Rapid Control Prototyping Tool for the Sirius High-Dynamics DCM Control System

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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 position control. The new high-dynamic double-crystal monochromator (HD-DCM) [5–15], prototyped at the Brazilian Synchrotron Light Laboratory (LNLS), was designed for the future X-ray undulator and superbeam beamlines of Sirius, the new Brazilian 4th generation synchrotron [6–8]. At this kind of machine, the demand for stability is even higher and conflicts with factors such as high power loads, power load variation, and vibration sources. To identify and ensure sufficient control of the dynamic behavior of all subcomponents in the prototype, an implementation in MATLAB / Simulink Real-Time environment in a Speedgoat Real-Time Performance Machine (RCP) [12] was developed. This approach enables rapid prototyping, by allowing a shared environment for system modeling and testing. The tool was developed in a modular architecture aiming at a practical model iteration and platform migration to beamline controllers, which can prove portability and scalability features.

Introduction

This work presents a Rapid Control Prototyping (RCP) tool, used for designing and testing the new High-Dynamic Double-Crystal Monochromator. This tool was implemented with the objective of speeding up control design and testing phases, considering the upcoming high demand for designing and commissioning multiple high-end systems in a short time for Sirius. Its architecture and parameterization focuses on a smooth migration to a standard control platform, chosen for advanced applications at Sirius beamlines [10].

High-Dynamic DCM Concept

- Completely reviewed version of usual DCM design
- Control-Oriented Mechanical Design
- Balance-Mass Concept
- Contactless Actuators
- Leaf-Springs
- Thermal Control

High-Dynamic DCM Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Bridge</th>
<th>Angle</th>
<th>Stroke</th>
<th>Long Stroke</th>
<th>Short Stroke</th>
<th>Thermal Control</th>
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<tr>
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<td>Resolution</td>
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<td>30 kHz</td>
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</table>

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Model Based Design

RCP Tool Architecture

The demand for quickly testing the HD-DCM system and future projects has put modularity and flexibility as key factors when structuring the RCP tool. This way, the software architecture for its implementation in Simulink Real-Time was made in blocks, and organized in preliminary layers, namely: low-level interface, mid-level, and high-level interface.

RCP Hardware Performance

Performance Real-Time Target Machine:
- Intel Core i7 3.5GHz CPU
- 4GB RAM
- 256GB SSD (540MB/s)
- Custom FPGA Implementation
- Speedgoat library for MATLAB

System Validation

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 position control. The new high-dynamic double-crystal monochromator (HD-DCM) [5–15], prototyped at the Brazilian Synchrotron Light Laboratory (LNLS), was designed for the future X-ray undulator and superbeam beamlines of Sirius, the new Brazilian 4th generation synchrotron [6–8]. At this kind of machine, the demand for stability is even higher and conflicts with factors such as high power loads, power load variation, and vibration sources. To identify and ensure sufficient control of the dynamic behavior of all subcomponents in the prototype, an implementation in MATLAB / Simulink Real-Time environment in a Speedgoat Real-Time Performance Machine (RCP) [12] was developed. This approach enables rapid prototyping, by allowing a shared environment for system modeling and testing. The tool was developed in a modular architecture aiming at a practical model iteration and platform migration to beamline controllers, which can prove portability and scalability features.

Conclusion

The RCP tool implemented in Speedgoat’s xPC target accelerated the design and testing phases, permitting the model and hardware tests to coexist in the same platform. The proposed architecture modularity and flexibility, allows parameters and even complete structures to be directly exported from the Simulink model to the standard beamline control platform, which has a more advantageous cost-benefit relation. Indeed, once the development of the HD-DCM is finished, its final control plat-form will take over and the RCP tool will be modified for a new system.

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References