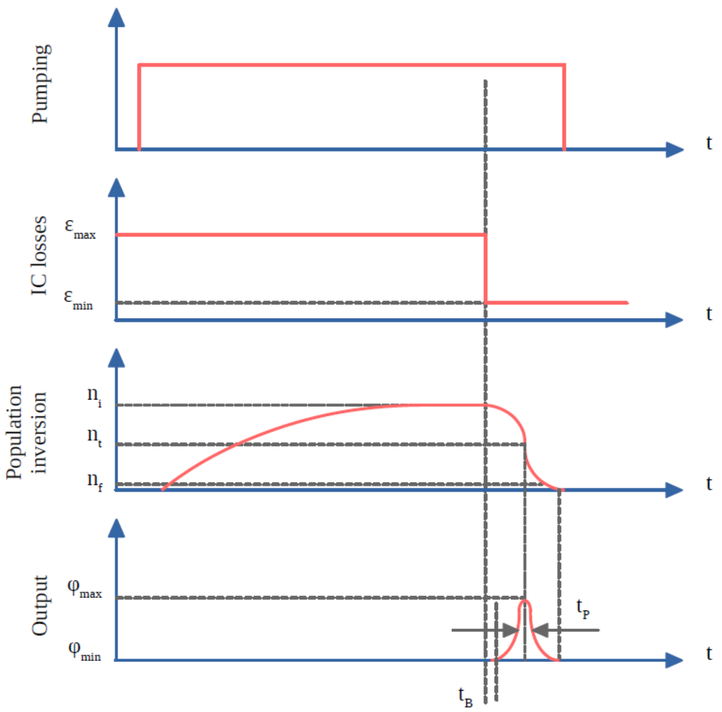
Passive and Active Q-Switched DPSS Solutions

Q-switching is a widespread technique to achieve pulsed operation in lasers by modulating the laser cavity losses in such a way to emit the energy stored in the active media (e.g. YAG crystal) as population inversion (a physical phenomenon involving the temporary excitation of the ions of the active medium) in the form of short pulses, with durations from a few hundreds of nanoseconds down to few tens of picoseconds.
Even though pulsed laser operation in DPSS lasers can be achieved simply by pulsing the optical pump in the so-called free-running regime, Q-switching technique allows to store the pump energy in inverted ions over a time interval (called upper state lifetime of the active medium or storage time) of the active medium upper state lifetime in the order of tens of microseconds up to a few milliseconds-depending on the chosen active medium- and emit that energy in shorter pulses with a time-scale related to the laser cavity features, i.e. round-trip time which is usually orders of magnitude smaller than storage time. The most impacting consequence of this energy redistribution is the possibility to achieve peak powers orders of magnitude much higher than the average power, basically the key-enabling feature for most of the laser applications in the industrial, military, medical and scientific fields.
Q-switching operation can be achieved by both active and passive techniques in which the external control is required or bypassed by some kind of self-adjusting physical process, respectively. More deeply, active methods are performed using electro-optical, acousto-optical or mechanical modulation schemes. A passive method is to employ a saturable absorber, an optical element (e.g. a Cr:YAG crystal) in which the transmission is dependent on the incidence fluence, which prevents laser emission for low circulating intra-cavity power during the pulse build-up stage until a certain threshold is reached.

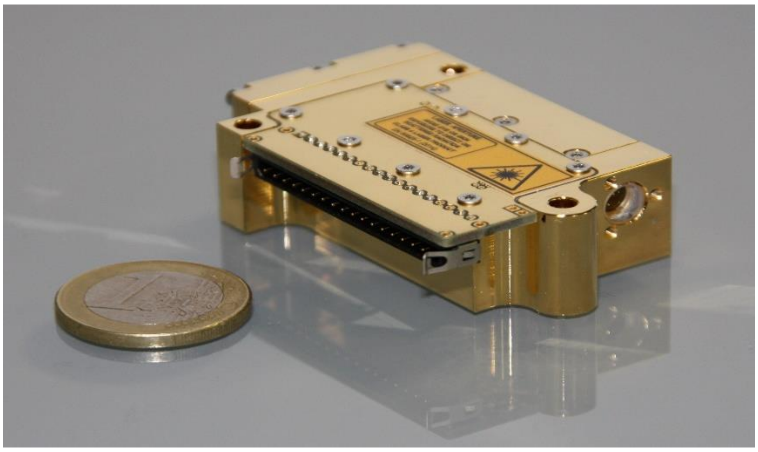


Concept diagram of Q-Switching technique

Potentially, the required external control in actively Q-swiched lasers gives complete control of the laser repetition rate to the user (with residual timing jitter related to electronics and build-up time fluctuations), being the maximum pulse energy limited by the storage capabilities of the active medium, maximum pump energy available and optical damage considerations. On the other hand, in passively Q-switched laser, the pulse energy is fixed by the laser design and the repetition rate is somehow determined by the average pump power. To make it simple, active solutions offer precise control of the laser repetition rate and jitter at the price of a worse pulse-to-pulse energy stability, while passive techniques provide a tighter control on the pulse energy at the price of stronger timing fluctuations. To make it simple, active solutions offer precise control of the laser repetition rate and jitter at the price of a worse pulse-to-pulse energy stability, while passive techniques provide a tighter control on the pulse energy at the price of stronger timing fluctuations.

Actively Q-Switched DPSS laser is monitoring Etna volcano from a remote station in Catania,Sicily

In application involving time-of-flight (TOF) measurements like LIDAR and Bathymetry, the precise synchronization is a key parameter, thus actively Q-Switched solutions are usually preferred, as well as in material processing where precise frequency control is essential in applications where regularly spaced single-spots are employed, while highly spot-overlapping marking processes might be benefited by compact and cost-effective passively Q-switched laser systems. Other considerations are that usually through passive Q-switching lower pulse energy can be achieved than in active Q-switching due to the lower damage threshold of the saturable absorbers. On the other hand, passive Q-switching is more suitable to get shorter pulse durations, even in the picosecond and sub-nanosecond region, due to its simplified design and compactness (no modulator and its electronics are needed) Bright Solutions can offer both state-of-the-art actively (Onda, Sol, Wedge and Vento) and passively (Microchip) Q-switched DPSS lasers in order to cover many customer needs.



P4 Microchip laser head, Bright Microlaser

Thanks to its experience in advanced design and manufacturing of Q-switched lasers over more than two decades, Bright Solutions is able to offer unique actively sub-ns Q-switched lasers (Wedge HF and Wedge XF) with pulse duration down to 200ps, essentially because of a proprietary fast electro-optical Q-Switch modulator and driver.
In addition, Bright solutions can scale up the output power/energy of these rugged oscillators to the desired output level through its proven solid-state amplifiers, implementing a master oscillator power amplifier (MOPA) scheme. In this way, it is possible to preserve the good beam quality and the pulse duration of a low-power oscillator at high energy and power levels (Vento).

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