Generation of Ultrashort Microwave Pulses in Gyro-TWT with Saturable Cyclotron Absorber in the Feedback Loop

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***Abstract*— For gyro-TWT possibility of production of ultrashort microwave pulses with peak power strongly exceeding the power in stationary generation regime has been demonstrated. This effect can be achieved due to installation in feedback loop addition section with non-linear saturable absorber. In high power microwaves as such absorber an additional section may be used, where radiation interacts with initially rectilinear electron beam under cyclotron resonance condition.**

I. INTRODUCTION

IN the laser physics there exist well-known principles for production of extremely high power optical pulses, which generated in the system with modulation of its quality factor – Q-switching [1]. Naturally, it could be interesting to use a similar approach in classical electron masers. In particular in [2] the method of active optically controlled Q-switching are studied, that are based on induced photoconductivity effect in semiconductor elements implemented in resonant system. The period of pulses from a driving laser should be closed to e.m. signal round trip inside interaction space.

In this paper we suggest the alternative method of passive modes synchronization based on installation of saturable absorber in the feedback loop of electron generator. In high power microwaves as such absorber the additional section may be used, where radiation interacts with initially rectilinear electron beam under cyclotron resonance condition.

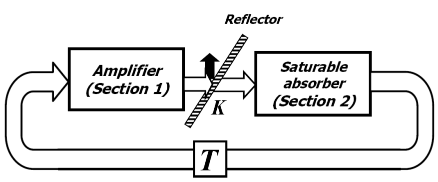

Fig. 1. Principal scheme of generation of

II. BASIC EQUATIONS AND RESULTS OF SIMULATIONS

The principal scheme of generator of ultrashort em pulses is presented in Fig.1. As an amplifier let us consider the gyro-TWT (section 1) where amplification process is described by well-known equations [3]:

$$\frac{\partial a_1}{\partial Z}+\frac{\partial a_1}{\partial Z}=\frac{I_0}{2\pi}\int_0^{2\pi} p\,d\theta_0, \qquad \frac{\partial p}{\partial Z}+ip(\Delta-1+|p|^2)=-a_1, \tag{1}$$

with boundary conditions for transverse momentum of particles $p(z=0)=\exp(i\theta_0)$, $\theta_0\in[0,2\pi)$. We will assume that in the section 2 the nonlinear absorber with an absorption coefficient $\sigma=\sigma\left(|a_2|^2\right)$ is implemented. According to the scheme in Fig.1 the field amplitudes at the output of amplifier and input of absorber are connected by relation: $a_2^{in}(\tau)=Ka_1^{out}(\tau)$, where $K<1$ is the transmission coefficient. Total power passed through the absorber with a time delay T comes to the input of the amplifier: $a_1^{in}(\tau)=a_2^{out}(\tau-T)$.

In Fig.2a regime of stationary generation is presented which realizes in the case of linear absorption in the feedback loop. Introduction of nonlinearity, providing the saturation of the absorber, leads to the replacing of stationary generation by spike regime with periodic sequence of pulses (Fig.2b). It is important to note that the amplitude of the field in the spike regime exceeds in several times the amplitude of the stationary generation.

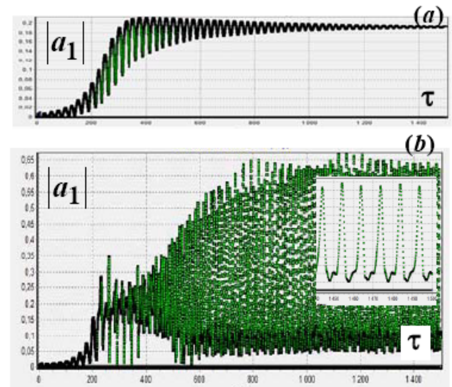

Fig. 2. Time dependence of field amplitude at the output of section 1: (a) stationary regime of generation for the case of linear absorption, (b) spikes regime in the case of non-linear saturable absorber in the feedback loop.

In the paper based on results of simulation we discussed possibility of experimental realization of regimes of ultrashort microwave pulses generation in application to traditional gyro TWT with regular waveguides [3] as well with helically corrugated waveguides [4].

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