Generation of Pulses From Periodically Phase-Modulated CW Laser Field Using the Temporal Fractional Talbot Effect

R Shakhmuratov[1]

[1] *Kazan Physical-Technical Institute, 10/7 Sibirsky trakt st, 420029, Kazan, Russia.*
Contact Phone: +79600367595
Contact Email: shakhmuratov@mail.ru

Ultrashort optical pulses have wide applications in physics, chemistry, biology, optical communication, optical signal processing, optical measurements and sensing, material processing, and optical manufacturing. One of the widespread methods of ultrashort optical pulse generation is based on use of mode-locked lasers. However, in this method it is difficult to control the pulse width and shape, the signal-to-noise ratio, the pulse position in a time slot, and the repetition frequency for fine tuning and synchronization with other electrical signals. Jitters of the peak-power and duration of the pulses are challenging to control when these fluctuations are on a short time scale. These limitations can be surmounted by external modulators that permit ultrashort pulse generation from the continuous wave (CW) light emitted from a narrowband stabilized laser. Since amplitude modulators suffer from large insertion losses and a low signal-to-noise ratio, phase modulators are more perspective for pulse pattern generation. Arbitrarily complex optical waveforms of pulses can be synthesized at high repetition rates by appropriate phase-intensity spectral shaping of frequency comb sources in expense of the field energy [1]. Another possibility is electrooptic modulation method [2]. It converts CW light with a narrow spectrum to phase-modulated light with ultrawide optical sidebands on the order of terahertz. Then, by using the successive group-delay-dispersion (GDD) circuit, the chirped CW light is compressed to generate trains of ultrashort pulses in the sub-picosecond range.

In this report sawtooth phase modulation of CW laser field and successive treatment by GDD circuit [3] are presented. It is shown that binary (rectangular shape) and sawtooth phase modulation produce perfect square-wave-type optical pulses with no radiation field between them after propagating GDD circuit at a quarter of the Talbot condition. Moreover, these phase modulations produce different pulse shapes at the other fractional Talbot conditions (1/3, 1/6 and 1/8). However, pulse shapes are very sensitive to the accuracy of fractional Talbot condition implementation which makes a problem with adjusting the length of GDD circuits based on a single mode optical fiber or a linearly chirped fiber Bragg grating. Luckily, this problem can be solved by fiber or waveguide couplers 1×M and M×1 with phase shifters proposed in [4-5]. Advantages of a sawtooth phase modulation compared to the binary phase modulation are discussed.

Thus, the fractional Talbot effect opens up new possibilities for development of a wide variety of integrated ultrashort optical pulse generators.

References

[1] S T Cundiff and A M Weiner, Nature Photon. **4**, 760 (2010)

[2] H Murata, A Morimoto, T Kobayashi and S Yamamoto IEEE J. Sel. Top. Quantum Electron. **6**, 1325 (2000)

[3] R Shakhmuratov, J. Lightwave Techno. **40**, 1895 (2022)

[4] N K Berger, B Levit, A Bekker and B Fischer, IEEE Photon. Technol. Lett. **16**, 1855 (2004)

[5] N K Berger, B Vodonos, S Atkins, V Smulakovsky, A Bekker and B Fischer, Opt. Commun. **217**, 343 (2003)