IM0623

Acousto-Optic Modulator / Deflector Driver

Including: Basic D600 / D1199 / D1435 Alignment

Instruction Manual

RNx-4060-2-90

RNxBR-4060-2-90 with Brass Heatsink

Models –

Digital Modulation
RN2-4060-2-90 : 40/60MHz, 100W output, dual frequency, phase controlled.
RN2BR-4060-2-90

Analog Modulation
RN3-4060-2-90 : 40/60MHz, 100W output, dual frequency, phase controlled.
RN3BR-4060-2-90

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1. GENERAL

The RNx(BR)-4060-2-90 series are class-A RF drivers compatible with D600 / D1199 / D1435 series of Isomet high power Germanium Acousto-Optic modulator/deflectors, delivering up to 180Watts power at 40 / 60 MHz. These drivers feature phase shifting between the two RF output channels. Phase shifting is the basis of the acoustic beam-steering technique used in Isomet wideband AO deflectors and ensures optimum efficiency at across the bandwidth of the deflector.

The driver accepts a modulating input signal and provides a double-sideband amplitude modulated RF outputs to the acousto-optic device. A second input selects the carrier (centre) frequency.
A summary of the driver specification is shown in the following table:

Model	Application	Center Frequency	Total Output Power
RN2-4060-2-	Dual spot Modulator. Digital Modulation.	40MHz and 60MHz. Generates 2 active 1st orders. (Not simultaneously)	> 180.0 Watt
RN3-4060-2-	Dual spot Modulator with proportional analog modulation		

Figure 2 is a conceptual block diagram of the driver. The two center frequencies are determined by free-running quartz-crystal oscillators. The frequency is accurate and stable to within ± 25ppm. The oscillators are not temperature stabilized.

High-frequency, diode ring mixers are used to amplitude-modulate the RF carriers. Single turn potentiometers provide gain control for adjusting the maximum RF power for both outputs of the driver. One pot for each frequency.

A delay unit generates the correct phase control between the outputs depending on the selected spot frequency (i.e. 40 or 60 MHz). MMIC pre-amplifier stages isolate the modulation and phase control circuitry from the power amplifier stages.

The two power amplifier stages function in parallel and are designed to operate at full rated power into a 50Ω load with 100% duty cycle.

There are two control inputs,

- **Fsel:** Frequency select for switching the RF output frequency.
  TTL compatible 5V logic.
  Note: This input is internally pulled low.
  - TTL low level (< 0.8V) will select 60MHz.
  - TTL high level (>2.7V) will select 40MHz.

- **MOD**: Amplitude Modulation input.

This input controls both RF outputs simultaneously and there are two options depending on the driver model:

RN2-4060-2-, Digital Modulation (Dmod), TTL equivalent ON:OFF control.

An input swing of > 2.7V volt (positive with respect to ground) will drive the RF On.

An input voltage of less than 0.8V will drive the RF Off.

RN3-4060-2-, Analog Modulation (Amod), proportional control of RF amplitude.

The response is pseudo linear.

An input of <0.4V will give minimum RF (OFF).

An input voltage of 10V will give maximum RF output.

The RF switching rise and fall time at full power is approx. 400nsec / 100nsec.

The maximum RF output at each frequency is set by the power adjust potentiometers PWR ADJ1 (40MHz) and PWR ADJ2 (60MHz)

NOTE : Maximum RF power = fully clockwise

The digital input levels must not exceed 7 volts

The analog input levels must not exceed 15 volts

Water cooling is mandatory. The heatsink temperature must not exceed 70°C.

SERIOUS DAMAGE TO THE AMPLIFIER MAY RESULT IF THE TEMPERATURE EXCEEDS 70°C. SERIOUS DAMAGE TO THE AMPLIFIER MAY ALSO RESULT IF THE RF OUTPUT CONNECTOR IS OPERATED OPEN-CIRCUITED OR SHORT-CIRCUITED.

A low impedance DC power supply is required. The operating voltage is +24V or +28Vdc at a current drain of approximately 16A. The external power source should be regulated to ± 2% and the power supply ripple voltage should be less than 200mV for best results. Higher RF output power is achieved at 28Vdc.

2.0 MODULATION

The RF POWER ADJUST control sets the peak driver output for the fully ON condition.

RN2-4060-2-, modulation full ON = logic High

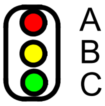
RN3-4060-2-, modulation full ON = 10V

Figure 3 illustrate the modulation waveforms.

2.1 LED INDICATORS

The front panel LEDs serve to indicate a number of possible operating states.

The LEDs [A] illuminates when the DC power is applied, and the Interlocks are valid.



- [A] shows RED when the (thermal) Interlocks are enabled.
- [B] shows YELLOW when outputs are active.
- [C] shows GREEN when the RF power amplifiers are enabled.

Normal operating condition = all LEDS are ON

LEDs Off

The LED [A] will not illuminate if:

i. the internal driver thermal interlock switch is open (Over Temperature Fault)

ii. the AOM thermal interlock switch is open (Over Temperature Fault)

iii. the AOM thermal interlock is not connected to the driver interlock input.

iv. the DC supply is off.

The LED [B] may not illuminate or run dim if:

i. zero or no modulation signal.

ii. low modulation duty cycle.

iii. the DC supply is off.

The LED [C] may not illuminate if:

i. the <u>optional</u> Gate input is set logic high, disabling the amplifier.

ii. LED [A] is off.

iii. the DC supply is off.

iv. high reflected RF power (High Reflected Power fault).

2.2 Resetting over temperature fault (OTF)

The thermal interlocks will reset once the AO device and / or RF driver are cooled below the switching temperature.

- The driver thermal switch over-temperature trip point is 50deg C
- The AOM thermal switch over-temperature trip point is 32deg C

The trip-to-reset hysteresis of the thermal switches is 7-10deg C.
Once in the fault state, the heatsink temperature will need to be reduced to ~22deg C to reset the thermal switches.

See **AN1710** Resetting the AO Thermal Interlock (https://isomet.com/appnotes.html)

2.3 Resetting high reflected power (HRP) fault.

Ensure the RF outputs are terminated correctly, and the RF cables are undamaged.
To reset the fault,

- cycle DC power to the RF driver.
  or
- momentarily connect pin 3 to pin 11.

If the fault persists then there may be a fault with the AO device.

3 INSTALLATION AND ADJUSTMENT

Connect cooling water to the driver. Minimum flow rate of 1 litre/minute at <25 degC.
For optimum AO performance ensure the flow rate is more than 2 litres/minute at <20 degC

Refer to Figure 1. Use of a Corrosion inhibitor is strongly advised.

Connect cooling water to the AO device.

Due to the high RF power dissipated in the AO modulator, it is paramount that the device is operated only when water cooling is circulating.

3.1 Connect +24V (or +28V) DC power to the screw terminals as marked. A 20A supply is recommended. DO NOT APPLY POWER.

3.2 Align the deflector head to ensure that the incident light beam is centred in the active aperture of the deflector.

3.3 Connect the (2) RF output BNC jacks to the (2) SMA RF inputs of the acousto-optic deflector (or a 50-ohm RF load, if it is desired to measure the modulator RF output power). **The order of connection is important. This depends on the Bragg orientation. Figure 4 illustrates the options.**

The deflector will not be damaged if the order is incorrect but the amplifier outputs must be terminated. If the RF cable connections are incorrect, it will not be possible to achieve high efficiency at both frequencies / spot positions.

The cable lengths from the amplifier to the two RF connections of the deflector must be equal.

3.4 Connect the Interlock of the acousto-optic device (Binder 719 3-pin snap connector) to the enable inputs on the Interlock connector on the RNx-4060-2-90. Connect pin 1 to pin 1 and pin 2 to pin 2. (See Figure 5)

If the temperature of the modulator exceeds 32ºC or the internal driver temperature exceeds 50ºC, then the interlock connection becomes open circuit, disabling the RF output. LED indicators illuminate when the Interlocks are closed and the RF is enabled. In addition, an voltage free signals are provided on the D-type connector for remote monitoring purposes.

3.5 Adjustment of the RF output power is best done with driver connected to the acousto-optic device. The driver maximum output power is factory preset to approx 70W per output (140W total).

The optimum RF power level required for the modulator to produce maximum first order intensity will be different at various laser wavelengths and/or frequencies. Applying RF power in excess of this optimum level will cause a decrease in first order intensity (a false indication of insufficient RF power) and makes accurate Bragg alignment difficult. It is therefore recommended that initial alignment be performed at a relatively low RF power level.

3.6 Locate the two PWR ADJ access holes on the driver end plate.

3.7 If uncertain of the RF power adjustment, start at a moderate power level.

Using an insulated alignment tool or screwdriver, rotate both PWR ADJ1 (40MHz) and PWR ADJ2 (60MHz) potentiometers fully anti-clockwise (CCW) i.e. OFF, then increase clockwise (CW) approx. 1/2 turn.

3.8 Apply DC to the driver.

3.9 **RN2-4060 series,** digital modulation:

Apply a TTL high (or 5V) constant modulation signal to the modulation input.

Connect the modulation signal to pin 7 of 'D' type and signal return (0V) to pin 14.

RN3-4060 series, analog modulation:

Apply 10V constant modulation signal to the modulation input on the 15way D-type connector.

Connect the modulation signal to pin 7 of 'D' type and signal return (0V) to pin 14.

3.10 Select a spot frequency.

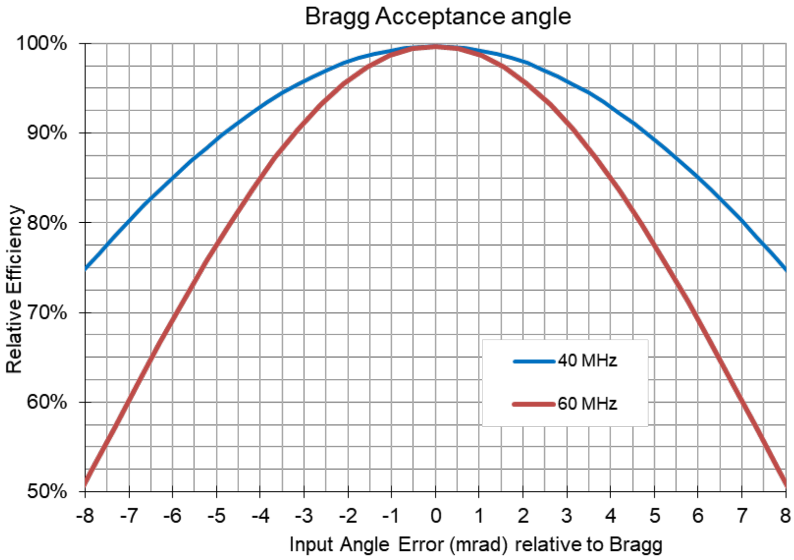
Connect the Freq Select signal to pin 8 of 'D' type and signal return (0V) to pin 15.

-
- For the 40MHz diffracted spot, apply a constant TTL high level (or 5V)
- For 60MHz output, apply a TTL low level (or leave unconnected).

Bragg angle sensitivity increases with frequency, therefore it is recommended that the initial Bragg angle adjustment be made at 60MHz. See figure below.

This graph shows typical sensitivity to Bragg angle error.

This plot also gives an estimate of the DE reduction due to Input Beam Divergence or Convergence.



3.11 Alignment (Also refer to Appendix A)

Input the laser beam toward the centre of either aperture of the AO device. Ensure the polarization is horizontal with respect to the base and the beam height does not exceed the active aperture height of the AO device.

Start with the laser beam normal to the input optical face and very slowly rotate the AO device. Direction is related to the RF connection order. See Figures 4 & 5 for possible configurations.

3.12 Observe the diffracted first-order output from the acousto-optic modulator and the undeflected zeroth order beam. Adjust the Bragg angle (rotate the modulator) to maximise first order beam intensity.

3.13 After Bragg angle has been optimized for 60MHz (Freq Select signal = Low), slowly increase the RF power. Rotate PWR ADJ2 for 60MHz until the maximum first order intensity is obtained.

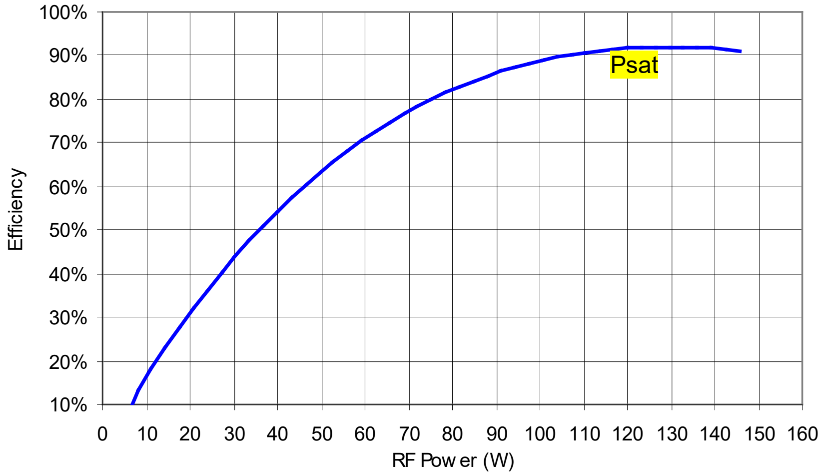
3.14 Change the selected Frequency to 40MHz (Freq Select signal = High).
Increase the RF power for this frequency. Rotate PWR ADJ1 for 40MHz until the maximum first order intensity is obtained at this spot.

To equalise deflection efficiency, alternate between the two frequencies and carefully re-adjust Bragg angle and RF powers to give the same efficiency for both. (Note: the optical power meter may require repositioning for the two beam angles.)

3.15 RF power considerations

Refer to the fundamental Efficiency vs. RF power characteristic below

Typical response



The optimum RF drive power for maximum diffraction efficiency is given by ‘Psat’ (e.g. at 120W). This scales with active aperture height and the wavelength^2

Due to the sin^2 response, a ~20% reduction in RF power from the absolute maximum at Psat, results in a ~5% reduction in efficiency. This small sacrifice should be considered to reduce thermal dissipation and minimize undesirable thermal lensing effects.

PLEASE NOTE

3.16 If high efficiency cannot be achieved at both frequencies, it is probable that the RF connections to the AO device are incorrect. In this case the phase delayed output of the RNx-4060-2 is connected to the incorrect input of the AO deflector. See Fig 4 for guidance.

Turn off the DC power to the driver and swap over cable connections to the RF output BNC’s. Repeat the above alignment procedure.

3.17 The driver and deflector are now ready for use.

4. MAINTENANCE

4.1 Cleaning

It is of utmost importance that the optical apertures of the deflector optical head be kept clean and free of contamination. When the device is not in use, the apertures may be protected by a covering of masking tape. When in use, frequently clean the apertures with a pressurized jet of filtered, dry air.

It will probably be necessary in time to wipe the coated window surfaces of atmospherically deposited films. Although the coatings are hard and durable, care must be taken to avoid gouging of the surface and residues. It is suggested that the coatings be wiped with a soft ball of brushed (short fibres removed) cotton, slightly moistened with clean alcohol. Before the alcohol has had time to dry on the surface, wipe again with dry cotton in a smooth, continuous stroke. Examine the surface for residue and, if necessary, repeat the cleaning.

4.2 Troubleshooting

No troubleshooting procedures are proposed other than a check of alignment and operating procedure. If difficulties arise, take note of the symptoms and contact the manufacturer.

4.3 Repairs

In the event of deflector malfunction, discontinue operation and immediately contact the manufacturer or his representative. Due to the high sensitive of tuning procedures and the possible damage which may result, no user repairs are allowed. Evidence that an attempt has been made to open the optical head will void the manufacturer's warranty.

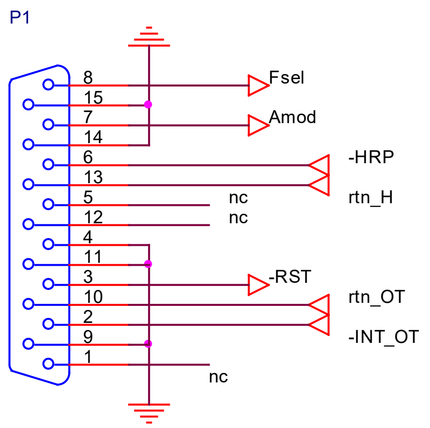
5.0 Connection Summary

5.1 15-way male 'D' Type Control Connection

Signal	Type	Pin out connection
Fsel: Frequency Select, TTL. High = 40MHz, Low = 60MHz	Input	Signal pin 8 Return pin 15
RN2-4060- **Dmod**: Digital Modulation TTL * < 0.8V(off), >2.7V(on)	Input	Signal pin 7 Return pin 14
(or)		
RN3-4060- **Amod:** Analog Modulation. < 0.4V(off), 10.0V(full on)	Input	Signal pin 7 Return pin 14
-INT_OTF: Over Temperature Fault monitor. Open Drain logic, Low = OK **Maximum applied voltage** **(via external pull up resistor) = 5.5V** **Maximum current = 10mA**	Output	Signal pin 2 Return pin 10
-HRP: High reflected power fault monitor. Open Drain logic, Low = OK **Maximum applied voltage** **(via external pull up resistor) = 5.5V** **Maximum current = 10mA**	Output	Signal pin 6 Return pin 13
-RST: Reset high reflected power fault. Internal pull up to 5V via 22Kohm . Momentarily contact to 0V-return to initiate a reset	Input	Signal pin 3 Return pin 11

DO NOT connect:
Pins 1,5,12

Spare 0V (Gnd)
Pins 4,9

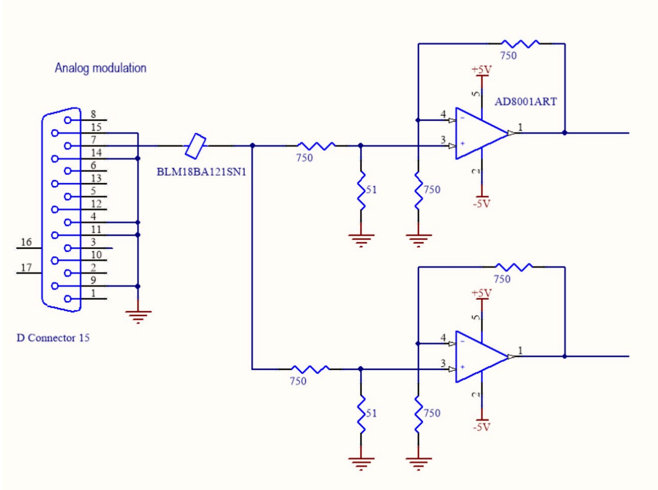


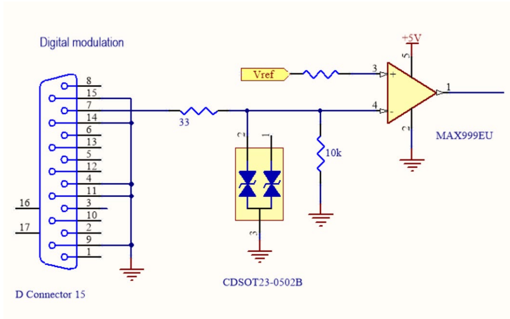
Notes:

A modulation input signal (pin 7) needs to be applied.
The interlock signal must be connected. Contacts closed for normal operation.

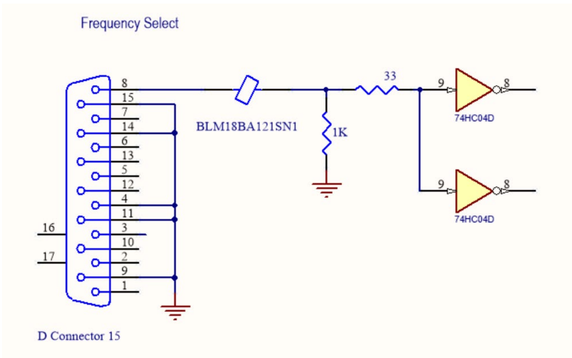
5.2 Interface details

Analog Modulation (Amod) **(or)** **Digital Modulation** (Dmod)

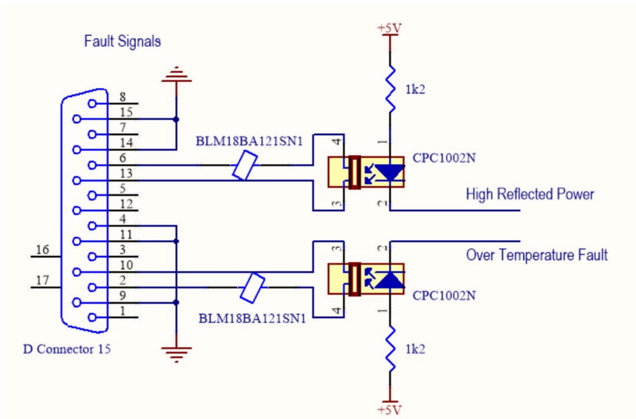




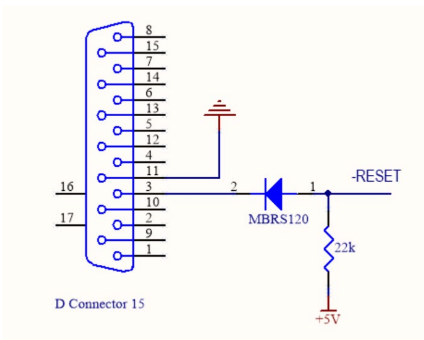
Frequency Select Input, TTL
(Fsel)



Fault outputs
Solid state relay



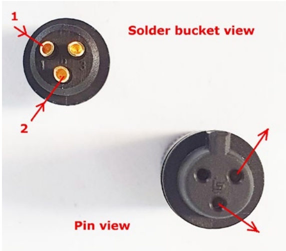
HRP reset



5.3 Interlock Connection (normally closed contact)

Binder 719 connector pin assignment
Isolated thermostatic switch in AO.

Cable Connector Binder719 – 3way		Driver Binder719 – 3way
Pin1	to	Pin1
Pin2	to	Pin2



Binder 719 3-way cable connector (supplied)

5.4 DC Power Connection

Screw Terminals as illustrated below.

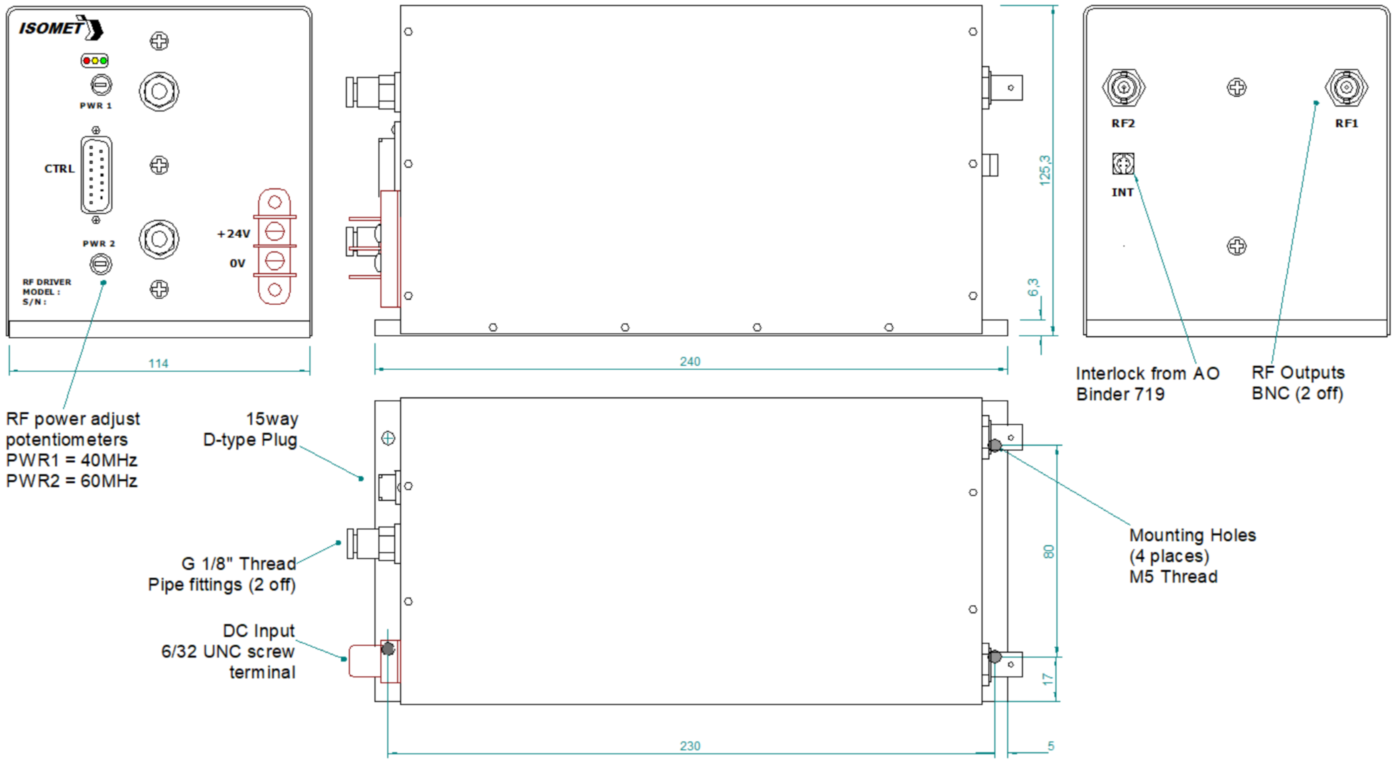


Figure 1: Driver Outline

5.5 RF Power Adjustment: Single turn potentiometers.

- PWR ADJ1 sets the 40MHz RF maximum power.
- PWR ADJ2 sets the 60MHz RF maximum power.

5.6 Mounting

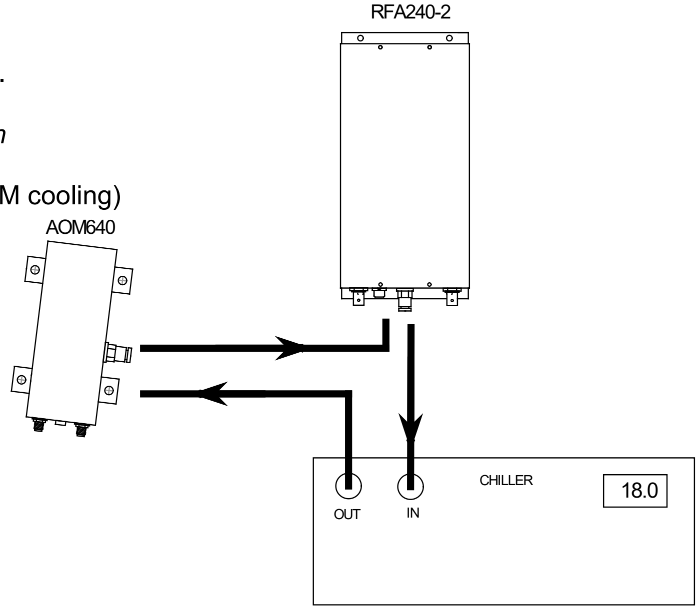
Mounting Holes: 4 x M5
Centres spacing: 220mm x 80mm

5.7 Coolant connection

Recommended coolant flow path.

Chillier out > AO > Driver > return

(see appendix B for dual port AOM cooling)



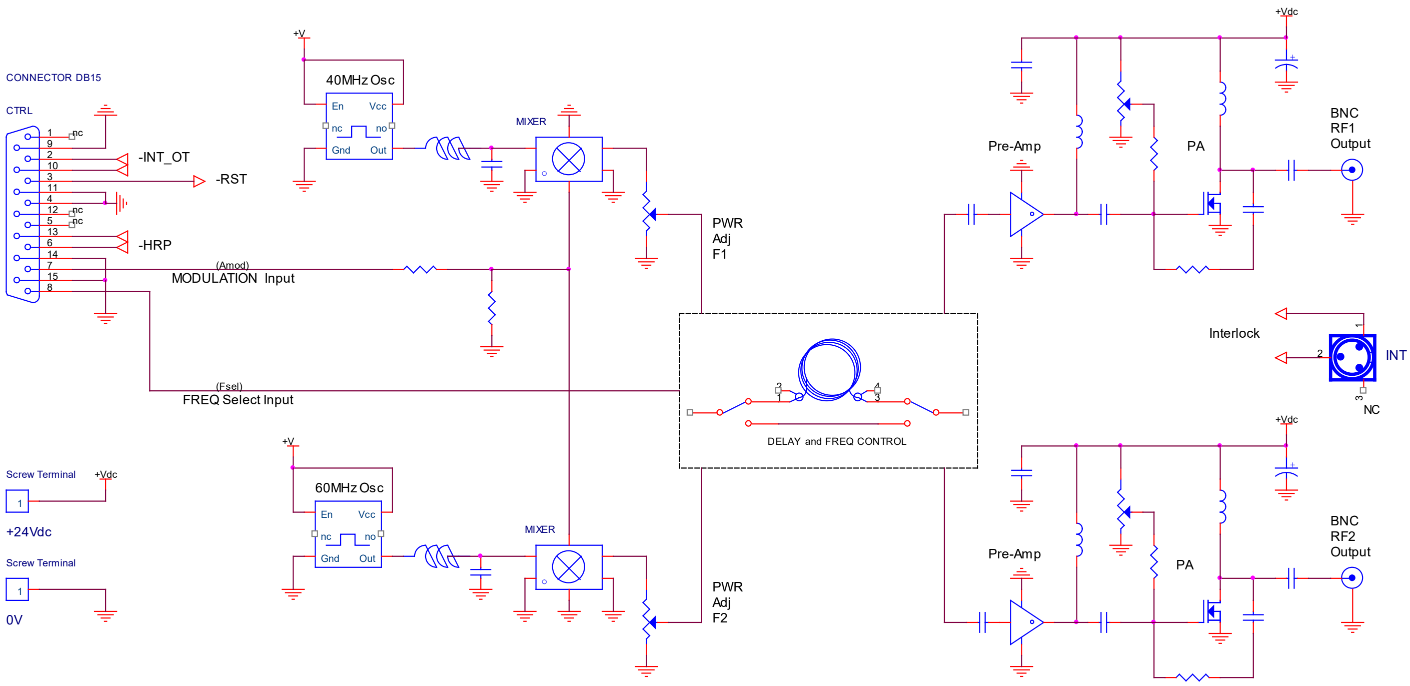
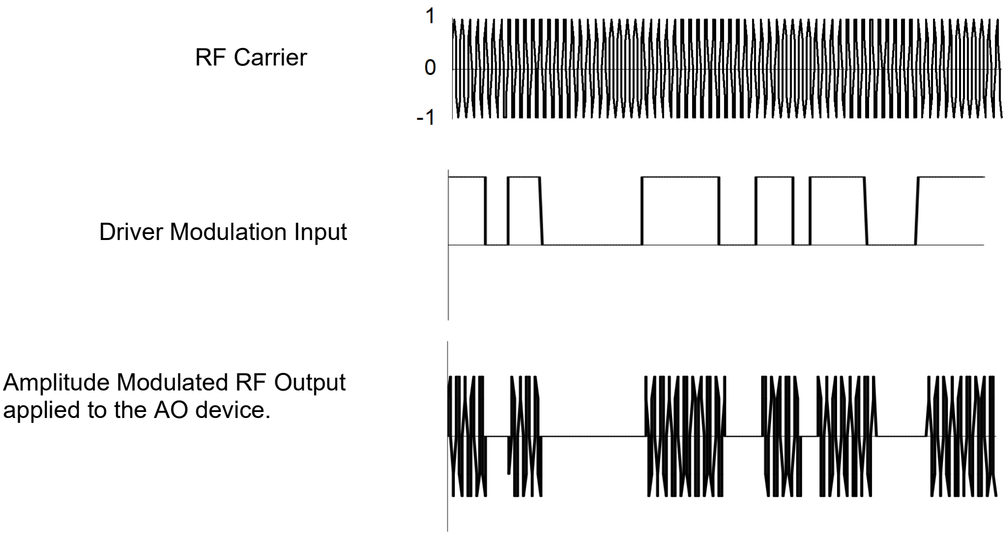


Figure 2: Conceptual Block Diagram

RN2-models: Typical digital modulation RF waveforms.



RN3-models: Typical analog modulation RF waveforms.

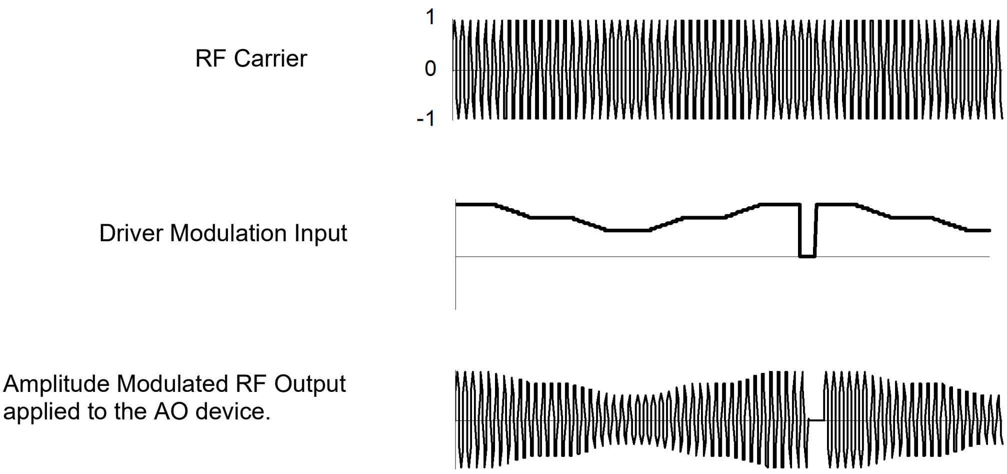
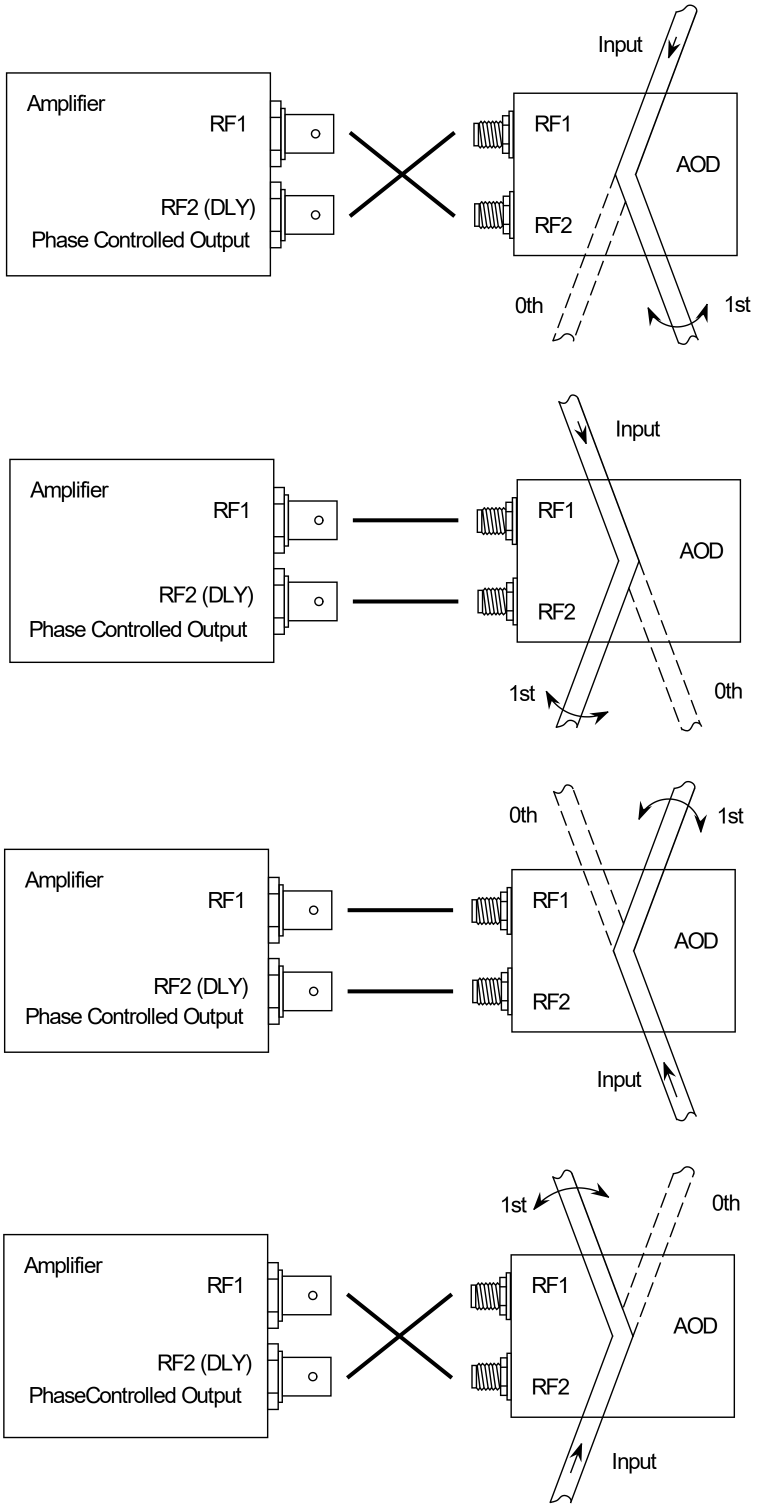


Figure 3: Typical Modulation Waveforms

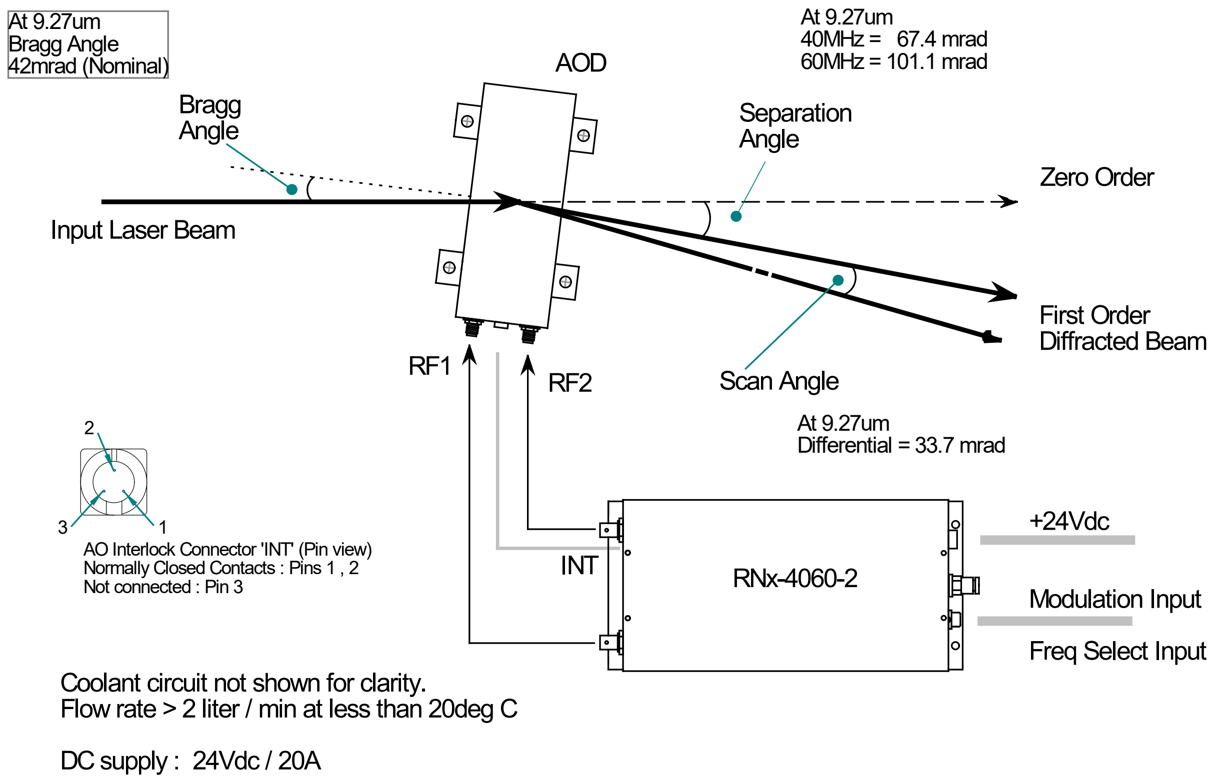
Connection options for Beam Steered AO Deflectors



Correct orientation as viewed from top of AOD

(Connector type and identification may differ)

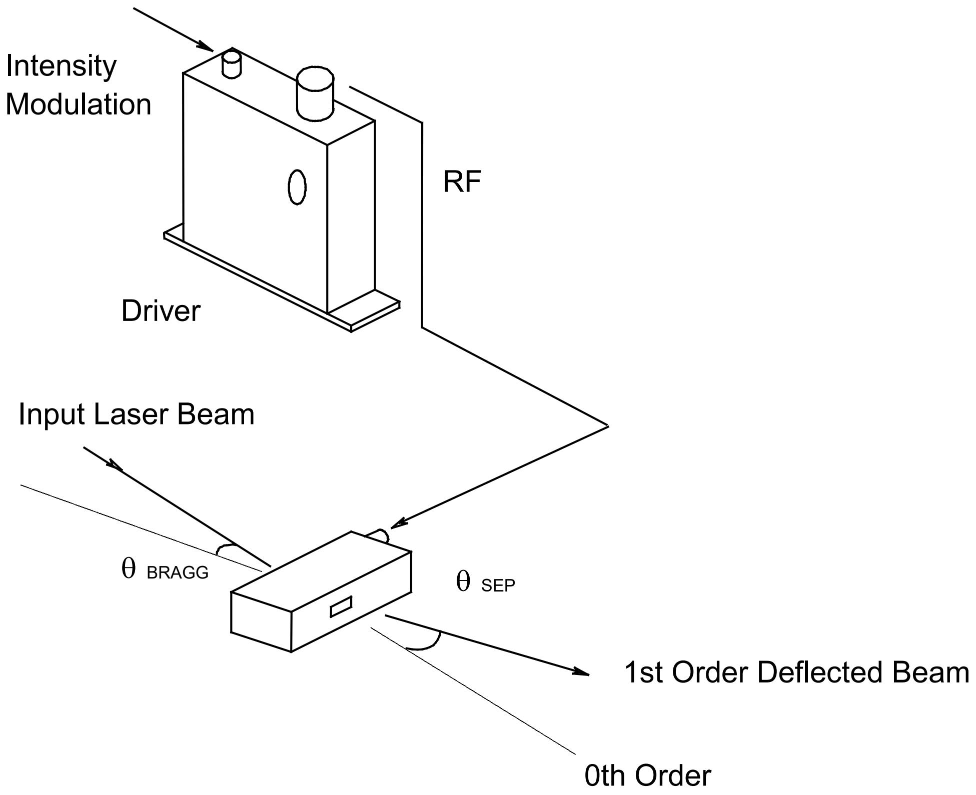
Figure 4: Connection orientations (J1 = RF1, J2 = RF2)



See Figure 4 for alternate beam orientations.

Figure 5: Typical Connection Configuration.

Basic AO Modulator Parameters



The input Bragg angle, relative to a normal to the optical surface and in the plane of deflection is:

$$\theta_{BRAGG} = \frac{\lambda . fc}{2.v}$$

The separation angle between the Zeroth order and the First order is:

$$\theta_{SEP} = \frac{\lambda . fc}{v}$$

Optical rise time for a Gaussian input beam is approximately:

$$t_r = \frac{0.65.d}{v}$$

where: λ = wavelength
fc = centre frequency = 40MHz / 60MHz
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)

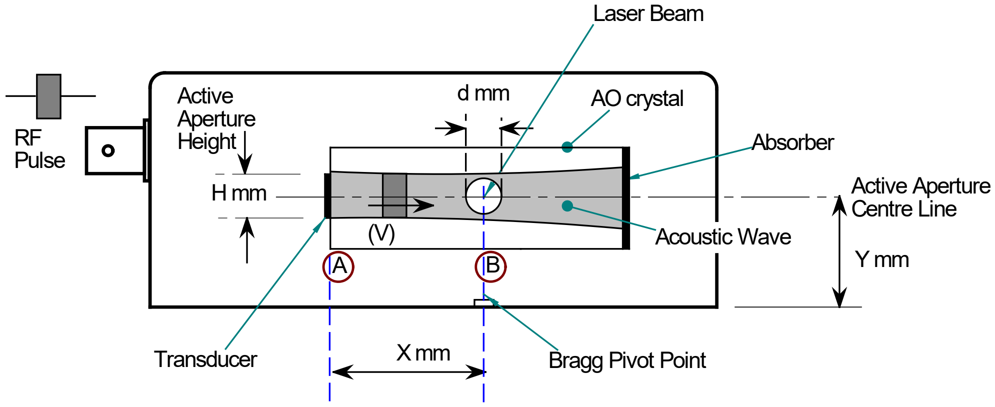
d = $1/e^2$ beam diameter

Figure 6. Modulation System

Appendix A: Beam Position

Timing Considerations for AO Devices in Pulsed Lasers Applications

When attempting to synchronize a pulsed laser beam with a pulsed RF acoustic wave in an AO device, the designer must consider the transit time of the acoustic wave from the transducer to the laser beam position. This is called the *Pedestal delay*.



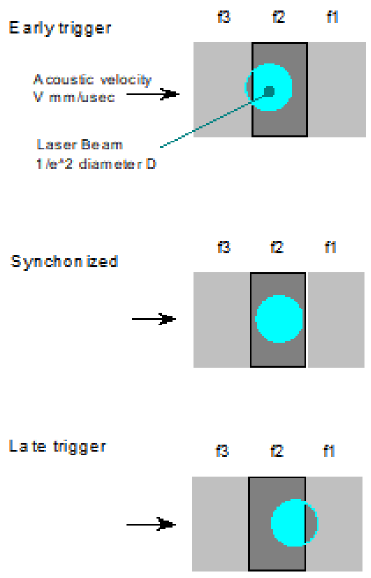
Input Beam Location

Vertical axis: Place the laser beam at the centre of the active aperture at Y mm above the base.
Horizontal (Diffraction) axis: Place beam above the Bragg pivot point.

Timing considerations with respect to the RF modulation signal

An acousto-optic device is characterized by a travelling acoustic wave. This wave is launched from the RF excited transducer and travels at velocity V across the laser beam and into the absorber.
It is important to consider this transit period when synchronizing a pulsed laser output with a pulsed AOM/AOD driver signal.

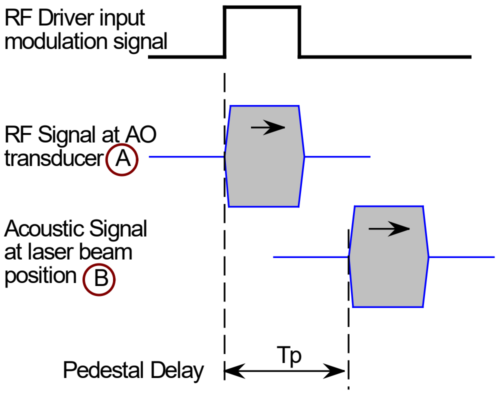
Early/later refers to the laser trigger timing relative to the RF driver modulation signal



Pedestal delay

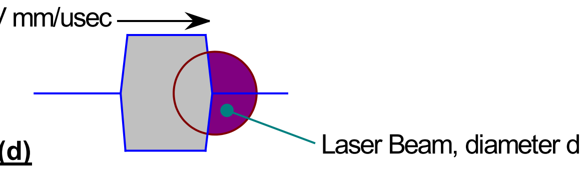
The time taken for the acoustic wavefront to reach the laser beam centre [2].

$$Tp = \frac{\text{beam position from transducer (X)}}{\text{acoustic velocity (V)}}$$



Transit time

The time taken for the acoustic wavefront to cross the entire laser beam diameter.



where: $$Tt = \frac{\text{beam diameter (d)}}{\text{acoustic velocity (V)}}$$

This equates to the minimum RF pulse width.

Optical rise / fall switching time

For a Gaussian beam is approximately **Tr = 0.65 x Tt**

Total Sync Time

This represents the total delay time between the electronic modulation signal and the corresponding acoustic signal at the laser beam centred over the Bragg Pivot Point. This is given by:

Tst = Pedestal delay + ½ pulse width duration

The minimum RF pulse width duration will depend on the beam diameter. See 'Transit Time'
In the limiting case, pulse width duration = transit time.

Laser sync output

Please be aware, there may be an additional delay between the laser input trigger signal and the laser output pulse. This delay should also be considered when synchronizing.

Appendix B

D600 / D1199 / DBM enhanced coolant flow

Flow rate enhancement using T-piece