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Author: Dr. Stefan Bedrich
OHB System AG - Munich, Germany

Dr. Stephan Rapp
OHB System AG - Munich, Germany
Mr. Alexander Kuisl
OHB System AG - Munich, Germany

PREDICTING OPTICAL INSTRUMENT PERFORMANCE UNDER MICRO-VIBRATIONS

Abstract

Due to increasing resolution requirements in optical EO and science instruments, micro-vibrations affect more and more the end-to-end performance in terms of line of sight (LOS) jitter and wavefront error. Typical micro-vibration sources are reaction wheels and cooler compressors. To accurately predict and maintain the optical instrument performance under micro-vibration loads, an integrated modeling approach is necessary due to the manifold internal system dependencies, including optical, thermal and mechanical disciplines. In order to address this issue properly, Kayser-Threde (KT) has developed a LOS prediction Tool in MATLAB that combines the structural model, implemented in NASTRAN, with the optical model, implemented in ZEMAX. The structural model itself can be varied dynamically depending on the thermal load case. To validate the software, Kayser-Threde has developed a demonstrator breadboard, representing a typical-scale optical instrument.

It could be shown that the KT MATLAB tool can predict the LOS jitter accurately. This has been achieved by building a detailed finite element model of the demonstrator breadboard structure and performing a modal survey of the breadboard using laser scanning vibrometry. The modal data has been used in a Nastran model updating procedure using the SOL200 solver to create a correlated model. The experimental verification has been achieved by exciting the demonstrator by an inertial actuator, measuring the LOS jitter and comparing the measurement data with the simulation results of the integrated model. Different excitation locations, load paths and load types were used, such as harmonic, random and impact loads.

The solving of the equations of motion for LOS prediction in the KT MATLAB tool is fast and offers several opportunities for further analysis, such as controller implementation or coupling with multi-body simulations. In many cases a good agreement between simulation and experiment was achieved, which today enables KT to perform fast and accurate micro-vibration simulations in time and frequency domain. Moreover, it was discovered that good knowledge of the noise source(s) characteristics and the damping effects are essential for a good prediction quality. The architecture of our micro-vibration simulation tool and some representative prediction and correlation results will be shown.