Abstract: A method of obtaining steplike pulses at the output of high energy high efficiency amplifiers, i.e., in the high saturation regime is proposed.

Keywords— pulse shaping, high saturation regime, high energy amplifiers.

I. INTRODUCTION

The efforts to achieve high output intensity and/or high amplifier efficiency are accompanied by strong pulse shape distortions. This occurs because the pulse energy is comparable with the saturation energy of laser transition. Distortions of the shape are insignificant for bell-shaped, quasi-Gaussian pulses. Saturation results, primarily, in pulse displacement in time [1]. For pulses with a steep leading edge, shape distortions are very important. The pulse at the amplifier output resembles a triangle with a steep leading and a flat rear edge. The effective pulse duration decreases and probability of laser elements damage increases. We propose a method that would enable reducing distortions of the amplified pulses and achieving steplike pulses at the amplifier output.

II. SHAPE DISTORTION PARAMETER OF A PULSE WITH STEEP EDGES.

Distortions in the shape of pulses with steep edges can be best assessed by parameter $N$ defined as the ratio of the gain at the initial $G_0$ and final $G_{\text{end}}$ moments of time

\[ E_{\text{out}} = E_s \ln \left( \exp \left( \frac{E_{\text{out}}}{E_s} - 1 \right) G_0 + 1 \right) \]

We can show that

\[ N = \left( G_0 \right)^\eta = \exp \left( \frac{E_{\text{out}} - E_{\text{in}}}{E_s} \right) \text{where } \eta = \frac{E_{\text{out}} - E_{\text{in}}}{E_{\text{sat}}} \]

If the amplifier comprises several ($m$) cascades, then the parameter $N_{\text{total}} = \prod_{j=1}^{m} N_j$.

For several ($n$) pulses propagating successively through the amplifier, we can analogously obtain the formula

\[ N_{\text{total}} = \prod_{i=1}^{n} N_i \]

III. THE CONCEPT OF REDUCING SHAPE DISTORTIONS.

For obtaining a steplike pulse at the amplifier output, the input pulse must have the ratio of the intensities at the rear and front edges intensity equal to $N_{\text{total}}$. But for the $n$ pulses of the same total energy, the ratio of the each $i$-th pulse is much less, and being equal to $\frac{n}{\sqrt{N_{\text{total}}}}$ in the ideal case.

Hence, in the high saturation regime (when $N_{\text{total}}$ is large) division even into two pulses greatly reduces distortions. It is rather easy to obtain two pulses dividing them by their polarizations. This will allow changing the ratio of their energies at the amplifier input. They may be either summed at the amplifier output in the polarizer or in the SHG of the second type, or use them independently as different pump channels.

IV. RESULTS OF CALCULATIONS OF DISTORTIONS OF TWO PULSES V/S ONE PULSE FOR THE PUMP LASER OF THE PEARL FACILITY.

Consider as an illustration results of computation of distortions of the shape of the pulse with steep edges at amplification in a 7 cascade Nd:glass rod amplifier. Part of the Gaussian beam with a duration of 5 ns, with monotonic edges was taken as a model pulse.

Fig. 1. Output single pulse (a) and two pulses with the same total energy.

Clearly, for a single input pulse the ratio $N$ of the intensities at the front and rear edges is more than 30 times. In the case of two input pulse replicas, the ratio $N$ of intensities does not exceed 6 times, and the output pulse shape is much closer to the rectangle (see Fig.1).
