Driver for an external Mach-Zehnder intensity modulator with high propagation delay stability

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Chromatic dispersion of the optical fiber is one of the key parameters that influence the uncertainty of calibration of any bidirectional fiber optic time transfer system[1]. To assure that the difference of the propagation delays in both directions are determined with picosecond accuracy it is essential to use an externally modulated lasers, featuring very low chirp. From this point of view the best solution is the Mach-Zehnder (M-Z) modulator capable of zero-chirp operation.

Commercially available modulator shows, however, some temporal drift of their transfer function, that is directly related to the properties of $LiNbO_3$ material used for their construction. Apart from the desired electro-optic effect, this material is affected by temperature and presence of stray electric charges because of $LiNbO_3$ pyrroelectric and ferroelectric nature. This may result in slow drift of the M-Z modulator transfer function that must be corrected by the modulator driver.

In the paper we are describing the electronics we developed to set the stable operating point of the modulator, having the requirement of very high stability of the propagation delay in mind. The method of control we proposed is based on comparison between the mean and RMS values of the optical signal at the output of the modulator (Fig. 1a). In addition dedicated start-up controller is required because of periodic transfer function of M-Z modulator (See Fig. 1b).

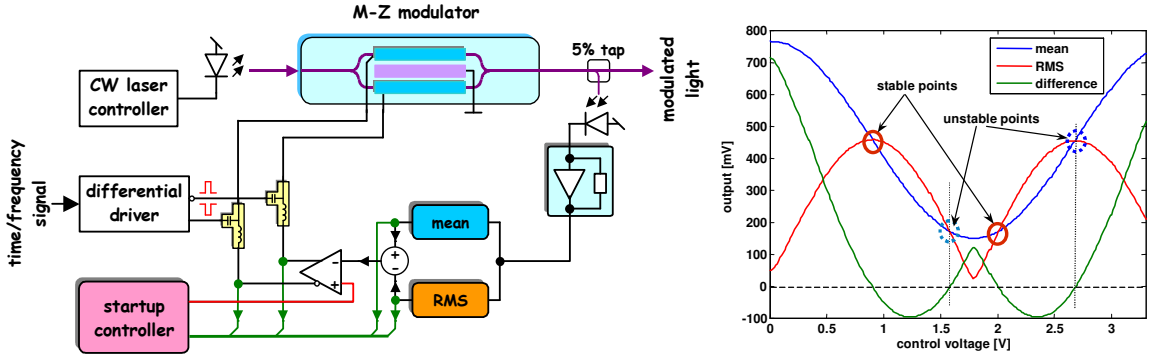

Fig. 1: Block diagram of the developed M-Z intensity modulator (a) and its operation characteristics (b).

We performed a set of tests of designed system, determining the stability its propagation delay. Temperature coefficient on the order of 1 ps/K was obtained, being very close to the temperature coefficient of the measurement setup (~0.7 ps/K). Resistance to both large shifts of the modulator transfer function and variations of the power of CW laser were confirmed in the tests.

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[1] Ł. Śliwczyński, P. Krehlik, A. Czubla, Ł. Buczek, M. Lipiński, „Dissemination of time and RF frequency via a stabilized fiber optic link over a distance of 420 km", Metrologia, vol. 50, pp. 133-145, 2013