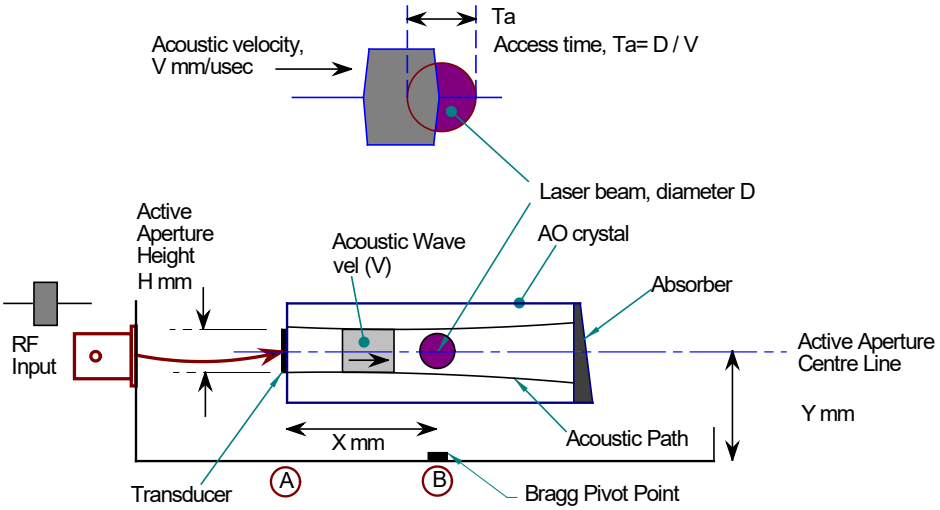
**Timing considerations for pulsed laser applications.**

Synchronizing pulsed laser output with the RF frequency points in iMS4 Image mode.

Considerations:

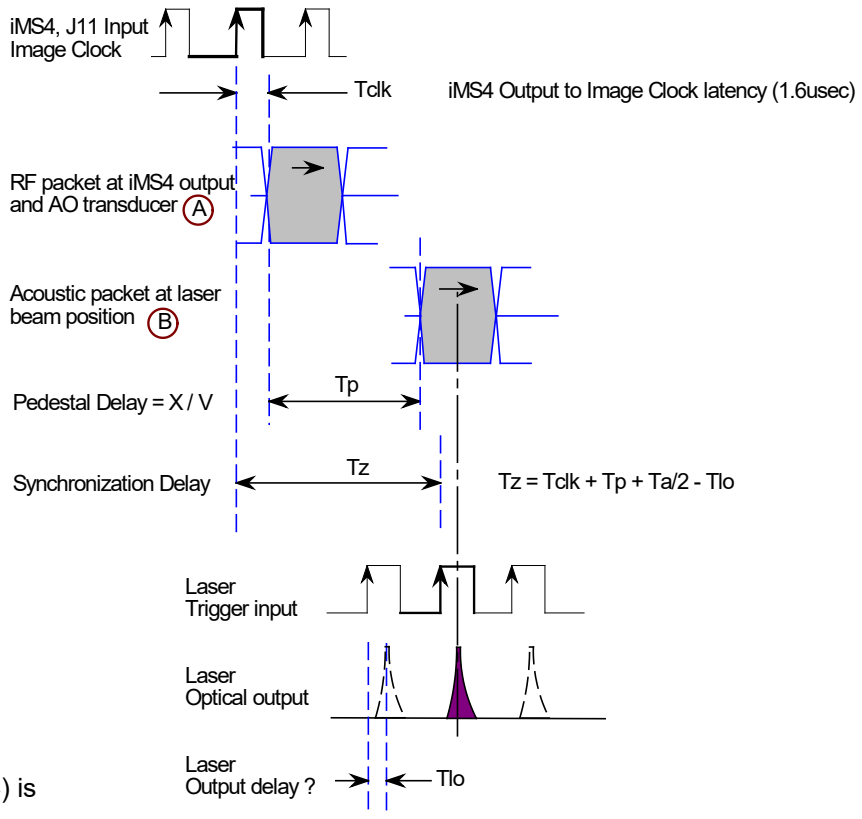
**AO device**
Pedestal delay ($T_p$) is the time taken for the acoustic packet, (RF frequency) to transit from the AO transducer to the centre of the laser beam.

Access time ($T_a$) is the time taken for an acoustic packet to transit across the laser beam diameter.




**RF driver**
iMS4 output delay ($T_{clk}$) is the latent delay between a change in RF output on J1:J4 and the external Image clock input edge on J11

The remaining delay through the RF power amplifier(s) is minimal (<0.1usec)




**Laser**
Laser output delay ($T_{lo}$) is the delay between the laser output and laser trigger input.

**Rep-Rate**
The fastest repetition that can be supported is determined by the iMS4 update iMS4 rate or more typically, the beam diameter in the AOD.

- In X-Y mode, the iMS4 (revC) is limited to a maximum Image point update rate of 2MHz.

- The AO deflector 'spot to spot' limit is determined by the access time ($T_a$). Highest laser input rep-rate is thus $1/T_a$.

Note: Reducing the beam diameter to increase the rep-rate limit will degrade deflector resolution

**Example1: D1384-aQ110-7 or D1384-aQ120-9, (v = 5700m/s)**

iMS4 Image clock to RF output latency, $T_{clk}$ = 1.6usec

Bragg Pivot point is located ~12mm from transducer. For a laser beam is aligned over this point, $T_p$= 2.1usec

For a 5mm beam diameter, the access (or transit) time $T_a$ = 0.88usec
This defines the upper theoretical rep-rate limit of 1.13MHz

Assume 0.1usec delay between laser trigger input and the laser output pulse. $T_{lo}$ = 0.1usec

$T_z = T_{clk} + T_p + T_a/2 + T_{lo} =$ 4.24 usec

This is the synchronization delay required between the Image clock and laser trigger.
For a continuously running pulsed laser the synchronization delay may be shortened by integer periods of the laser rep rate.

In this example $T_{z1} = T_z$ – (period x n), where n = quotient of ($T_z$ / period).

Using an 800KHz laser, pulse period = 1.25usec, n =3

$T_z$ becomes 0.49usec

**Example2: D1422-T85-4, (v = 4200m/s)**

iMS4 Image clock to RF output latency, $T_{clk}$ = 1.6usec

Bragg Pivot point is located ~3mm from transducer.
For a laser beam is aligned over this point, then $T_p$= 0.7usec

For a 3.6mm beam diameter, the access time $T_a$ = 0.86usec
This defines the upper theoretical rep-rate limit of 1.16MHz

Assume 0.1usec delay between laser trigger input and the laser output pulse. $T_{lo}$ = 0.1usec

Then $T_z = T_{clk} + T_p + T_a/2 + T_{lo} =$ 2.83usec

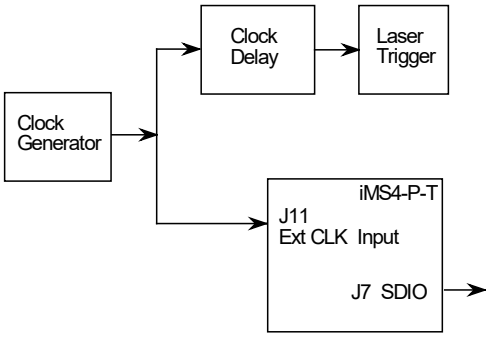
This is the synchronization delay required between the Image clock and laser trigger.
For a continuously running pulsed laser the synchronization delay may be shortened by integer periods of the laser rep rate.

In this example $T_{z1} = T_z$ – (period x n) , where n = quotient of ($T_z$ / period).

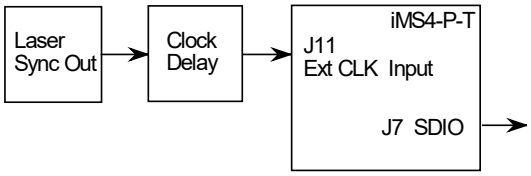
Using a 1MHz laser, pulse period = 1usec, n =2 and $T_z$ becomes 0.83usec

**Laser Trigger / iMS4 Image Clock Configurations**

A: System drives both the Laser Trigger and iMS4 Image Clock



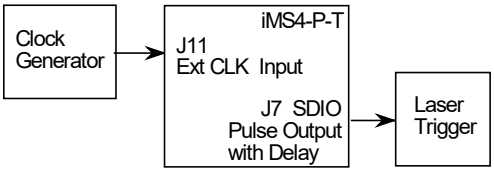

B: Laser Sync Out signal drives the iMS4 Image clock




**Important Note:**

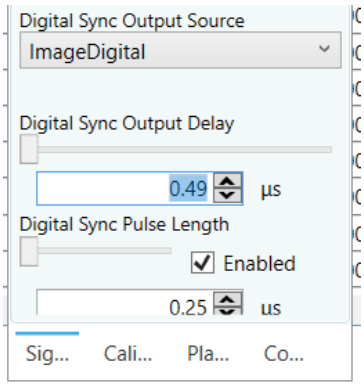
The '**Clock Delay**' function in the above schematics A: and B: is not an internal feature of the iMS4. An external clock delay generator will be required.

C: Using a sync output bit on iMS4 connector J7 to trigger the laser

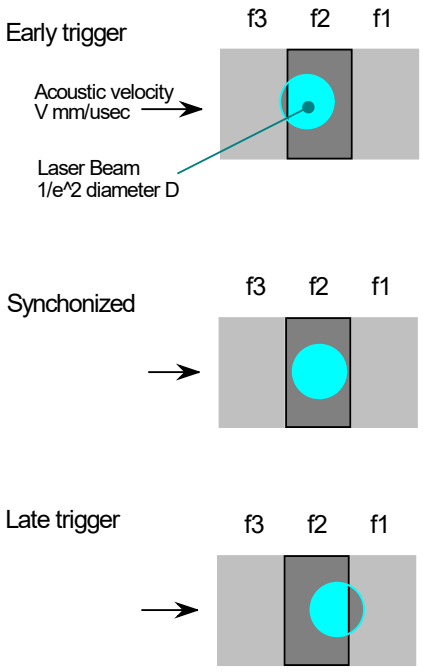



(iMS4 shown with an External Clock input. The Internal clock source can also be selected)

Example Sync Output settings usingh iMS4 Isomet Studio GUI
SDIO pulsed output enabled, with output delay
Pulse width 0.25usec, delay 0.49usec (excludes latency)



When the beam diameter is increased, the access time $T_a$ ( = beam diameter / acoustic velocity) approaches the Image clock period. Synchronization timing becomes more critical.




For a dual Axis XY AO deflector, correct synchronization is required in both axis.
Careful alignment of the laser beam above the Bragg pivot point on both AODs will aid this process.