1.55μm全ファイバーコヒーレントドップラーLiDAR

1.55μm All-Fiber Coherent Doppler LiDAR

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Coherent Doppler LiDAR (*CDL)* is a range and velocity sensing technology used in many domains, from meteorology to aerospace [1,2]. However, with the advance of communication technology, especially in fiber optics, there has been a recent trend towards constructing all-fiber equivalents instead of the traditional free-space based CDLs. This is because the change to a fiber based CDL presents a low-cost, robust and eye safe alternative compared to their free-space counterparts [3]. Therefore, these reasons are generating a lot of interest in producing working prototypes of an all-fiber CDL. To this end, this report presents a 1.55μm all-fiber CDL and some preliminary results characterizing the device.

CDL measures the velocity v of a moving target through a phenomenon known as the Doppler effect, whereby the light reflected off a target will have a measurable change in frequency, known as the Doppler shift f_d. The range r of the object (or volume of aerosol in the case of windspeed) is calculated by the measured Time-of-Flight (*TOF)* Δt. The equations below summarize these relationships, where λ is the laser wavelength and c is the speed of light.

$$v = \frac{f_d}{2\lambda} \qquad\qquad r = \frac{c \cdot \Delta t}{2}$$

The All-Fiber CDL is shown in Figure 1. A CW 1.55μm narrow-linewidth laser at 25mW is split into its local oscillator (*LO)* arm and transmitter arm. Before being transmitted, the CW light is pulsed via an AOM to a pulsewidth of 300ns at a repetition rate of 10Khz, while also providing a shift 80MHz. Next, the pulse is amplified to 50mW with an EDFA and transmitted into the air using a 7mm diameter collimator. However, a small portion of the transmitted pulse is tapped into a PD, which marks the starting time of the emitted pulse, for TOF purposes. The receiver end of the CDL uses a 70mm lens to collect and focus reflected light off target which is recombined with LO light. The corresponding beat frequency is obtained with a BPD and digitized via a 400MHz 14-bit ADC, to be processed on a PC. In terms of Digital Signal Processing *(DSP)*, a Tukey window is applied to the return pulse, after which it is zero padded 10x. Following this, the periodogram is calculated and 500 pulse accumulation is carried out. In Figure 2, the resultant spectrum of a stationary target 71.54m away is shown. Calculation of the speed and range of the target based on these results are 0m/s and 71.62m, respectively, representing a small margin of error. Next steps in the project are to quantify the accuracy of the all-fiber CDL with a moving target.

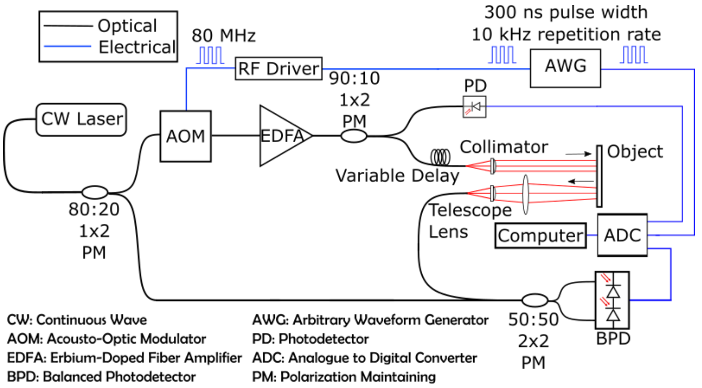

Figure 1. All-Fiber CDL setup.

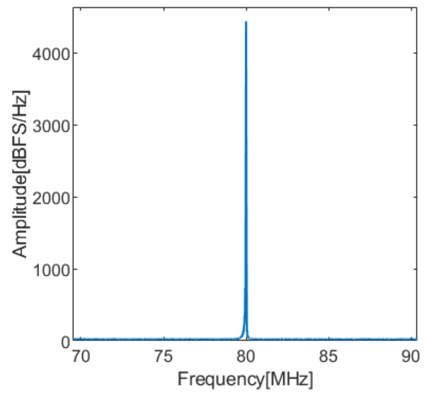

Figure 2. Post DSP received signal.

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[2] S. Wu et el., Optics Express, vol. 27, no. 2, pp. 1142–1163, 2019.
[3] R. T. Menzies et al., Proceedings of the IEEE, vol. 77, no. 3, pp. 449–462, 1989.