

Basic Considerations on Power and Pulse Energy for Pulsed Lasers

Pulsed lasers emit pulses with a certain energy content and at a certain repetition rate. In the following, the relation between peak power, average power, energy per pulse and repetition rate is displayed.

An important parameter of a pulsed laser is the pulse energy (how much energy one pulse contains). This is determined by the pulse repetition rate and the average power (i.e. how much pulses create the average power over one second). The respective formula is:

$$\text{Average Power [W]} = \text{Pulse Energy [J]} \cdot \text{Repetition Rate [Hz]}$$

or, more generally formulated:

$$\text{Average Power [W]} = \frac{\text{Pulse Energy [J]} \cdot \text{Number of pulses}}{\text{Time interval [s]}}$$

Example I: A laser with an average power of 75 W and a 10 kHz repetition rate has the following pulse energy:

$$\text{Pulse Energy} = \frac{75 \text{ W}}{10^4 \text{ s}^{-1}} = 75 \cdot 10^{-4} \cdot \text{Ws} = 7.5 \text{ mJ}$$

The peak power (how much peak power is reached within this pulse) is important information. This is determined by the pulse width. Assuming a rectangular pulse, the respective formulas are:

$$\text{Peak Power [W]} = \frac{\text{Pulse Energy [J]}}{\text{Pulse Width [s]}}$$

$$\text{Peak Power [W]} = \frac{\text{Average Power [W]}}{\text{Repetition Rate [Hz]} \cdot \text{Pulse Width [s]}}$$

Example II: A laser with a pulse energy of 7.5 mJ and a pulse width of 60 ns has the following peak power:

$$\text{Peak Power} = \frac{7.5 \cdot 10^{-3} \text{ J}}{60 \cdot 10^{-9} \text{ s}} = 0.125 \cdot 10^6 \text{ W} = 125 \text{ kW}$$

If the given values are the average power of 75 W, the repetition rate of 10 kHz and the pulse width of 60 ns, the calculation would be as follows:

$$\text{Peak Power} = \frac{75 \text{ W}}{10^4 \text{ s}^{-1} \cdot 60 \cdot 10^{-9} \text{ s}} = 1.25 \cdot 10^5 \text{ W} = 125 \text{ kW}$$

Disclaimer

This article does not attempt to cover all aspects of laser beams. All references and numbers are typical. Scientific literature dealing with these aspects is readily available. A list of articles and books can be provided upon request.