Self-sustained optical frequency comb generation using a phase-modulator-based dual-loop optoelectronic oscillator

Juanjuan Yan*, Ruifeng He
School of Electronic and Information Engineering, Beihang University, Beijing, China.
*Email: yanjuanjuan@buaa.edu.cn

Introduction

➤ In our work, a self-sustained optical frequency comb (OFC) generator by using a dual-loop optoelectronic oscillator (OEO) has been proposed and experimentally demonstrated. In this generator, two PMs are cascaded, GHz the conversion of phase modulation to intensity modulation is realized with a 2-km delay line. In our experiment, a 17-line OFC with a spacing of 10 and a flatness of 7.7 dB is experimentally generated.

Principle

➤ Fig. 1 shows the schematic of the PM-based a dual-loop OEO for OFC generation. The light from a CW laser is modulated by two PMs, and a polarization controller (PC) is used to align the polarization state of the injected light to the PMs. The modulated light is amplified by an Erbium-doped fiber amplifier (EDFA) and divided into two parts with an optical coupler (OC1). One part is for measurement with an optical spectrum analyzer (OSA), and the other part is again divided into two branches with OC2. At each branch, the signal is delayed with a length of SMF. In the long SMF, the phase modulation is converted into intensity modulation via the dispersion in the fiber. The two delayed signals are detected with a balanced photo-detector (BPD). The generated electrical signals are combined with an electrical coupler (EC1) and amplified by an electrical amplifier (EA1) before passing through a band-pass filter (BPF). The output of the filter is again amplified and divided with another two couplers (EC2 and EC3), one part is outputted and the other two parts are respectively fed back to drive the two PMs.

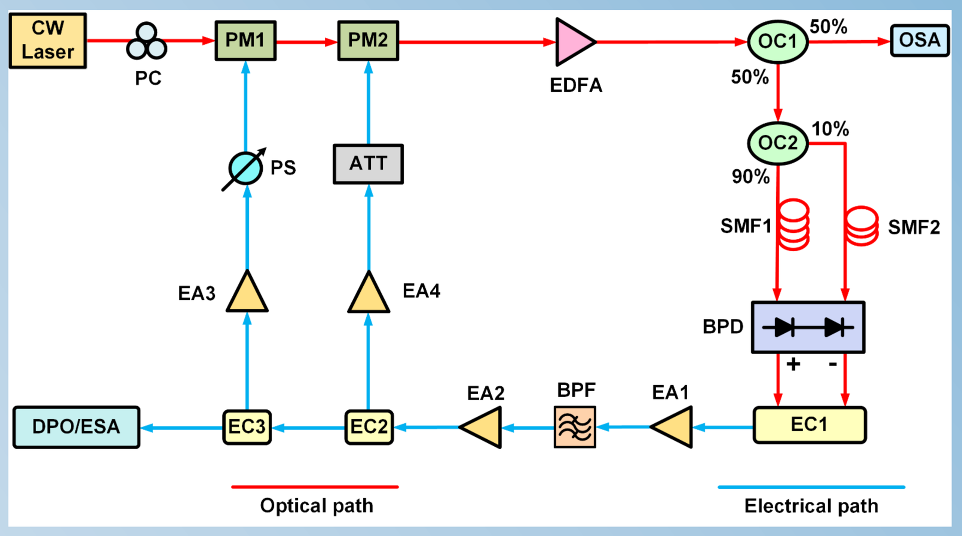
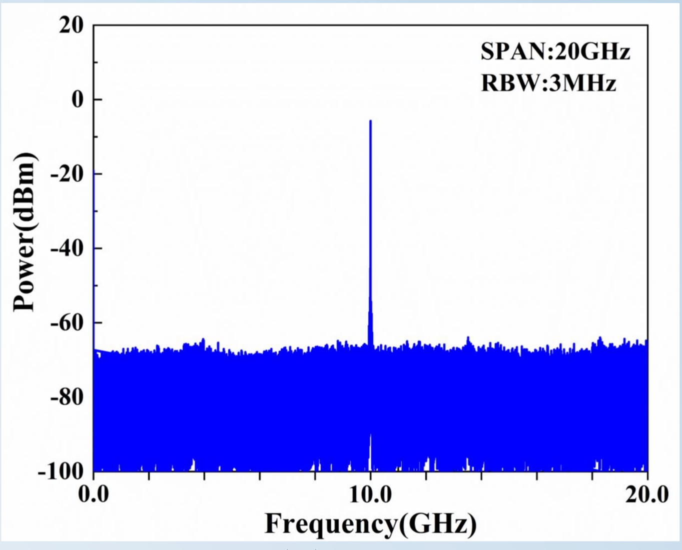


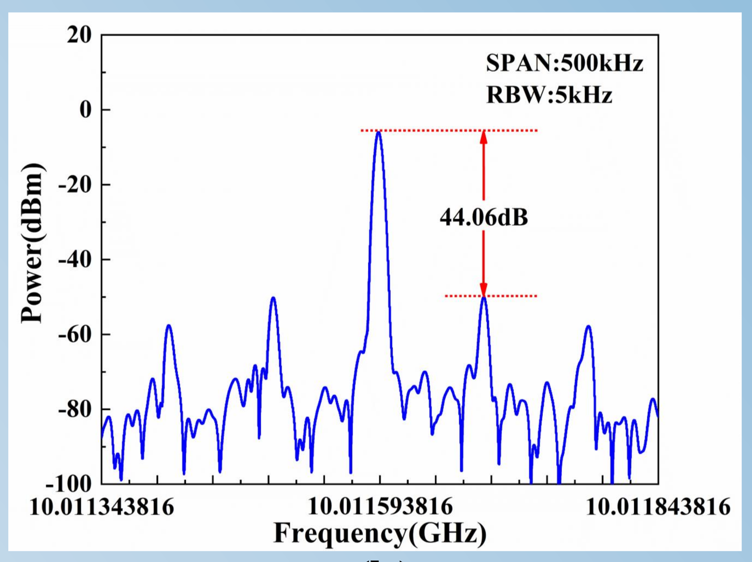
Fig. 1. OFC generator based on a dual-loop OEO.

● When the loop net gain is large than 1 and the phase matching condition is satisfied, an oscillation can be formed, and the oscillating frequency is equal to the center frequency of the BPF.

Experiment results and discussion



(a)



(b)

Fig. 2. The electrical spectra of the generated 10-GHz oscillating signal in a span of (a) 20 GHz and (b) 500 kHz.

● Different modes are observed in Fig.2(b) due to the non-ideal mode selection, and the mode spacing is about 100 kHz. The side mode suppression ratio (SMSR) is measured to be about 44.06 dB.

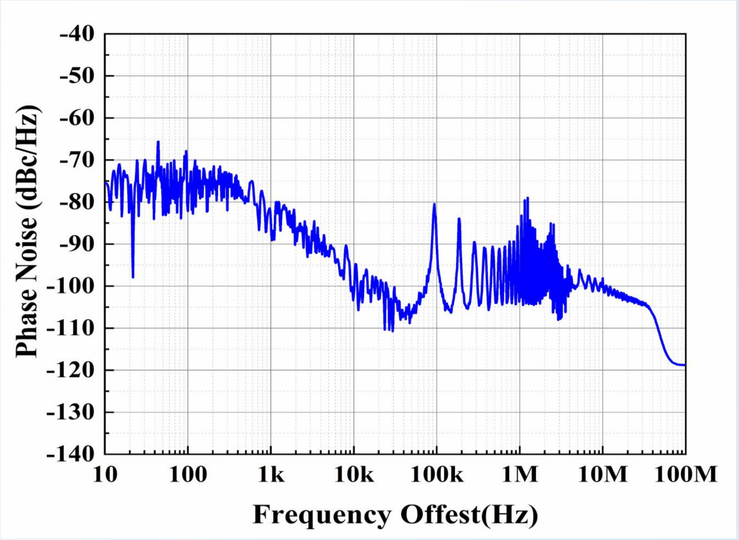


Fig. 3. SSB phase noise of the generated 10 GHz oscillating signal.

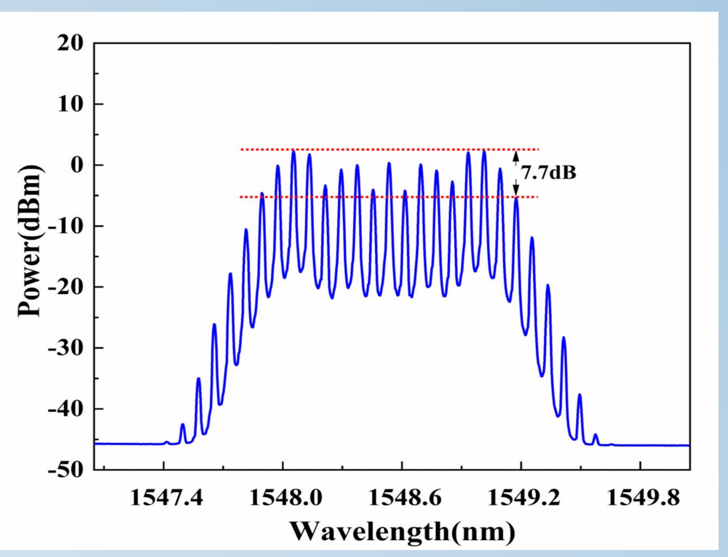


Fig. 4. The generated OFC with a spacing of 10 GHz.

● Several spurs are found at offset frequencies of multiple of 100 kHz equal to the FSR of the long loop in the OEO. The phase noise is about -95 dBc/Hz for the 10 GHz oscillation signal at 10 kHz offset frequency. A 17-tone frequency comb with a 7.7-dB power deviation is realized. The comb line spacing is 10 GHz equal to the oscillation frequency.

Conclusions

➤ In our experiment, a 10-GHz oscillation is achieved, and the phase noise @ 10 kHz offset frequency is about -95 dBc/Hz. Simultaneously a 17-tone OFC is produced with a flatness of 7.7 dB. Our work shows that OFCs with a line spacing of 10 GHz or higher can be produced with a PM-based OEO without an IM in the loop, and thus a complicated bias control circuit is avoided.

Acknowledgement

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