Investigation on linear sweeping VCSEL for OCT

Degree programme: Master of Science in Engineering | Specialisation: Information and Communications Technologies
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Optical coherence tomography (OCT) is a non-invasive 3d image acquisition technology especially suited to acquire images of the human retina. The newest generation of OCT devices utilizes so-called Swept-Source lasers. OCTLIGHT develops such a laser module using Vertical-Cavity Surface-Emitting lasers. Swept Source lasers are the core of an SS-OCT system and influence its performance profoundly in respect to sensitivity, resolution, measurement range, and speed.

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Situation

The vertical-cavity surface-emitting lasers (VCSEL) used by OCTLIGHT are highly coherent due to the small cavity length. They are cost-efficient in mass production using semiconductor manufacturing. The laser cavity consists of a bottom mirror, an electrically pumped gain medium, and a movable MEMS top mirror. Changing the cavity length produces a wavelength tuning.
OCTLIGHT has two variants of the Swept Source laser 1) vacuum packaged and sweeps at the mechanical resonance of the MEMS and 2) runs in a forced oscillation with configurable sweep rate. For the latter case 2, the OCT post-processing needs an optical k-clock to extract the image information. As demonstrated with case 1, OCT imaging without k-clocking results in OCT system cost reduction.

The goal of the Thesis

An optical k-clock adds complexity, cost, and space requirements to an OCT system. To circumvent those, OCTLIGHT wants to improve their CaliperFLEX laser module to generate a stable, and if possible, even linear sweeping behavior.
The first goal of the thesis is to find the cause of the sweeping instabilities of their modules.
The second goal is to improve stability, allowing for resampling with a calibration vector to linearize the wavelength sweep mathematically.
The final goal is to linearize the sweeping to the point where no resampling is necessary anymore.

Method

The project embraces three phases. The first phase will be two months of investigating the laser modules. The expected result is finding a way to characterize and compare the sweeping behaviour of the modules. And further finding the cause of the instabilities.
The second phase is about finding and implementing solutions for the detected issues. Considered are changes to the optics, electronics, and software. A redesign of some parts may be possible too. This phase may take up to 2-3 months.
The last phase is conducting extensive characterization of the achieved improvements.

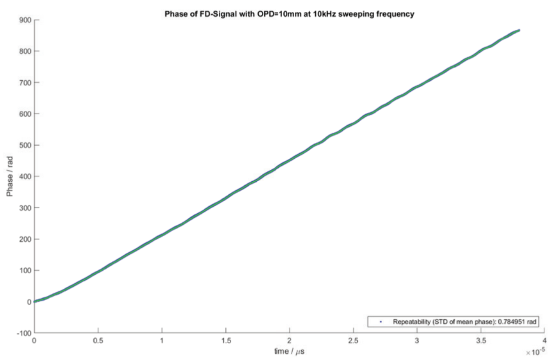

Figure 1: The phase of the FD signal is directly related to the wavelength sweeping characteristics of the laser. The

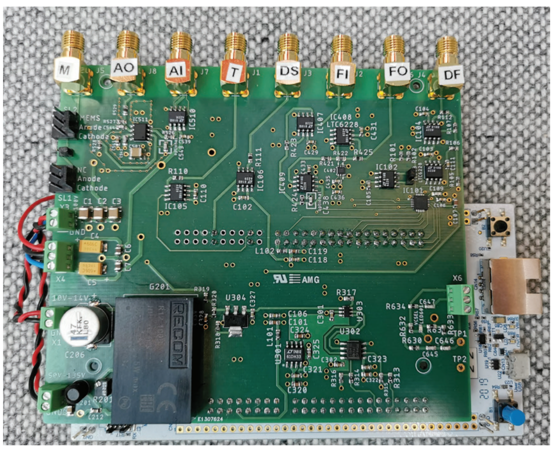

Figure 2: Developed NUCLEO-H723ZG shield to improve the driving signal of VCSEL MEMS mirror. The core components