Injection Seeding a Q-Switched Ho:YAG Laser based on a Self-Organizing Technique for Doppler Wind LIDAR

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For wind velocity measurements using direct/heterodyne detection Doppler techniques in a LIDAR system a pulsed laser with a single frequency is needed. The standard performance is to seed a high-power pulsed master oscillator with a continuous wave single frequency seed laser. The methods to control the cavity length to match the resonance criteria for the seed wavelength are either based on measurement of the pulse properties like pulse-built-up time as control signal or measurement of the transmitted/reflected cw seed-laser signal like cavity dithering, Pound-Drever-Hall method and ramp-fire method [1]. Either method operates via a servo system that adjusts the cavity length for the next pulse that occurs in the order of 10 to 100 ms later without an exact reliable single frequency operation.

We report on the investigation of an injection seeding technique that leaves the master laser in the single frequency domain based on a self-organizing technique. First, the piezo-electric transducer (PZT) is operated over the free spectral range of the resonator in a short time interval of a few seconds (ramp). Then, the PZT-voltage value is determined at the minimum pulse energy of the approximately 20% pulse energy reduced injection seeded laser condition by fitting the dip with an Airy function (left figure 1 in the lower trace 1). Finally, at the end of the PZT-ramp, the voltage of the PZT is set to the minimum pulse energy reduced injection seeded value and the system is left alone up to minutes without any enforced external influence. To test the robustness of the system, a mechanical shock enforced on the optical bench brings the injection seeded laser out of the resonance condition for a short time of milliseconds until the shock waves are damped out and the injection seeded condition is re-established due to the pre-set PZT voltage value.

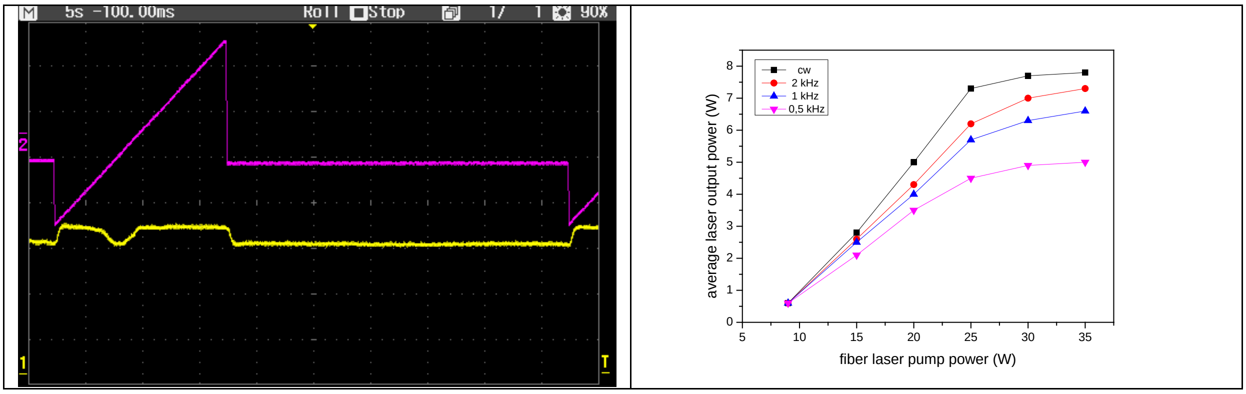

Fig. 1 Piezo-electric transducer voltage (left fig. upper trace 2) and pulse energy (left fig. lower trace 1) over time in s and average laser output power versus pump power for different repetition rates (right fig.).

On the right figure, the average laser output power is depicted for repetition rates up to 2 kHz approaching the cw output power of almost 10 W. The pulse duration of the single pulses are between 50 and 100 ns depending on the repetition rate and the output coupling of the resonator mirrors.

The injection seeded laser system is set up of a Tm fiber laser (IPG Photonics) to pump a 5 cm long 2.5% Ho :YAG rod crystal. The resonator length is 40 cm and the cw seed fiber laser (NP Photonics, wavelength 2089.6+/-0.1 nm, bandwidth < 50 kHz) delivers 20 mW which is brought into the resonator by a dichroic polarizer. The oscillator length is adjusted by a PZT, mounted onto the end mirror. The electro-optically Q-switched single pulse laser energies are determined by utilizing a PEM photodiode and an integrator. The control system for the setting of the PZT voltages of the ramp as well of the minimum of the pulse energy dip is done in a LabView environment in connection with an analog/digital converter.

Advantages of the investigated injection seeded laser system are that it operates in the eye-safe wavelength range and that the operation in a self-organizing regime minimizes the components of the system and makes it repetition rate independent.

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).