MECHATRONICS APPROACH FOR THE DEVELOPMENT OF A NANO-ACTIVE-STABILIZATION-SYSTEM

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Abstract

With the growing number of fourth generation light sources, there is an increased need of fast positioning end-stations with nanometric precision. Such systems are usually including dedicated control strategies, and many factors may limit their performances. In order to design such complex systems in a predictive way, a mechatronic design approach also known as "model based design", may be utilized. In this paper, we present how this mechatronic design approach was used for the development of a nano-hexapod for the ESRF ID31 beamline. The chosen design approach consists of using models of the mechatronic system (including sensors, actuators and control strategies) to predict its behavior. Based on this behavior and closed-loop simulations, the elements that are limiting the performances can be identified and re-designed accordingly. This allows to make adequate choices concerning the design of the nano-hexapod and the overall mechatronic architecture early in the project and save precious time and resources. Several test benches were used to validate the models and to gain confidence on the predictability of the final system's performances. Measured nano-hexapod's dynamics was shown to be in very good agreement with the models. Further tests should be done in order to confirm that the performances of the system match the predicted one. The presented development approach is foreseen to be applied more frequently to future mechatronic system design at the ESRF.

INTRODUCTION

See [1].

NANO ACTIVE STABILIZATION SYSTEM

MECHATRONIC APPROACH

NANO-HEXAPOD DESIGN

TEST-BENCHES

CONTROL RESULTS

CONCLUSION

ACKNOWLEDGMENTS

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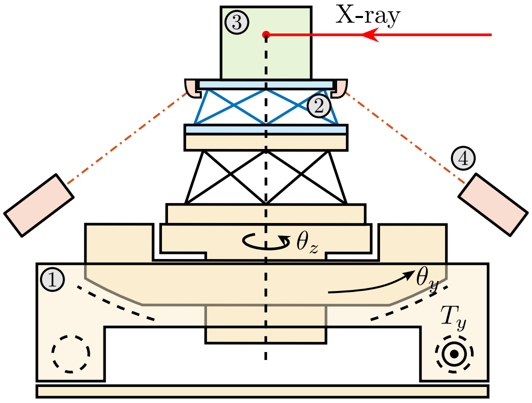

Figure 1: Nano Active Stabilization System - Schematic representation. 1) micro-station, 2) nano-hexapod, 3) sample, 4) metrology system

REFERENCES

[1] T. Dehaeze, M. M. Mattenet, and C. Collette, "Sample stabilization for tomography experiments in presence of large plant uncertainty", in *MEDSI'18*, (Paris, France), ser. Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation, Geneva, Switzerland: JACoW Publishing, Dec. 2018, pp. 153–157, ISBN: 978-3-95450-207-3. DOI: `10.18429/JACoW-MEDSI2018-WEOAMA02`. `https://doi.org/10.18429/JACoW-MEDSI2018-WEOAMA02`

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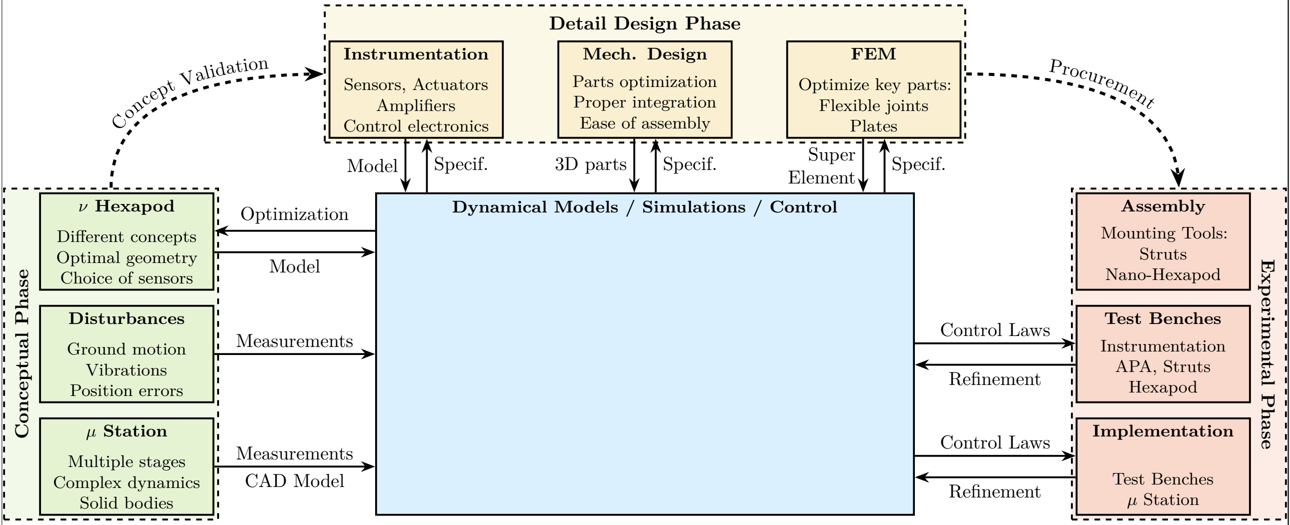
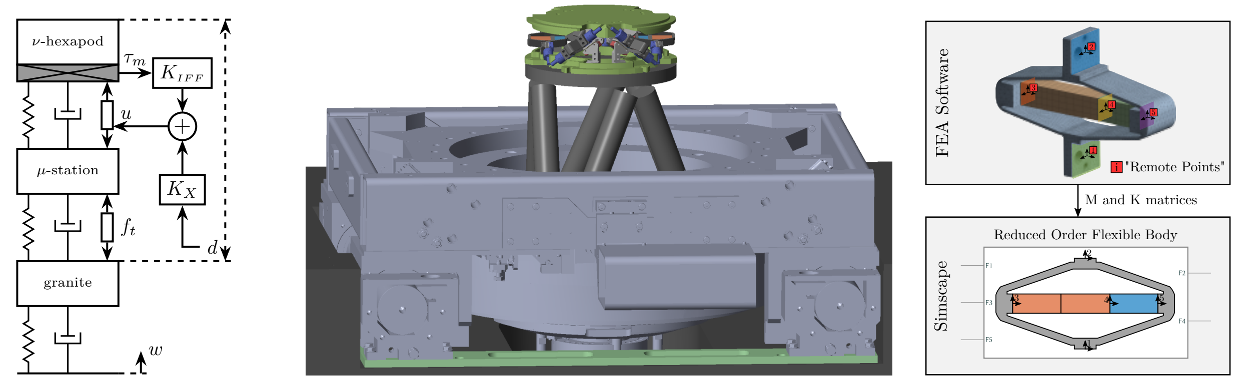


Figure 2: Overview of the mechatronic approach



(a) Mass Spring Damper model (b) Multi Body model (c) Finite Element Model

Figure 3: Models used during all the design process. From (a), (b), (c)

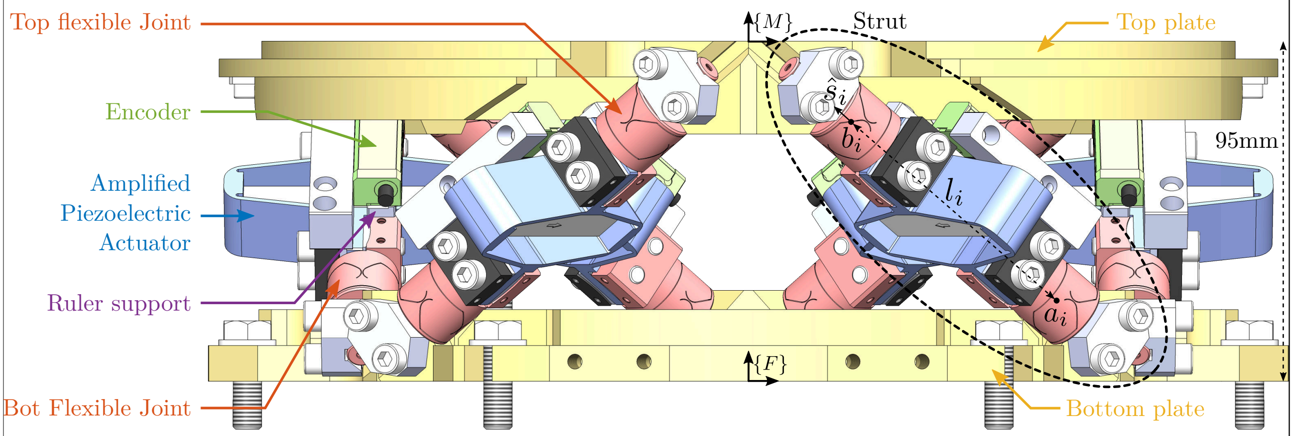


Figure 4: CAD view of the nano-hexapod with key elements

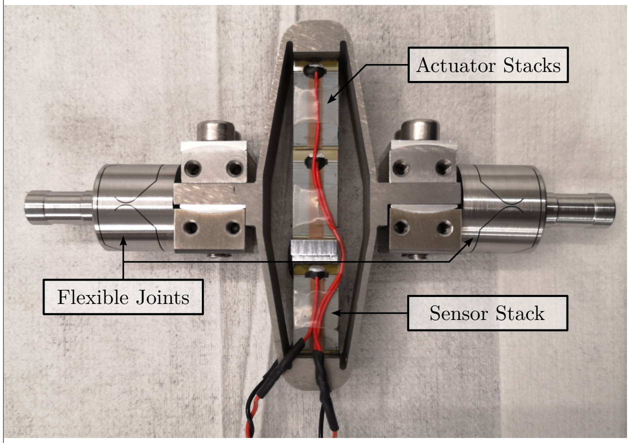


Figure 5: Picture of a nano-hexapod's strut

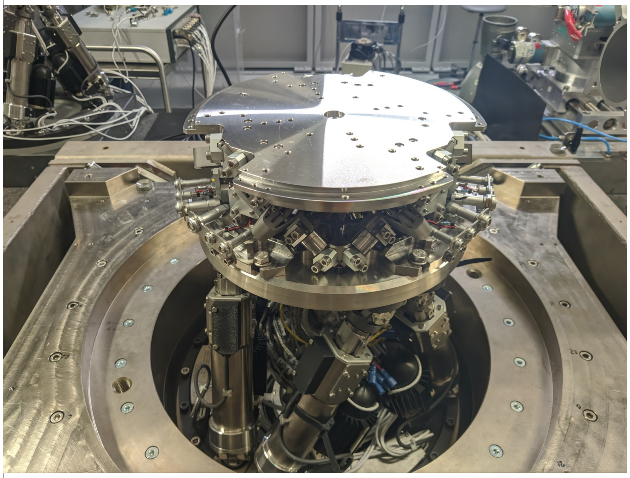


Figure 6: Picture of the Nano-Hexapod on top of the ID31 micro-station

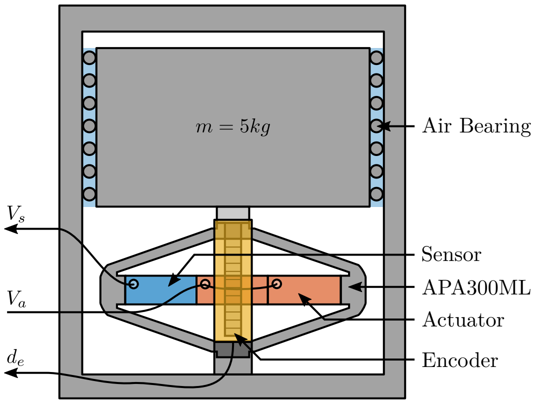
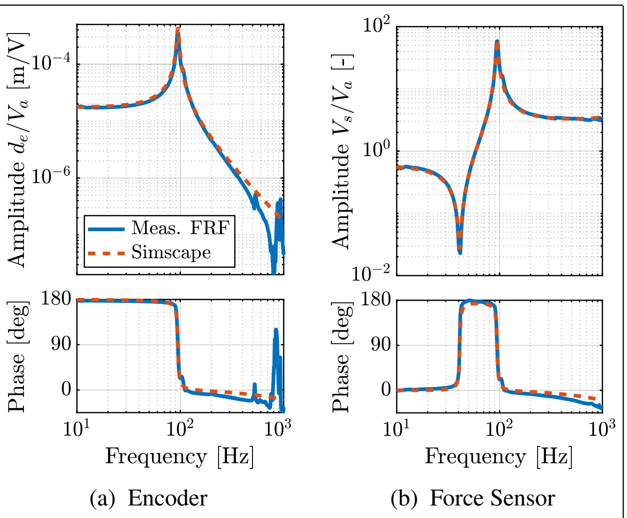


Figure 7: Schematic of the bench used to identify the APA dynamics



(a) Encoder

(b) Force Sensor

Figure 8: Measured Frequency Response functions compared with the Simscape model. From the actuator stacks voltage to the encoder (a) and to the force sensor stack (b).

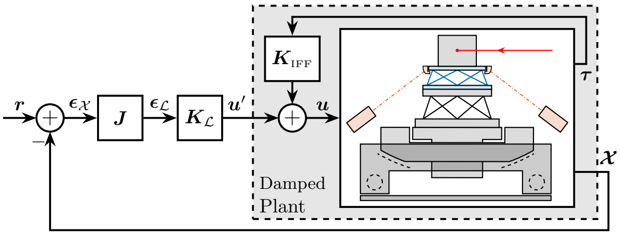


Figure 9: HAC-LAC Strategy - Block Diagram. The signals are: $\boldsymbol{r}$ the wanted sample's position, $\boldsymbol{X}$ the measured sample's position, $\boldsymbol{\epsilon}_{\mathcal{X}}$ the sample's position error, $\boldsymbol{\epsilon}_{\mathcal{L}}$ the sample position error expressed in the "frame" of the nano-hexapod struts, $\boldsymbol{u}$ the generated DAC voltages applied to the voltage amplifiers and then to the piezoelectric actuator stacks, $\boldsymbol{u}'$ the new inputs corresponding to the damped plant, $\boldsymbol{\tau}$ the measured sensor stack voltages. $\boldsymbol{T}$ is . $\boldsymbol{K}_{IFF}$ is the Low Authority Controller used for active damping. $\boldsymbol{K}_{\mathcal{L}}$ is the High Authority Controller.

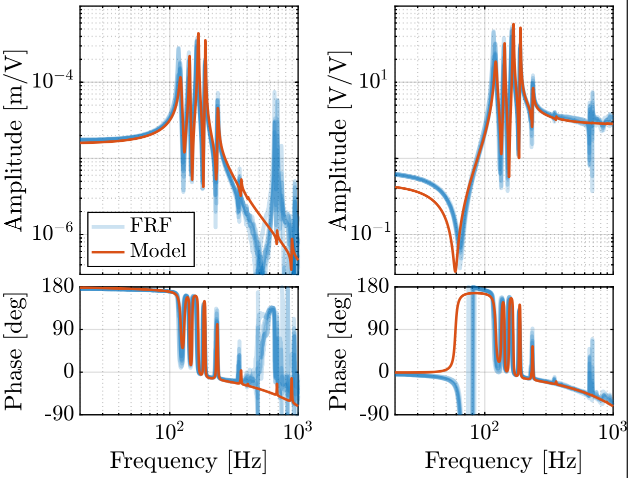


Figure 10: Measured FRF and Simscape identified dynamics.

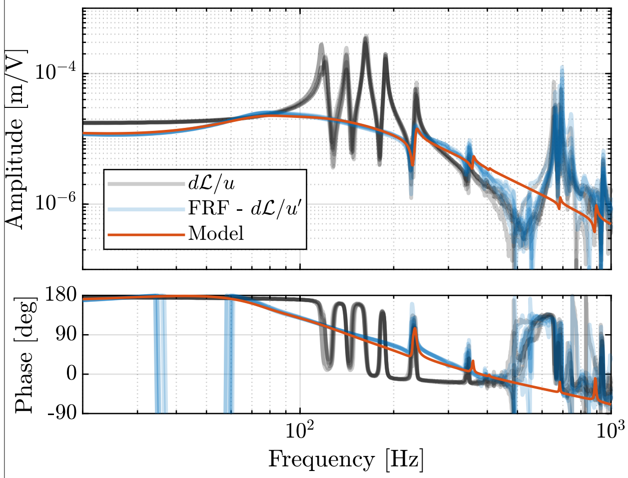


Figure 11: Undamped and Damped plant using IFF (measured FRF and Simscape model).