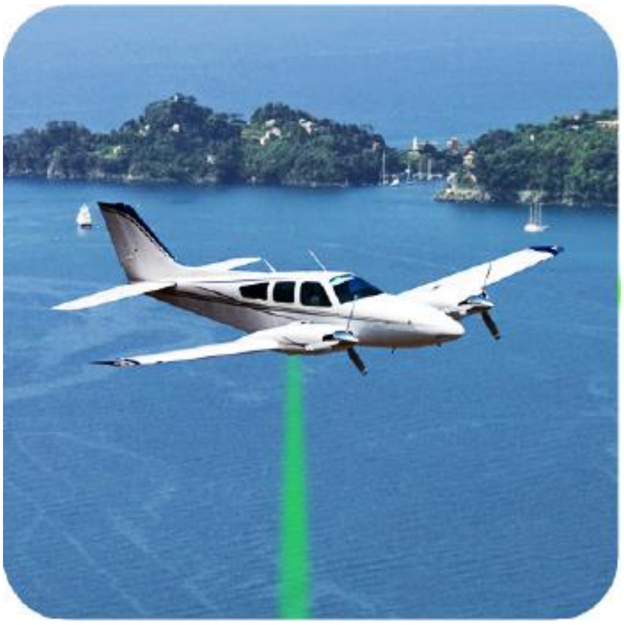
Low Jitter feature in Actively Q-Switched DPSS lasers

In actively Q-Switched lasers the pulsed laser output is controlled by the user, so that no laser pulse emission occurs without providing a proper input signal- the *trigger*.
Due to the trigger signal propagation through the interface electronics and Q-switch driver chain and laser resonator build-up time,a time delay (Td) is present between the externally-supplied trigger signal and the actual laser pulse emitted by the laser source.
Td can show drift or fluctuation if any pulse generation -involved electronics or optics of the laser system- is functionally varying in time.
Parameter Td is very relevant in the timing management of some applications.
In addition to delay Td, a time jitter (Tj) must be considered too, i.e. a statistical variation of the time delay depending mostly on:

- electrical noise in the trigger-chain
- pulse-to-pulse fluctuation of trigger-chain electrical parameters
- laser pulse build-up time mechanism and associated fluctuations.
- fluctuation of rising (-falling) edge temporal profile of the trigger signal

Because of the jitter phenomena the actual value of the time delay is *statistically* altered therefore the laser pulse emission event happens (in the vast majority of cases) inside a normal time distribution defined by an average time delay Td and a standard deviation value Tj i.e 68,2 out of 100 pulses develop in the time interval Td ±*Tj*.
Bright Solutions lasers like Onda, Wedge and Vento are also available in "low jitter" configuration in order to minimize the time jitter Tj (in some cases to 1/10 or even 1/20 of the laser pulse width).



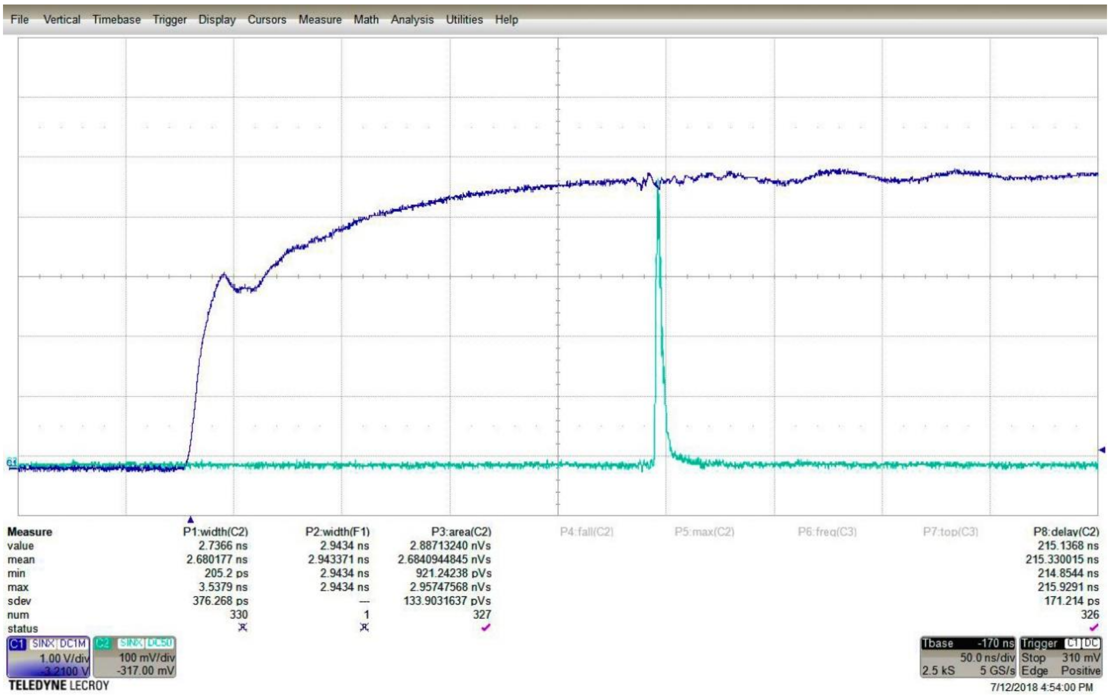
This option can be very useful in applications like Time Of Flight (TOF) metering. In these applications the laser pulse is mainly used to measure the distance of a fixed or moving target: after directing a laser pulse toward the target, an optical detector collects the photons reflected or back-scattered from it while the detection electronics counts the time between the emission of the laser pulse and the collection of photons coming back from the target.
Considering that the speed of an electromagnetic wave in air is approximately 3 x 10^8 m/s, the linear spatial resolution (**r**) achievable by a 3 ns pulse is of the order of:

$$\mathbf{r = 3 \times 10^{8}\ m/s \times 3 \times 10^{-9}\ s = 0.9\ m}$$

Modern detection techniques can significantly reduce this figure.
If the laser emission and the time counter are triggered by the same electric signal, jitter will introduce (in 68,2% of the measurements assuming normal distribution) an error distance De of :

$$\mathbf{De = \pm c\ (speed\ of\ light) \times Tj/2}$$

where **c** is the speed of light.
If the above-defined jitter Tj is in the order of 1 ns, the error in the measurement could be ±15 cm that can be excessive for some critical applications.
Configuring lasers in “low jitter” mode, we can reduce Tj for a 3ns-pulse width laser down to ±200 ps or less, therefore the error can be reduced five times **down to 3 centimeters**.
Of course the user must take care of signal generation in terms of output impedance (50 Ohm) and in terms of sharp and short rising edge of TTL trigger.



The oscilloscope screenshot above shows an example of jitter measurement for a Bright Solutions 2.7ns-long low-jitter airborne LiDAR illuminator. The blue curve is the trigger IN signal, while the green one is the laser pulse detected by a fast photodiode. The standard deviation of the delay of the laser pulse respect to the rising edge of the trigger IN signal is the jitter.

Measure	P1:width(C2)	P2:width(F1)	P3:area(C2)	P4:fall(C2)	P5:max(C2)	P6:freq(C3)	P7:top(C3)	P8:delay(C2)
value	2.7366 ns	2.9434 ns	2.88713240 nVs					215.1368 ns
mean	2.680177 ns	2.943371 ns	2.6840944845 nVs					215.330015 ns
min	205.2 ps	2.9434 ns	921.24238 pVs					214.8544 ns
max	3.5379 ns	2.9434 ns	2.95747568 nVs					215.9291 ns
sdev	376.268 ps	---	133.9031637 pVs					171.214 ps
num	330	1	327					326
status	✗	✗	✓					✓

C1 SINX DC1M 1.00 V/div -3.2100 V
C2 SINX DC50 100 mV/div -317.00 mV
TELEDYNE LECROY

Tbase -170 ns 50.0 ns/div 2.5 kS 5 GS/s
Trigger C1 DC Stop 310 mV Edge Positive
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Looking at measure P8 and its statistics, it turns out that the average delay Td is 215ns (mean of P8) and the jitter Tj is 171ps (sdev of P8), which corresponds to approximately 1/16 of the laser pulse width. Thus, in this specific case the error in the distance measurement is reduced down to about ±2.5cm.

For more detailed information do not hesitate to contact us!

Visit our website www.brightsolutions.it and write to sales@brightsolutions.it
for more information.

BRIGHT SOLUTIONS SRL, via Artigiani, 27, CURA CARPIGNANO, PV 27010, Italy