Fiber Laser for Wind Speed Measurements - DTU Orbit (28/05/2019)

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This PhD thesis evaluates the practical construction and use of a Frequency Stepped Pulse Train modulated coherent Doppler wind lidar (FSPT lidar) for wind speed measurement.

The concept of Doppler lidar is introduced as a means to measure line of sight wind speed by the Doppler shift of reflected light from aerosols. Central concepts are introduced and developed, i.a. heterodyne detection, carrier-to-noise ratio, probe length, measuring distance, and velocity precision. On this basis the concepts of a FSPT lidar are introduced and its general setup explained.

The Lightwave Synthesized Frequency Sweeper (LSFS) is introduced and analyzed as a light source for the FSPT lidar. The setup of the LSFS is discussed, and the necessary concepts for modeling and analyzing LSFS noise are developed. The model and measurements are then used to discuss the growth of optical noise in the LSFS and the impact on its use in the FSPT lidar.

A complex ABCD model is developed and described as a method for calculating spatial and frequency dependency of a lidar’s signal strength. The model includes both spatial and temporal components of the lidar system, enabling a model capable of describing both CW, pulsed and FSPT lidars.

Measurements of the range dependency of a FSPT lidar are shown, along with the mapping of range gates into frequency slots. The measured range dependencies are shown to correlate with the dependencies predicted by the complex ABCD model, thus corroborating the model.

Finally, proof of concept wind speed measurements obtained with the FSPT lidar are shown. This is followed by a discussion of the advantages and disadvantages of a FSPT lidar compared to a CW and a pulsed lidar system, and further avenues for evolving the concepts.

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