Lidar echo emulator to characterize a lidar detector chain

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The optical detector response time is crucial for the spatial resolution of the LIDAR systems. Simultaneously, LIDAR applications require detectors with a large dynamic range, since both diffuse low-intensity backscattering and high-intensity object reflections must be detected [1]. HgCdTe (MCT) detectors seem perfect candidates since their responsivity spans from MIR down to UV range. Recently, in the project HOLDON, aiming at greenhouse gases monitoring, a MCT avalanche photodiode detector chain was developed with high dynamic range (>60 dB) to replace existing detector in CHARM-F instrument for the future Merlin German-French mission [2].

In a space-born application it is mandatory to test the devices in real case scenario 'you test as you fly.' Therefore, it was necessary to design a kind of optical pulse shaper, called lidar echo emulator, which could discriminate the power level of at least 60 dB between both signals, faint background echo (LE) and strong short pulses (SE). To make the system compact, we have proposed a technique of the overlapping echoes using single laser diode and arbitrary waveform generator to superimpose both echoes by means of the optical delay line. In brief, the input signal with both echoes is divided into two channels, in one of the channels, the signal is left unchanged whereas in the second channel attenuation is applied together with the delay line which shifts the position of the LE as can be seen in the Fig.1. Finally, at the output we receive both echoes overlapped and using the trigger, this signal is synchronized with the MCT detector to measure characteristics of the detector. To measure the detection limits of the MCT APD, variable attenuators are placed in both channels to decrease the optical power even to fW level in LE and adjust the power of SE to reach more than 60 dB difference between maxima of both echoes. Fig. 1. (right) shows measured signals at higher power levels, where SE with 10 ns FWHM and power of 0.45 W is overlapped over 4 µs LE with 0.45 nW resulting in a separation of 60 dB. This system works from UV to NIR wavelength range [3] and in the next step it will be expanded to the MIR range to cover full response range of the MCT detector.

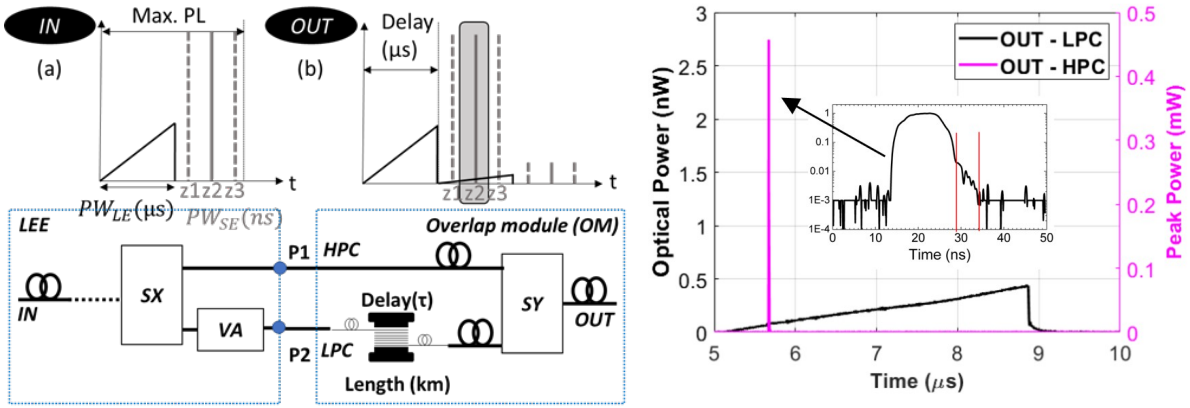

Fig. 1. Setup and the technique of short and long echo overlapping (left), the measured signal at the output. The inset shows the normalized SE in the logarithmic scale (right).

[1] M. Rodríguez-Cortina *at al*., *IEEE Trans. Instrum. Meas.* **70**, 7005307 (2021).
[2] J. Rothman *et al*., *Proc. SPIE* **11852**, 118520F (2021).
[3] M. Rodríguez-Cortina *at al*., *Opt. Express* **30**, 2173 (2021).