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Innovation Services

High-precision equipment

Calibration strategy for a rotary stage

High-precision engineering example

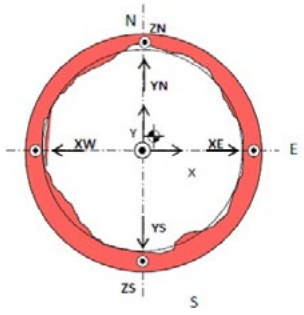
For one of our customers, a rotary stage is developed (see picture). Due to the strict performance requirements, and as a tradeoff with component costs, an elaborate calibration strategy is employed.

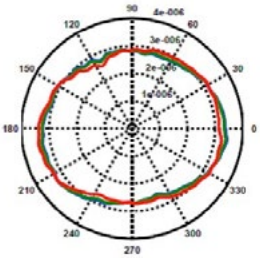
Precision engineering calibration challenge

To enable the lithographic process, the rotor needs to be positioned with an accuracy of tens of nanometers. However, on this scale the sensor counterparts are far from flat (see figure). Consequentially, both axial and radial correction tables need to be implemented to guarantee the stage positioning performance. By over- sensing (i.e., using more sensors than required by rigid body degrees of freedom), initial values for sensor target shape are derived. Performance is further improved by model based observer design. An additional step in performance is achieved by extension of the model: the sensor target shape is a function of rotational velocity, which is a consequence of the centrifugal force!

Rotary stage concept

To overcome the need for large acceleration forces, and to drastically reduce the varying magnetic fields, a rotary stage was proposed for a direct-write lithographic process. The rotor, diameter 1.2 m, is magnetically levitated by reluctance actuators, enabling a very low energy consumption. Furthermore, the rotor contains no active components and it is contactless. Consequently, it can be directly implemented in an environment with very high requirements on vacuum.





Implementation

The calibration procedure and correction algorithms have been implemented in a control platform that has been developed in-house, and is implemented on prototypes that are installed at the customer.

Generalization of findings

- Calibration is critical in most high-performance applications. Already in the design phase, calibration strategies should be accounted for.
- Model-based strategies (for example observers) allow for easy extension of the model to describe the underlying physical phenomena.

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