TeraXion

BLOG ARTICLE

# Design challenges of industrial femtosecond lasers – Part 2: Pulse energy

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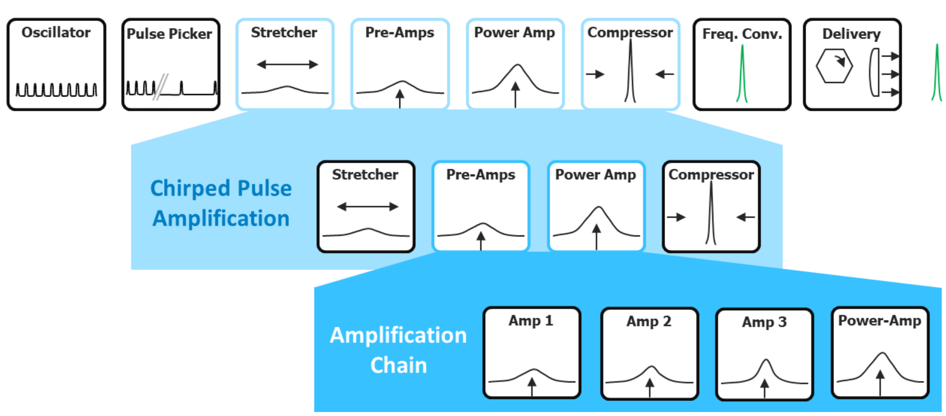
*In this series of articles, I lay down a few of my thoughts about the constraints influencing the design of femtosecond industrial lasers and parameters I believe should be considered before even starting the design process. I'd like to state that I am not a laser design expert; I spent the last 15 years developing and commercializing components for high-power and ultrafast lasers. The observations I write about come from my own experience and discussions I held with different stakeholders over the course of the last few years. I hope they will lead to interesting discussions and hopefully help a few of you with the design of your lasers.*

Purchasing an industrial femtosecond laser represents quite an investment, pushing end-users to look for the best possible performance ($/throughput) for the price they pay. In order to improve that $/throughput ratio, laser manufacturers work hard to increase laser performance through more pulse energy and average power. As long as end-users are able to leverage this extra performance, by using high-speed scanners or beam splitting techniques, these parameters will be worth improving.

The core of an industrial femtosecond laser is the amplification chain. Not only are amplifiers necessary to reach the energy levels needed for cold ablation, they are also a big part of the bill of materials of the laser. Because the energy of the seed pulse is relatively low and losses are incurred along the optical path, amplification by 6 or 7 orders of magnitude is usually needed. To do this, a typical amplification chain includes several stages. A few different technologies are available. Each of these technologies can influence the design of the whole laser. This explains why most amplification chains often use more than one technology.



The main limiting constraint of ultrafast amplifiers is their capacity to amplify high peak power pulses, while minimizing non-linear effects. As seen in the first article of the series, a pulse stretcher/compressor pair is used to reduce the peak power of the pulse travelling through the amplification chain. As a rule of thumb, the stretcher will reduce the peak power by a factor of 500X to 1000X with solid-state amplifier configurations and by a factor of 2000X to 3000X with fiber amplifiers. Knowing this, it is possible to easily calculate the required peak power handling capacity of the last amplifier in the chain, based on the targeted market requirements for the output pulse of the laser.

To simplify and accelerate the design phase of the laser, I personally believe that the design process should start from the output pulse requirements and then proceed backwards. Starting with the power amplifier (the last amplification stage) and ending with the seed laser could avoid subsequent iterations. Because the power amplifier is the most expensive building block of the laser, it could be more effective to adapt the remaining parts of the architecture to the choice of the main amplifier. Doing so is often in opposition with the typical design process, in which the seed is designed first and the remaining building blocks are added to meet the output pulse requirements.

In the next article, I will discuss the most frequently used amplification technologies, namely fiber and solid-state amplifiers, and how pulse energy/peak power influence their use in the amplification chain. In the meantime, I'd like to know what you think should be the starting point of ultrafast laser design.



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