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MICROWAVE GENERATORS WITH PASSIVE MODE-LOCKING*

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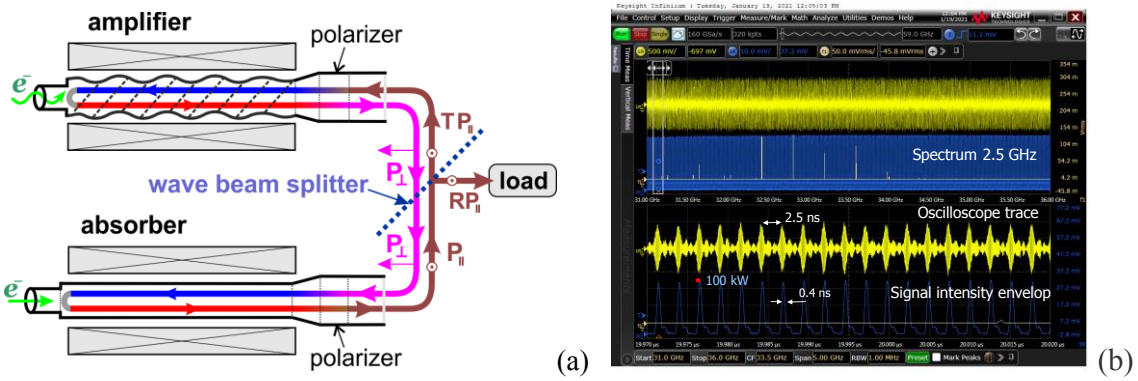
Passive mode-locking as a method for generating periodic sequences of ultrashort optical pulses (USPs) is well known in laser physics [1]. This effect is achieved by incorporating a saturable absorber (nonlinear filter) into the laser resonator. The theoretical studies carried out [2-4] have shown the possibility of transferring the described method to microwave electronics. The key point for the development of electronic USP generators with passive mode-locking was the development of an absorber that should provide saturable absorption in the microwave range at a power level of tens and hundreds of kilowatts. For this purpose, it was proposed to use cyclotron resonant absorption of radiation by an initially rectilinear electron beam, when the absorption saturation is caused by the relativistic dependence of the gyrofrequency on the particle energy [3]. Based on the theoretical analysis, the two-section Ka-band USP generator has been developed which comprised a helical-waveguide gyro-TWT as an active unit (Fig. 1a). In good agreement with theoretical predictions, periodical trains of 0.4 ns pulses with peak power of 100 kW and repetition period of 2.5 ns were measured (Fig. 1b). Phase coherence of radiated pulses was demonstrated based on analysis of the auto-correlation function [4]. Performed experiments open essential new possibilities in generation of wide-band coherent radiation highly demanded for numerous applications.



(a) (b)

Fig.1. (a) Principal scheme of a microwave mode-locked generator comprising a helical-waveguide gyro-TWT (amplifier) and a regular-waveguide saturable cyclotron resonance absorber (blue and red arrowed lines inside both tubes correspond to idle and active wave propagation, respectively. (b) Oscilloscope traces of recorded signal in the experiment.

REFERENCES

[1] U. Keller, “Recent developments in compact ultrafast lasers”, Nature, vol. 424, 831-838, August 2003.

[2] N.S. Ginzburg, G.G. Denisov, M.N. Vilkov, I.V. Zotova, A.S. Sergeev, “Generation of “gigantic” ultra-short microwave pulses based on passive mode-locking effect in electron oscillators with saturable absorber in the feedback loop”, Phys. Plasmas, vol. 23, no. 5, art.no. 050702, May 2016.

[3] N.S. Ginzburg, G.G. Denisov, M.N. Vilkov, A.S. Sergeev, S.V. Samsonov, A.M. Malkin, and I.V. Zotova, “Nonlinear cyclotron resonance absorber for a microwave subnanosecond pulse generator powered by a helical-waveguide gyrotron traveling-wave tube”, Phys. Rev. Appl., vol. 13, art.no. 044033, April 2020.

[4] N.S. Ginzburg, S.V. Samsonov, G.G. Denisov, M.N. Vilkov, I.V. Zotova, A.A. Bogdashov, I.G. Gachev, A.S. Sergeev, R.M. Rozental, “Ka-band 100-kW subnanosecond pulse generator mode-locked by a nonlinear cyclotron resonance absorber”, Phys. Rev. Applied, vol. 16, art.no. 054045, April 2021.

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