S3-O-034901

DEVELOPMENT OF W-BAND SHORT PULSE GENERATOR WITH PASSIVE MODE-LOCKING*

M.N. VILKOV, N.S. GINZBURG, I.V. ZOTOVA, A.S. SERGEEV

Institute of Applied Physics RAS, Nizhny Novgorod, Russia

In laser physics, a well-known method exists for production of ultrashort optical pulses (USP) based on the effect of passive mode-locking [1], which is achieved by incorporating a saturable absorber (nonlinear filter) into the laser resonator. The similar method of USP generation was experimentally realized recently in high-power microwave electronics in a two-section Ka-band oscillator [2-3] consisting of a gyro-TWT amplifier and a nonlinear cyclotron resonance absorber in the feedback loop. The amplifier operated at the second cyclotron harmonic while the absorber operated at the first harmonic. This seriously restricts the advancement of the above scheme of USP generator into the shorter (W or G) wavebands and its use in the applications like spectroscopy.

In this paper, we suggest an alternative scheme of W-band USP generator with passive mode-locking, which includes two gyro-TWT [4-5] sections with helical corrugation (Fig. 1a). One of them is used as an amplifying unit, while the other operates in the regime of nonlinear Kompfner absorption [6-7]. The regime of amplification or absorption in a gyro-TWT is achieved by adjusting the cyclotron resonance detuning. Both sections operate at the second cyclotron harmonics, which allows the required magnetic field to be reduced. According to simulations for W-band gyro-TWT with electron energy of 60 kW and current of 10 A, it is possible to generate periodical trains of pulses with the peak power of about 400 kW and 60 ps duration (Fig.1b-c).

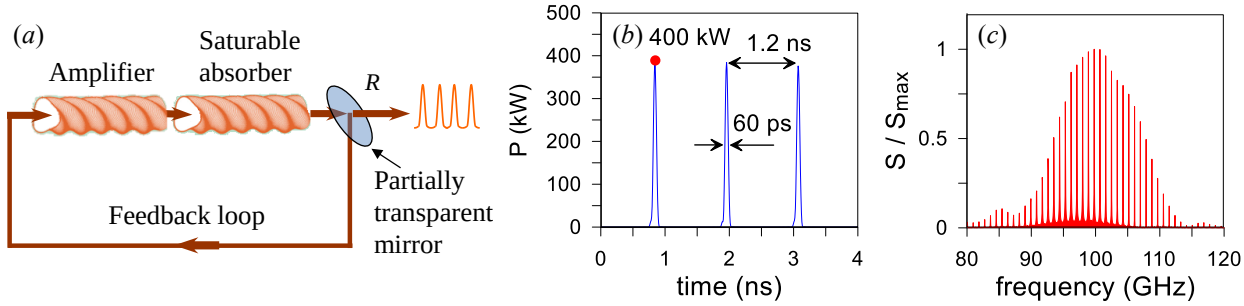

Fig.1. (a) scheme of a mode-locked microwave oscillator consisting of two coupled helical gyro-TWTs, (b) profiles of microwave pulses, and (c) radiation spectrum.

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, 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.

[3] 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.

[4] S.V. Samsonov, G.G. Denisov, I.G. Gachev, A.A. Bogdashov, "CW operation of a W-band high-gain helical-waveguide gyrotron traveling-wave tube", IEEE Electron Device Lett., vol. 41, no. 5, pp. 773-776, May 2020.

[5] W. He, C.R. Donaldson, L. Zhang, K. Ronald, A.D.R. Phelps, A.W. Cross, "Broadband Amplification of Low-Terahertz Signals Using Axis-Encircling Electrons in a Helically Corrugated Interaction Region", Phys. Rev. Lett., vol. 119, art.no. 184801, October 2017.

[6] R. Kompfner, "On the operation of the traveling wave tube at low level", J. Brit. IRE, vol. 10, pp. 283-289, August-September 1950.

[7] C.S. Kou, K.R. Chu, D.B. McDermott, and N.C. Luhmann Jr., "Effective bandwidth and the Kompfner dip for cyclotron autoresonance maser amplifiers", Phys. Rev. E, vol. 51, pp. 642-648, January 1995.

* The work was supported by Grant of the President of the Russian Federation No. MK-4048.2022.1.2