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TOWARD FULLY STABILIZED CHIP SCALE OPTICAL FREQUENCY COMBS SOURCES AND APPLICATIONS

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We present novel, carrier-envelope stabilized optical frequency comb from a photonic architecture comprised of an opto-electronic oscillator driving a series of electro-optic modulators. The system is self-starting, self-stabilizing and self-referenced. These results identify a pathway towards chip scale electro-optic modulator based optical frequency combs.

Summary

Optical frequency combs are becoming increasingly important in optical communications, signal processing and sensing applications. Many desirable applications can benefit from these sources, but need sources that are chip-scale in nature, owing to their small size, light weight and low power consumption. In this work, we show a photonic system architecture that lays the ground work for a fully integratable, self-starting, self-stabilizing and self-reference optical frequency comb, operating at 1550 nm, with at 10.5 GHz comb spacing, with the potential for chip-scale integration. This wavelength regime is technically relevant for current optical communications standards. The 10.5 GHz spacing is also attractive, as the repetition rate is readily known, and the optical combs can be easily individually accessed for WDM based coherent communications and signal processing applications.

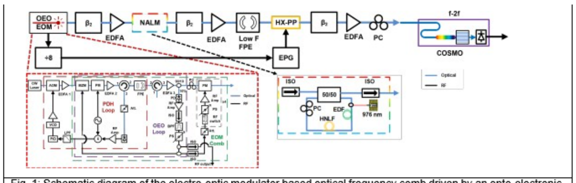


Fig. 1: Schematic diagram of the electro-optic modulator based optical frequency comb driven by an opto-electronic oscillator.

The system is comprised of a narrow linewidth (<10Hz) cw laser that is passed through a single intensity modulator, followed by 3 phase modulators. Each modulator is driven with the same RF signal and the frequency of this RF signal determines the optical frequency comb spacing. The cw laser is locked to a high finesse (100,000) finesse etalon comprised of ultralow expansion quartz (ULE), with a 1.5 GHz free spectral range. The portion of the output light from the etalon is detected by a photodetector. Since the etalon has pass bands separated by 1.5 GHz, the photo-detected signal will possess weak RF beat signals at 1.5 GHz and it harmonics. The photocurrent is passed through a filter that passes the 7th harmonic at 10.5 GHz. This RF signal is applied onto the modulators, which then create sidebands on the cw laser's carrier frequency. Since the 10.5 GHz sideband are resonant with the etalon, the sidebands are passed and detected by the photo-detector, creating a stronger photocurrent modulator at 10.5 GHz. This process continues and serves as an 'optoelectronic oscillator'. Because the optical pathlength between the modulators and photodetectors can be made long, using optical fiber, the Q factor of the optoelectronic loop can be made very high, and thus generate a very clean RF tone (Fig. 2a).

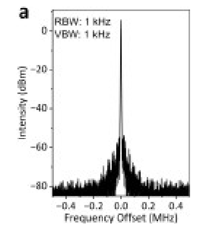
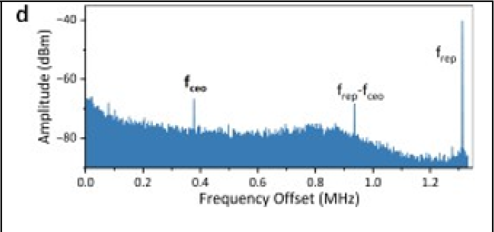


Fig. 2a: RF tone showing f_{rep}



b) RF spectrum from the f-2f detection, showing f_{ceo}

The output pulse is then sent to a nonlinear amplifying loop mirror, which spectrally broadens the pulse and reduces the optical pulse duration from the series of modulators is reduced in pulse repetition rate and amplified, to increase the peak power. Additional pulse train clean-up is employed, using a nonlinear loop mirror. The pulse is then dispersion managed, amplified and passed through a low finesse (500) cavity (FSR+10.5GHz) to provide additional spectral filtering on each combline. The pulse is then reduced in repetition rate through electro-optic gating, amplified and passed through a commercially available nonlinear interferometer for the detection of the carrier envelope signal.