# THE MULTIHARMONIC SUPERHETERODYNE FEMTOSECOND FREE ELECTRON LASERS OF KLYSTRON TYPE

Prof. Kulish V.V., Lysenko O.V., Majornikov I.G.

It is well known that the free electron lasers (FELs), as a class of devices, can be classified as 'large–scale equipment' [1]. This conclusion especially concerns the FEL amplifiers, where the signal amplification should be attained during only one passe through the FEL operational part. This is the main cause why the FELs do not found any remarkable industrial (civilian) utilization. At the same time, as analysis shown, relatively compact FEL-amplifiers could have most promising practical applications. They are, for known, the technological IR-FELs, mm–submm sources of coherent radiation for communication systems, UV-FELs for microelectronic technologies, etc. As the same analysis shown too, the compact FELs can be created actually in the case when the basic working mechanism of the traditional parametric FELs is replaced by some version of the *effect of superheterodyne amplification of electromagnetic waves* within relativistic electron beams [1]. The characteristic feature of this effect is the essentially higher magnitudes of the gain factor for the same (with the parametrical FELs) parameters. Apart from that, as it is shown in this paper, the SFELs constructed on the basis of two-stream instability can work in the multi-harmonic modes [2].

The main difference of the Two-stream SFEL (TSFEL) of klystron type with the traditional parametrical FELs is presence in the TSFEL of two-velocity electron beam, which is formed by two one-velocity beams. Owing to utilization of the two-stream instability, as a basis mechanism for amplification of electron beam waves, we have a possibility to introduce in the system the transit section. As a result, the system discussed, in contrast to analogous one-section systems, is characterized by extremely high level of decoupling 'input-output' that is very important for an amplifier of any type. A peculiarity of the system discussed is the choice of design of the second pumping section. It is made there as a multi-harmonic magnetic undulator. Due to this we have a possibility to form multi-harmonic output signal,

including, the signals in the form of a sequence of very narrow pulses (see Fig.). This means that the instant intensity of the output signal $\omega, k$ can be essentially higher (at equal averaged power) when comparing it with the traditional one-harmonic case. This could be beneficial for some special practical application. This effect, as analysis shows, can be realized only because of the explicitly expressed multiharmonical nature of the two-stream instability.

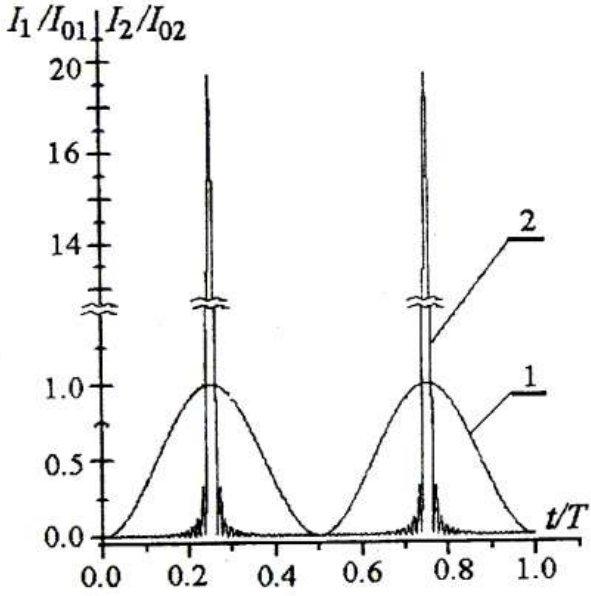


Fig. 3
Dependencies of the normalized ratios $I_j/I_{0j}$ for the initial (transformed) signal wave (the curve $j=1$) and output femto-second wave (the curve $j=2$). Here: $I_j$ are the current intensities, $I_{0j}$ are the initial intensities.

Thus, the proposed multiharmonic klystron two-stream free electron lasers can be effectively used as an oscillator of electromagnetic signal waves with given complex multiharmonical spectrum.

## REFERENCE


1. Kulish V.V. Hierarchical methods. Vol.II. Undulative electrodynamic systems, Dordrecht/Boston/London: Kluwer Academic Publishers, 2002.
2. Kulish V.V., Lysenko A.V., Savchenko V.I. Two-Stream Free Electron Lasers: Physical and Project Analysis of the Multiharmonical Models. // International Journal of Infrared and Millimeter Waves. –2003.- Vol. 24, N 4, P. 501-524.