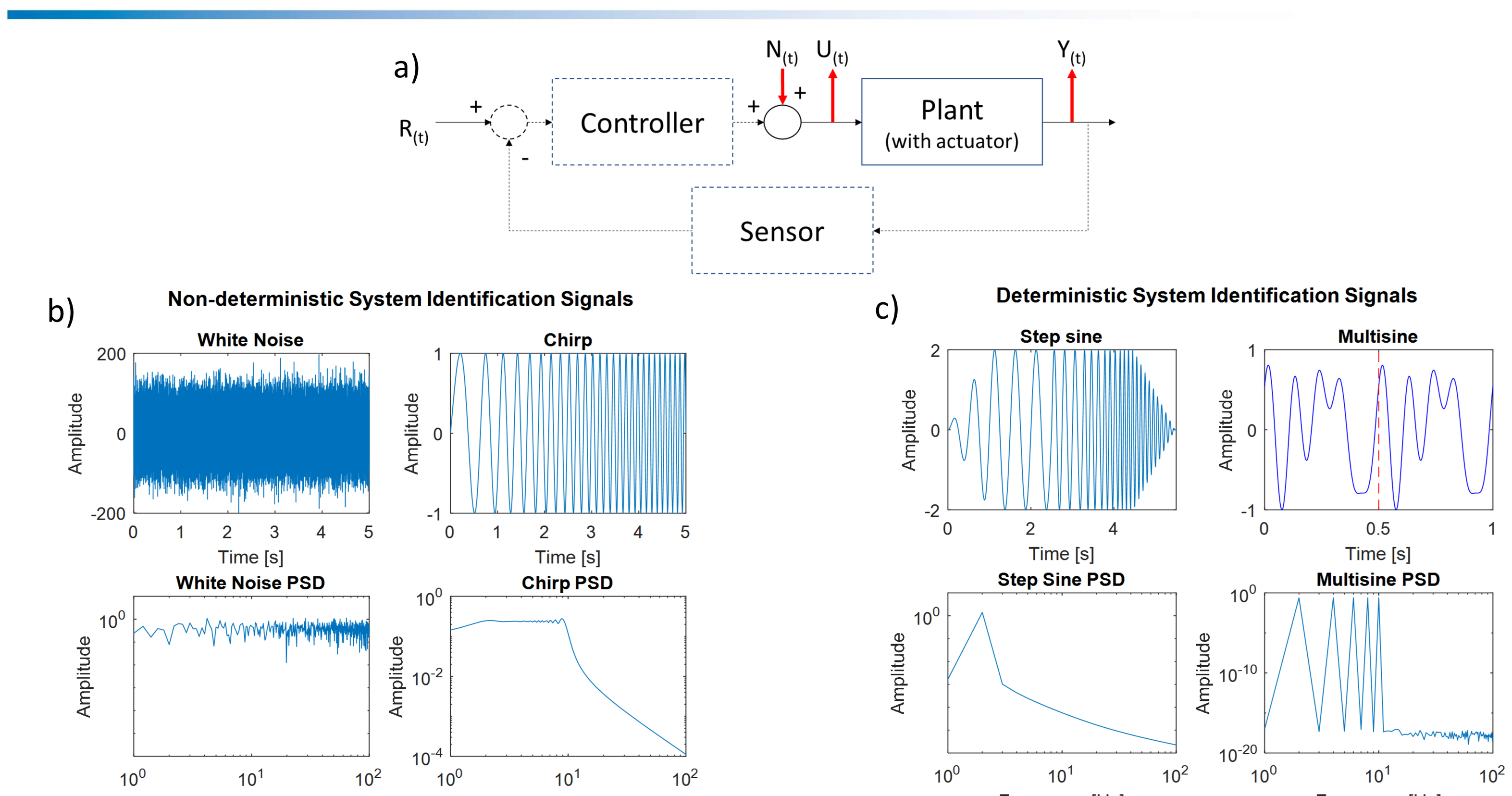
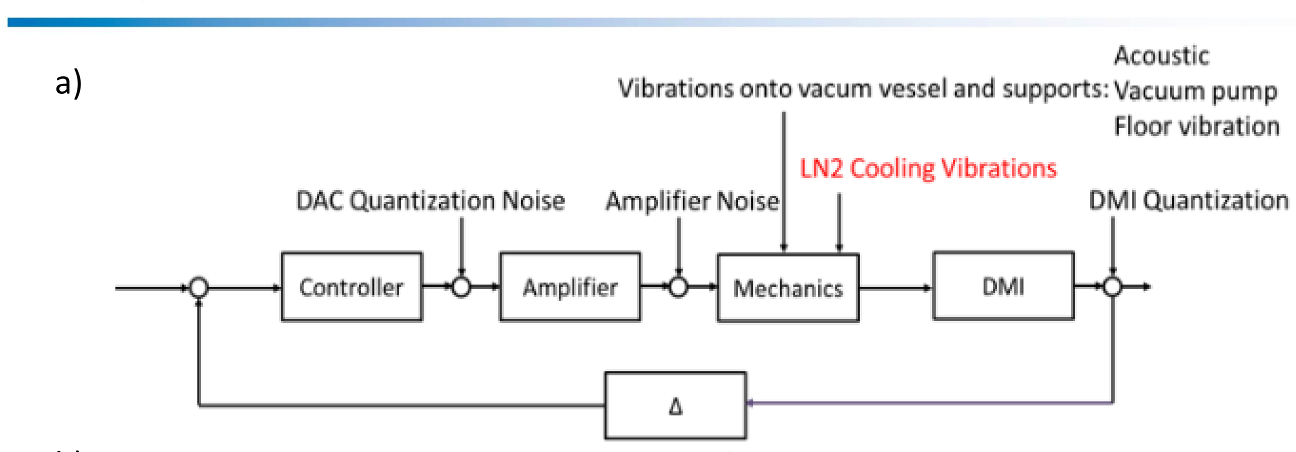


Figure 2: a) Block diagram for different methods of signal injection in open-loop and closed-loop (dashed lines). b) Non-deterministic signals: white noise, chirp and c) Deterministic signals: step sine and multisine.

Disturbances characterization



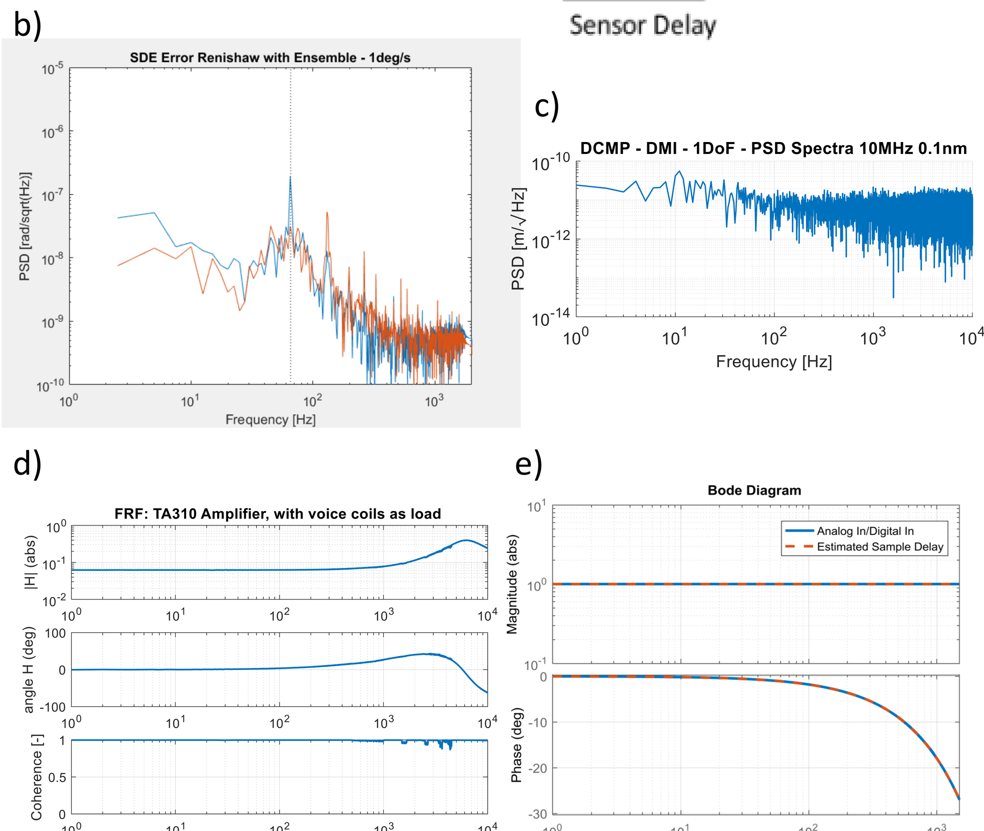
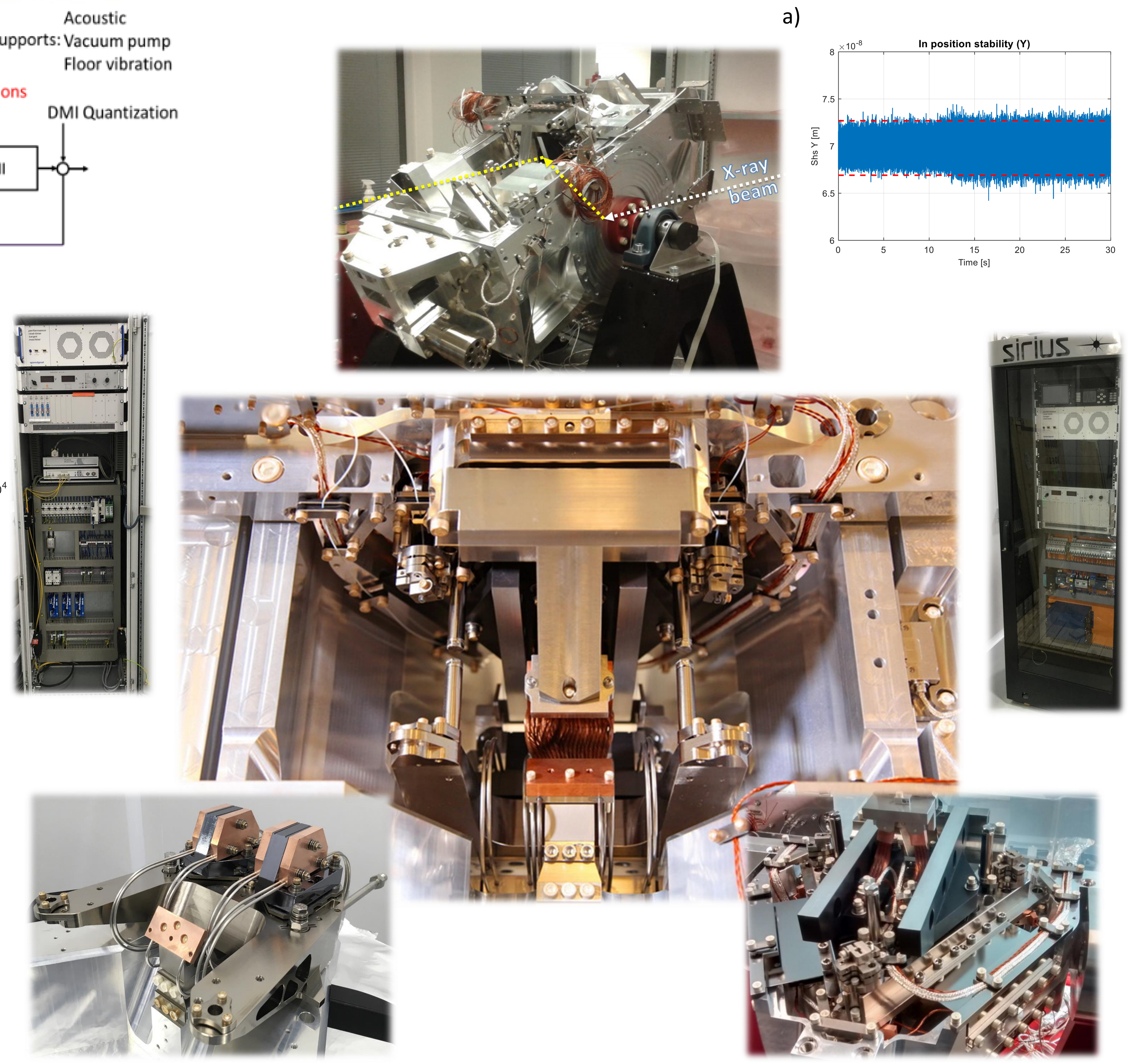


Figure 3:
a) Block diagram of a simplified representation of the main disturbances of the closed loop control;
b) SDE error characterization for a Renishaw rotary encoder;
c) Interferometer noise floor PSD;
d) FRF for the voice coil amplifier;
e) General controller delay characterization.



Plant identification

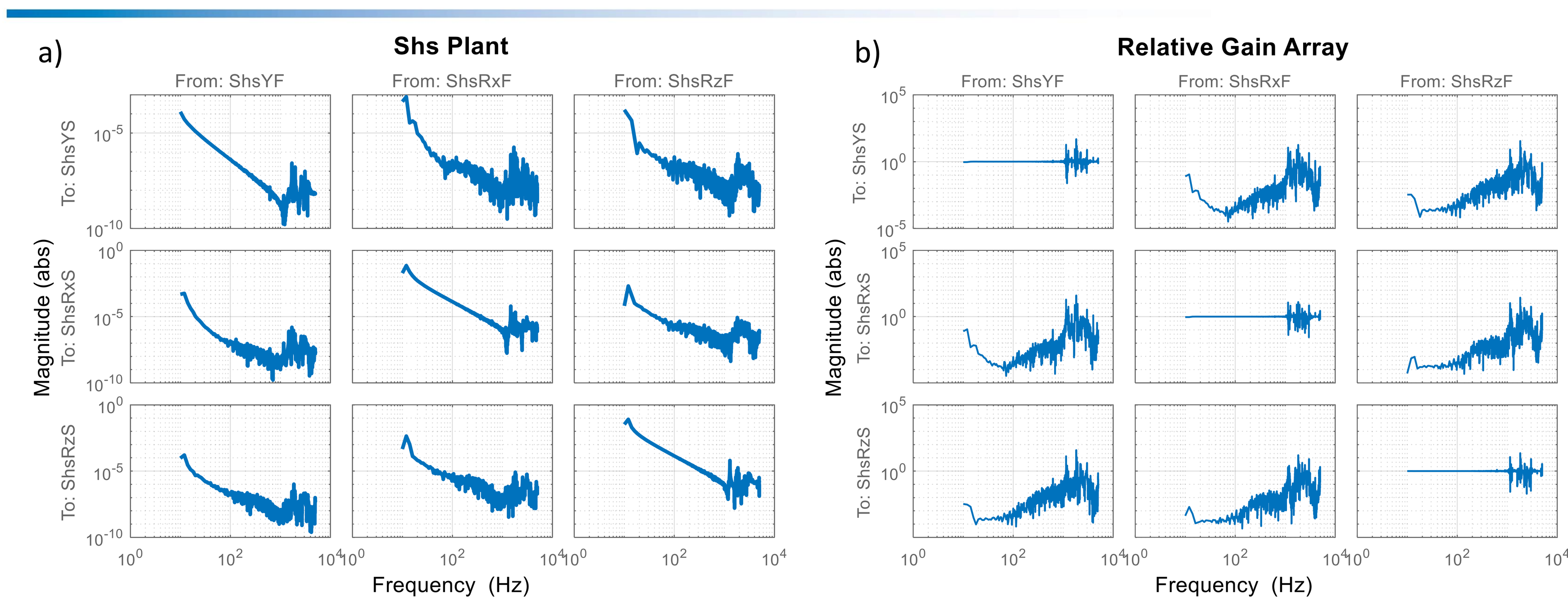
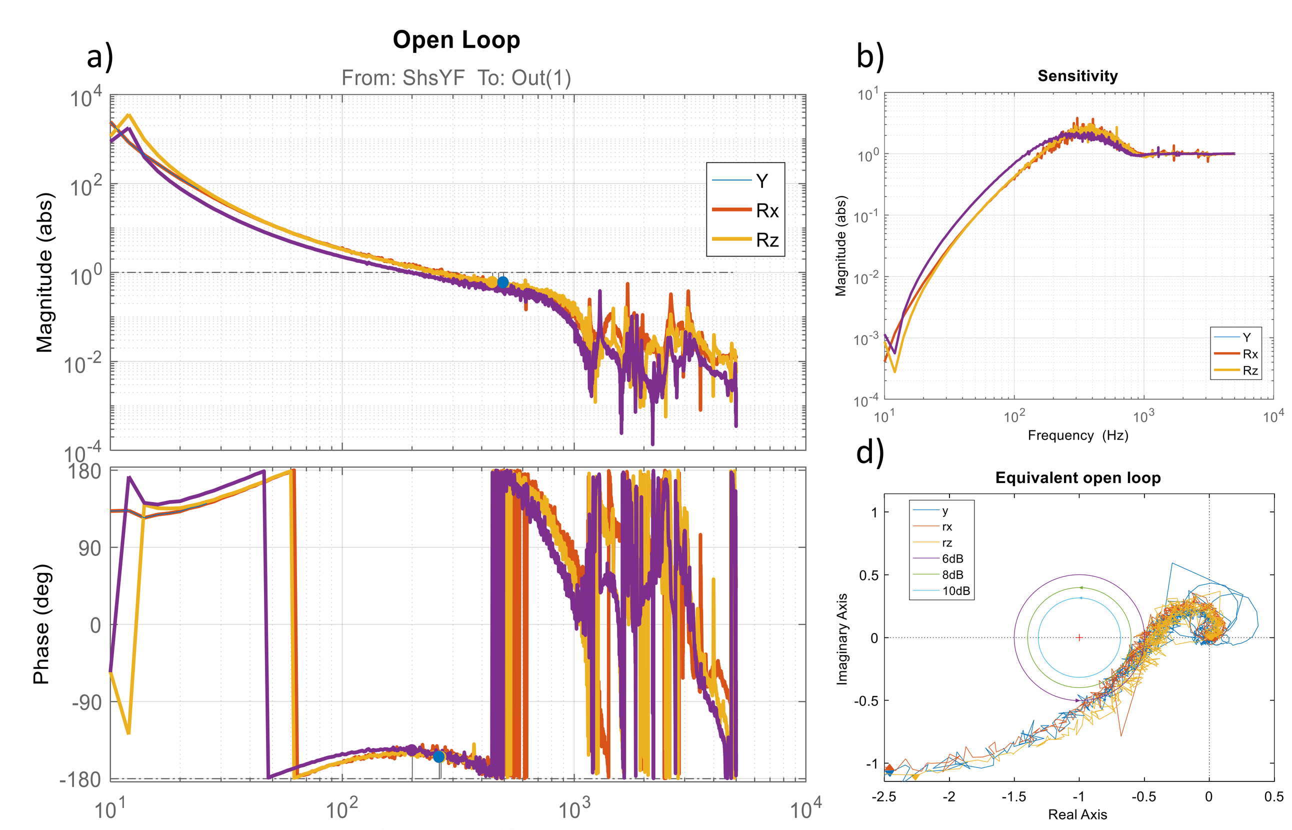


Figure 4: a) MIMO plant identification, using step sine;
b) Relative gain array plot for coupling analyses.

Controller design



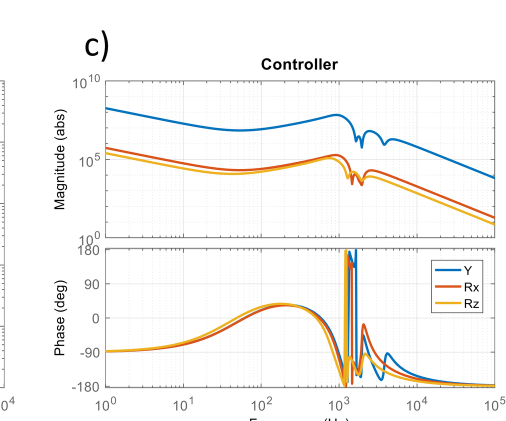
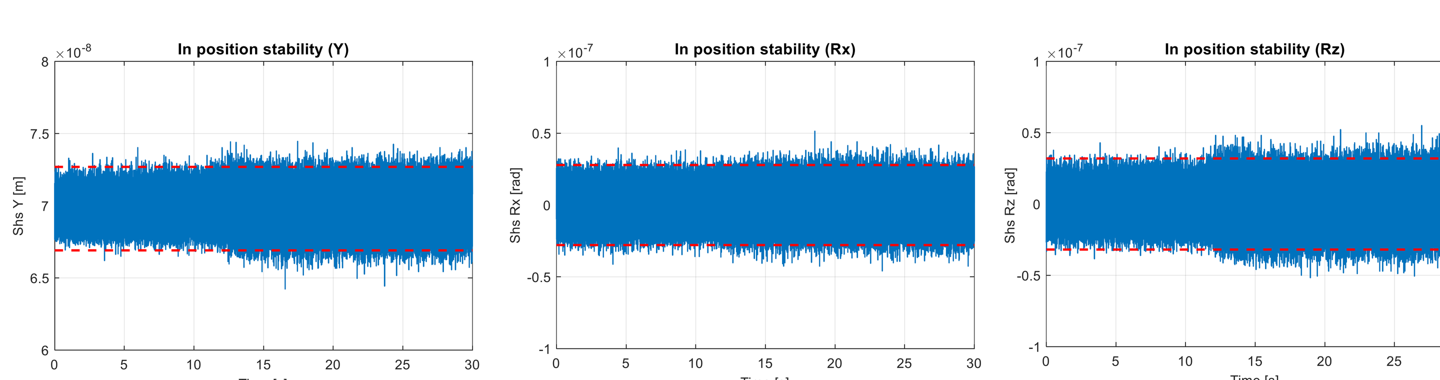


Figure 5: Control design and validation:

a) Open-loop bode diagram;
b) Sensitivity magnitude;
c) Controller bode diagram;
d) Equivalent open-loop nyquist diagram.

Partial results



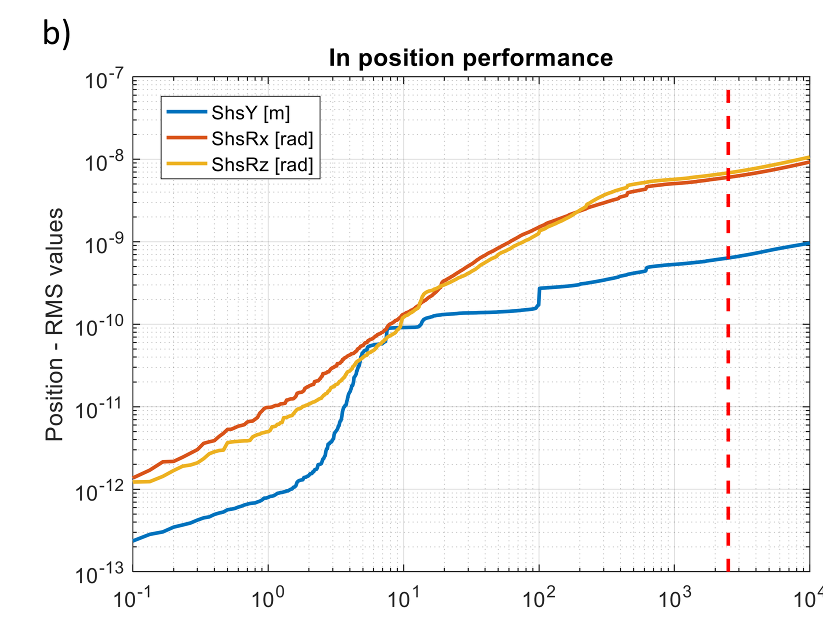


Figure 6: The partial results of the core of the HD-DCM were 9.2 nrad in relative pitch and roll and 0.9 nm in relative gap (RMS values integrated from 0 to 2500 Hz). These results were obtained with fixed Bragg angle and in air at room temperature:
a) Time domain plots for Y, Rx and Rz directions.
b) Cumulated PSD showing the position RMS values distribution over frequency.

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