Coherent Doppler LIDAR system switching the LOS direction by wavelength of laser

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Abstract: The expectation for coherent Doppler LIDAR (CDL) systems applied for wind energy and airport safety is rapidly increased and high reliability and the mass productivity are strongly required. To satisfy the requirements, we have developed a new coherent Doppler LIDAR (CDL) system that switch line-of-sight directions by switching the wavelength without a mechanical scanner. The CDL consists of μITLA, WDM and multi-beam scanner. We demonstrated wind velocity and wind direction measurement at more than 250-m distance using this system.

Keywords: Coherent Laser Radar, Non-mechanical system, multi-beam and scanner

1. Introduction

The role of coherent Doppler LIDAR (CDL) systems for wind energy and airport safety is rapidly increased. High reliability and the mass productivity are also demanded because (i) the setting environment is severe (heavy rain, salt damage, etc.) and (ii) the difficulty of replacement, in case used for turbine control. The conventional CDL uses the mechanical switch (wedge prism and motor, etc.) for switching the laser direction. We want to apply the passive switch to control the direction without mechanical devices for improving the reliability. In this paper, we introduce the new CDL system concept that switch line-of-sight directions by switching the wavelength without a mechanical scanner and the demonstration result.

2. System configuration

Figure 1 shows a non-mechanical CDL system using μITLA for the source light, wavelength-division-multiplexing (WDM) for switching the optical path which are used for the optical communication, and a multi-beam direction telescope with several fiber adaptor. This telescope can switch the LOS direction by position of that adaptor. By decreasing the number of the telescope, this concept contributes to the mass productivity. Moreover, we use LN modulator and the Semiconductor Optical Amplifier (SOA) which are also distributed for optical communication.

The new components (gray squares) are changed for realizing our concept to the general fiber-based CDL system. The operation flow is as follows. (1) μITLA omit the seed laser with wavelength $\lambda_1$, (2) that laser is modulated by LN modulator, (3) modulated laser is pulsed by SOA, (4) the pulsed laser amplified by Fiber-Amplifier (FA), (5) WDM switch the optical path depending on the wavelength (6) the laser is omitted to the air through telescope which can change the laser direction depending on the position of connecting adaptor (described later). (7) The received signal is detected with heterodyne detection through circulator, 4port copolar, and Balanced Receiver (B.R.). (8) line-of-sight (LOS) wind velocity is calculated with FFT in the signal processing as like conventional CDL. (9) Return to (1) with changing the wavelength $\lambda_2$. The omitting laser direction can be changed by changing the wavelength.
We developed the CDL system as shown in fig. 2. The new device “multi-beam scanner” as shown in fig. 3 is installed, moreover, the integrated TRX board which includes μITLA, LNM, SOA, B.R. and signal processor (see fig. 1) is also installed.

The telescope has 5 fiber adaptor whose position related to the laser direction is different. The laser direction is vertical, 0-deg(north), 90-deg(east), 180-deg(south) and 270-deg(west) in azimuth angle, respectively. The cone angle is 11deg except for vertical beam. The wave front aberration is set less than $1/14 \lambda$ ($\lambda=1550\text{nm}$) switch is well known as martial criteria. The photo of developed multi-beam scanner is shown in fig. 3. In case of using optical switch for changing the laser direction, same number of telescopes as number of direction is needed. To decrease the system size, and increase the mass productivity, we realize the function with only one telescope.
3. 1st Trial and measurement results

Using developed system, we test the measurement of wind velocity as shown in fig.4. In this time, we test using 3 kinds of wavelength (3 directions) for the demonstration. As the result, we can measure the wind velocity at more than 250-m distance.

![Figure 4. Wind velocity measurement demonstration result](image)

3. Summary

We introduced a new concept of wind lidar system for realizing high reliability and high mass productivity using μ ITLA, WDM and multi-beam scanner. Using this system, we demonstrate wind velocity measurement at more than 250-m distance. This system is easy to extend the number of LOS directions and to realize the simultaneous measurement.

4. References