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Development of Control Systems for the Stabilization of Synchrotron X-Ray beams

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This work investigates the study, design, and implementation of a control system for stabilizing focused X-ray beams in synchrotron beamlines. Due to the challenges and high costs associated with direct and continuous access to these facilities, a custom Lab-replica was instead employed.
This replica utilizes an analog oscilloscope to represent the X-ray beam, two electromagnets to simulate disturbances, and two electrical deflection plates to replicate the actuation system. A custom detection system was integrated to identify a first-order experimental model, establishing a correlation between the light spot position on the oscilloscope screen and the input voltage signals of the replica's actuators. Based on this model, a PID control loop was designed and validated, first through simulations and later through experimental campaigns.

As a proof of concept, a typical disturbance encountered in X-ray Absorption Spectroscopy (XAS) was simulated by inducing drift in the Lab-replica setup using an electromagnet. The PID controller, tested at control frequencies up to 1 kHz, successfully tracked the reference signal, maintaining an error below 0.2% of the total drift and achieving a rise time of less than 15 ms. These results demonstrate the controller's effectiveness in mitigating beam drift within the Lab-replica, highlighting its potential for optimizing real XAS measurements.

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