Improved Digital Control of a Laser Scanning System

Degree programme: BSc in Micro- and Medical Technology | Specialisation: Mechatronics
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Piezoelectric actuators provide fast motions together with a high resolution suitable for demanding positioning systems. However, they have resonances which have to be attenuated to prevent the actuator from oscillating. The goal is to improve the control design of a piezoelectric controlled laser scanning system. To attenuate the first resonance of the scanning system a parallel PID controller with a complex conjugate zero pair is implemented.

Background

The controlled scanning system is used to tilt a mirror which deflects a laser. The scanning system can be tilted in two axes allowing to deflect the scanner on any position in a certain range in two dimensions. The tilting is done with piezoelectric actuators which have a very high resolution and can move at high speed. To improve the performance, the first resonance of the system needs to be attenuated with the controller.

Approach

To attenuate the first resonance of the system this resonance has to be characterized. For this purpose, the frequency response of the laser scanning system is measured. To simulate the performance of a controller on the laser scanning system a suitable model is developed. The performance of the controller with different parameters is compared.

Characterization

A voltage is applied as control signal to the scanning system and the resulting current is analyzed and, more importantly the tilt is measured using strain gauges. The frequency response on both outputs is recorded with an impedance spectroscope.

Laser Scanning System

Model of the System

In this scanning system multiple piezoelectric actuators are mechanically connected together. To model piezoelectric actuators the linear Butterworth Van Dyke model is used. For this scanning system the Van Dyke model has been adapted and a parameterized state space description is developed. Those parameters are determined to fit the measured data optimally, resulting in a model representing the real life behavior of the scanning system.

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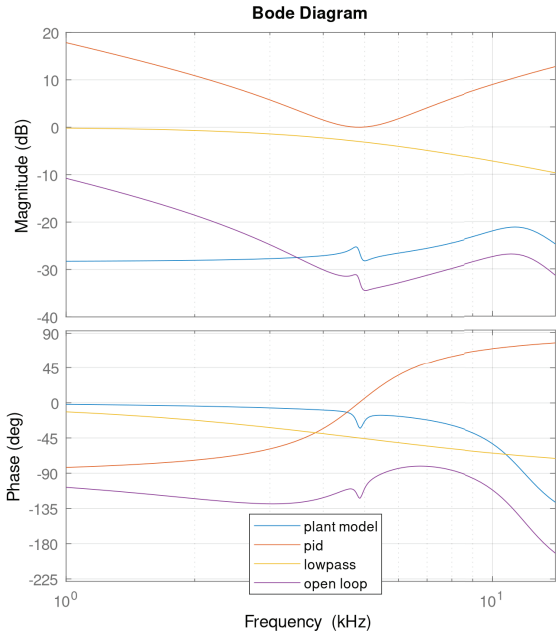
Control Design

A parallel PID controller with a complex conjugate zero pair in combination with a second order low pass filter is used to control this system. The simulation shows that the performance of the control system can be optimized implementing the before mentioned control design. Using a prototyping unit the control design is tested on the real scanner, to verify the simulation.



The plant model with the pid and a secound order lowpass gives the open loop response.