Frequency Stabilized Injection Seeded Q-Switched Ho:YAG Laser for 2 µm Doppler Wind LIDARs

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For obtaining a single frequency Q-switched laser output injecting a continuous wave single frequency master laser into a Q-switched laser is a commonly used technique [1]. For a stabilized injection seeding a Fast Fourier Transform (FFT) based single heterodyne beat signal technique will be presented.

Since the 2 µm Ho^{3+}:YAG laser system is a quasi-three-level system it is challenging to obtain high pulse energies due to high thermal lensing of YAG rod laser crystals and re-absorption and up-conversion losses in the Ho^{3+} system. Therefore, the Q-switched laser system will be operated in the multiple hundred to kilohertz repetition rates with output pulse lengths close to 100 ns and pulse energies of a few mJ.

The injection seeded laser system is set up of a Tm fiber laser (IPG Photonics) that pumps a 5 cm long 2.5% Ho :YAG rod crystal with cw output powers of a few Watt. The resonator length is 40 cm with an output coupling of 10 to 30% and includes a dichroic mirror for the pump and seed laser input into the resonator as well as an electro-optical Q-switch. The oscillator length is adjusted by a piezo-drive (Physik Instrumente (PI)) mounted onto the end mirror. For stabilizing the single frequency output of the Q-switched laser a part of the 100 MHz acousto optic frequency shifted master fiber laser (NP Photonics, wavelength 2089.6+/-0.1 nm, bandwidth < 50 kHz) will be interfered onto a InGaAs photodetector (EOT, bandwidth > 9 GHz) with a small part of the Q-switched laser power to extract the 100 MHz frequency error signal for the feedback-control system. The feedback-control system as well as the piezo drive for the laser resonator will be operated in a LabVIEW environment which runs at approximately 30 Hz.

In Figure 1 the heterodyne signal (upper trace) as well as the 100 ns long Q-switched laser pulse (lower trace) is depicted. The middle trace shows the FFT of the heterodyne signal (1.25 GSample/s oscilloscope). The peak on the left side close to 0 Hz is associated with the pulse intensity and the 100 MHz heterodyne beat signal peak as well as the 1st higher harmonic can be seen.

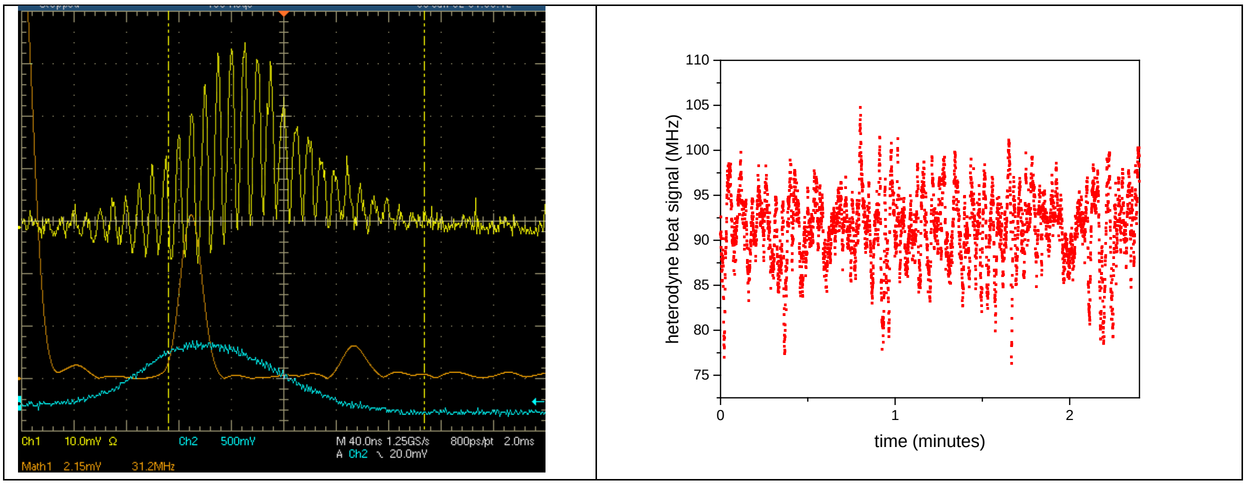

Figure 1 Heterodyne signal (left fig. upper trace), FFT (left fig. middle trace) and temporal pulse shape (left fig. lower trace) as well as the centre frequency of the heterodyne beat signal over an operation time of 2 minutes (right fig.).

The measured linewidth (FWHM) of the injection seeded laser pulse is smaller than 10 MHz (FWHM) and the frequency stability which depends on the yet unoptimized mechanical design of the resonator is roughly 5 MHz (std). Advantages of the investigated injection seeded laser system are that it operates in the eye-safe wavelength range and that the 100 MHz interference error signal allows the laser system to be operated up to kHz repetition rates.

References

[1] K. Nicklaus, V. Morasch, M. Hoefer, J. Luttmann, M. Vierkötter, M. Ostermeyer, J. Höffner, C. Lemmerz, and D. Hoffmann, 'Frequency stabilization of Q-switched Nd:YAG oscillators for airborne and spaceborne LIDAR systems', Proc. SPIE 6451, *Solid State Lasers* XVI: Technology and Devices, 64511L (February 20, 2007).