Acousto-Optic Modulator Driver

Including: Basic Modulator Alignment

Instruction Manual

RA2(z)-ff-1-nn Series, Digital modulation only
RA3(z)-ff-1-nn Series, Analog modulation only
RA5(z)-ff-1-nn Series, Dual modulation

Replacement models for the RFA2x1/RFA4x1 series

Models -

ff = 40 :	Fc = 40MHz
ff = 50 :	Fc = 50MHz
ff = 60 :	Fc = 60MHz
ff = 70 :	Fc = 70MHz
ff = 80 :	Fc = 80MHz

nn = maximum RF power (Watts) at 24Vdc

Options z:

- BR	: Brass Heatsink.
- L	: active low gate (no connection = RF disabled)
- Y	: 0-1V analog modulation range
- V	: 0-5V analog modulation range

ISOMET CORP, 10342 Battleview Parkway, Manassas, VA 20109, USA.
Tel: (703) 321 8301, Fax: (703) 321 8546, e-mail: isomet@isomet.com
www.ISOMET.com
ISOMET (UK) Ltd, 18 Llantarnam Park, Cwmbran, Torfaen, NP44 3AX, UK.
Tel: +44 1633-872721, Fax: +44 1633 874678, e-mail: sales-uk@isomet.com

1. GENERAL

The RA5 series combined Analog Driver and Power Amplifier is a fixed frequency RF power source specifically designed to operate with Isomet acousto-optic devices such as the M1208, M1346 and M1396. The driver accepts two independent modulating signals and provides a double-sideband amplitude modulated RF output to the acousto-optic modulator. Example driver specifications are shown in the following table:

Model	Center Frequency	Output Power	Option
RA5BR-40-1-70	40MHz	> 70.0 Watt	Brass Heatsink
RA3-40-1-90	40MHz	> 90.0 Watt	Analog mod'n only
RA5BR-50-1-60	50MHz	> 60.0 Watt	Brass Heatsink
RA5BR-60-1-60	60MHz	> 60.0 Watt	Brass Heatsink
RA2-80-1-60	80MHz	> 50.0 Watt	Digital mod'n only

Figure 2 is a functional block diagram of the driver. The center frequency of the driver is determined by the free-running quartz-crystal oscillator. This frequency and stability are accurate to within ± 25ppm. The oscillator is not temperature stabilized.

A high-frequency, diode ring mixer is used to apply analog amplitude modulation (A-mod).
A solid-state RF switch provides high-speed digital modulation (D-mod).

A MMIC r-f pre-amplifier stage isolates the low-level modulation and control circuitry from the power amplifier stage. A 12-turn potentiometer provides gain control for adjusting the peak RF power level when the modulation input is at maximum.

The rise and fall times for the amplifier from either the modulation inputs is near identical. Please refer to Table 1

The analog input level must not exceed 15 volts
The digital inputs must not exceed 7 volts

This amplifier is designed to operate at full rated power into a 50Ω load with 100% duty cycle.

Water cooling is mandatory. The case temperature must not exceed 50°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 supply is required. The operating voltage is +24V (+28Vdc MAX) at a current drain of approximately 5A-7A. Please refer to the model data sheet. The external power supply should be regulated to ± 2% and the power supply ripple voltage should be less than 200mV for best results. Increased RF output power is achieved at 28Vdc.

The output power level is set by the power adjust potentiometer (PWR ADJ)
At the pot mechanical end stops, the wiper idles.
NOTE : Maximum power = fully clockwise

1.1 AO MODULATION OVERVIEW

To intensity modulate a laser beam in an acousto-optic modulator requires that the input RF carrier voltage (power) be varied according to the video or baseband information. From the viewpoint of intensity modulation, the diffraction efficiency equation is normalized as:

$$i_1 = \mathrm{Sin}^2 (kE_{RF})$$

where i_1 is the instantaneous intensity in the first order diffracted beam and E_{RF} is the instantaneous RF envelop voltage across the AO transducer.

In effect, the acousto-optic interaction demodulates the RF carrier, transforming the modulation envelop (baseband signal) into intensity variation of the first order diffracted laser beam.

Figure 7 shows the key modulator parameters.

2 LED INDICATORS

The LEDs illuminate when the DC power is applied, and the Interlocks are valid.



- [A] Shows RED when DC power is on:

- [B] shows YELLOW when -GATE is active,
  and RF average output power is ~20% of maximum.

- [C] shows GREEN when the (thermal) Interlocks are valid
  and no fault condition

Caution, the RF output may be live even if these LEDs are not illuminated.

LED Fault Conditions

The LEDs [C] will not illuminate if:

a) the internal driver thermal interlock switch is open (over temperature fault).
b) the AO thermal interlock switch is open (over temperature fault).
c) the AO thermal interlock is not connected to the driver interlock input.
d) the DC supply is off.

Standard over-temperature trip points

- RF driver: 50deg C
- AO device: 32deg C (Germanium) or 40degC (Quartz, Fused Silica).

The thermal interlocks will reset once the AO device and / or RF driver are cooled below the trip temperature. The hysteresis of the thermal switches is 7-10deg C. Once in a fault state, the coolant temperature may need to be reduced below the normal operating point to reset the thermal switches.

See AN0725 Resetting the AO Thermal Interlock (https://isomet.com/appnotes.html)

3. INSTALLATION AND ADJUSTMENT

3.1 Connect cooling water to the driver AND the AO device (e.g. M1208, M1396, M1346). Use of a corrosion inhibitor is strongly advised.
Due to the high RF power dissipated in the AO modulators, it is paramount that the device is operated only when water cooling is circulating.
For optimum AO performance ensure the flow rate is more than 1 litre/minute at < 20 deg.C.

3.2 Connect the +24V (or +28V) and 0V DC supply to the feed-thru screw terminals as marked. See figure 1. (See page 9). DO NOT turn on DC supply until step 3.10

3.3 Connect the RF output BNC jack to the acousto-optic modulator (or a high power 50Ω RF load, if it is desired to measure the modulator RF output power).

3.4 Connect the Interlock of the acousto-optic modulator (SMA, SMC or 'Binder719' 3pin snap connector) to the 'Binder719' 3pin snap 'INT' on the rear panel of the RA5. See page 8.

3.5 The interlock connection becomes open circuit disabling the RF output if the temperature exceeds the trip point. The trip point depends on the modulator type*: Germanium 32ºC, Quartz 40degC, or if the internal driver temperature exceeds 50ºC. An LED indicator illuminates when the Interlocks are good (closed) and the RF is enabled (see Section 2). In addition, a CMOS 'interlock valid' signal output is provided on pin 1 of the D-type connector for remote monitoring purposes.

3.6 Adjustment of the RF output power is best done with amplifier connected to the acousto-optic modulator. The amplifier output power is pre-set to approximately half maximum. (Refer to the test data sheet).

The optimum RF power level required for the modulator to produce maximum first order intensity will be different at various laser wavelengths. 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 make accurate Bragg alignment difficult. It is therefore recommended that initial alignment be performed at a low RF power level.

3.6 Locate the PWR ADJ access on the driver front panel.

3.7 With an insulated alignment tool or screwdriver rotate the PWR ADJ potentiometer fully anti-clockwise (CCW) 12 turns , then clockwise (CW) approx' 6 turns.

3.8 RA3 and RA5, connect pin 8 to the analog modulation signal source and pin 9 to (0V) return.
Apply a constant ON modulation signal:

- Standard models, max ON level = 10V*.
- For RA2- option models, no connection required.

3.9 RA2 and RA5, connect pin 6 to the digital modulation signal source and pin 7 to (0V) return.
Apply a constant 5V logic high level to the digital gate input.
Alternatively connect to a 5V DC supply if not actively used.

- For RA3- models, no connection required.

3.10 If a supplementary GATE signal is required:
Connect pin 4 to a digital modulation signal source and pin 7 to the (0V) return.
Apply a 5V logic high to DISABLE the amplifier.
Apply a 0V logic low level or leave unconnected* to ENABLE.

- For option -L models, apply a 0V logic low level to ENABLE.

The GATE response time is ~ 5usec

3.11 Apply DC power to the driver.

Input the laser beam toward the centre of either aperture of the AOM. Ensure the polarization is correct for the AO crystal type and the beam height does not exceed the active aperture height of the AOM. Refer to Figures 4,5,6, and appendix-A for beam alignment. Start with the laser beam normal to the input optical face of the AOM and very slowly rotate the AOM (either direction).

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, slowly increase the RF power (rotate PWR ADJ CW) until maximum first order intensity is obtained.

3.14 The driver is now ready for use. Figures 3 and 4 illustrate typical modulation characteristics.

* Standard values. Check specific model test data sheet.

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 leaving 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.

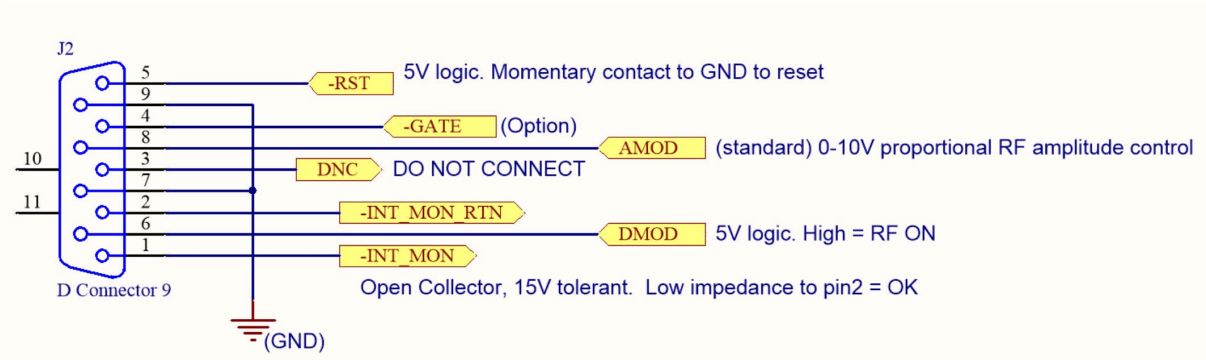
4.3 Repairs

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.

Connection Summary: **9-way D-type**

Description Model	Variant	Signal	Type	Signal Pin	Return Pin	Level	Action
GATE (Optional)	All	5V Logic	Input	4	7 or 9	>2.5V	OFF
						<0.8V or NC	ON
	Option -L	*5V Logic*	*Input*	*4*	*7 or 9*	*>2.5V or NC*	*OFF*
						<0.8V	*ON*
MODULATION INPUTS	Standard **RA5-**	Analog, proportional	Input	8	9	10V	Fully ON
		Digital, 5V logic	Input	6	7	>2.5V	ON
	RA3-	Analog, proportional	Input	*8*	9	5V	Fully ON
			NC	*6*			
	RA2-	Digital, 5V logic	Input	*6*	7	>2.5V	ON
			NC	*8*			
-RST (Reset)	All	5V Logic	Input	5	7 or 9	Closed contact	Reset
						Open / NC	Normal
INT-Monitor	All	Open collector	Output	1	2	< 1V	OK
						open	Fault

NC = Not Connected SEE NOTES NEXT PAGE, connections shown below:

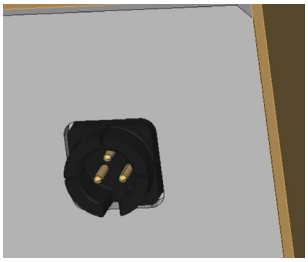


INTERLOCK CONNECTION
Isolated thermostatic switch in AO.

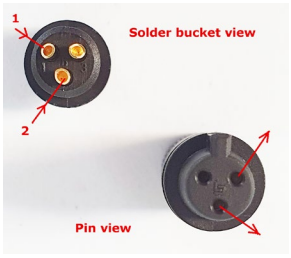
Binder 719 connector pin assignment.

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

Male socket (AO / Driver)



Female cable plug



Cable or Binder 719 3-way connector is supplied

Notes:

- **For RA5 models, both Digital and Analog Modulation signals need to be applied.**
- The interlock signal must be connected. Contacts closed for normal operation.
- **GATE signal is optional. IF used, this has a response time of ~5usec**

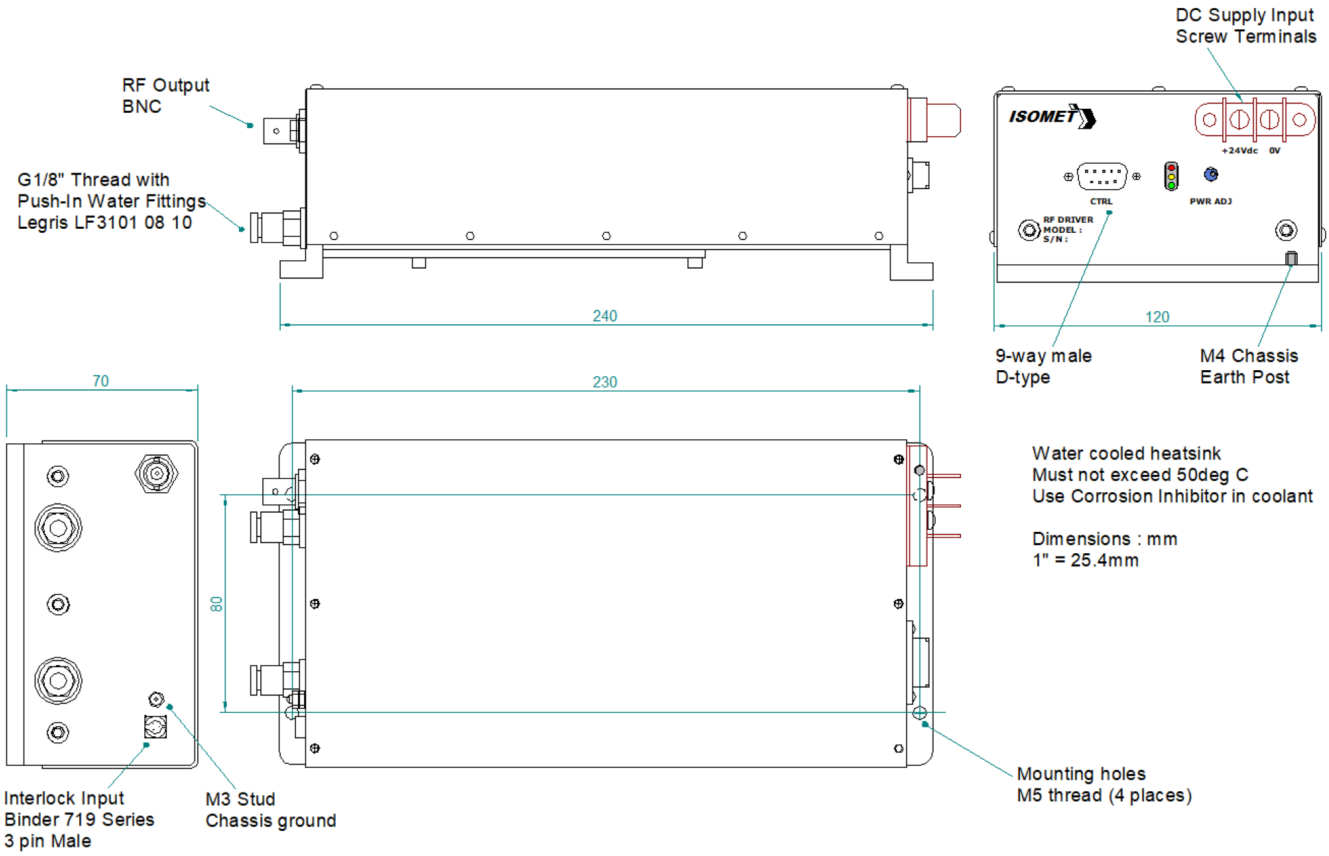


Figure 1: Driver Installation, mounting holes: 4 x M5

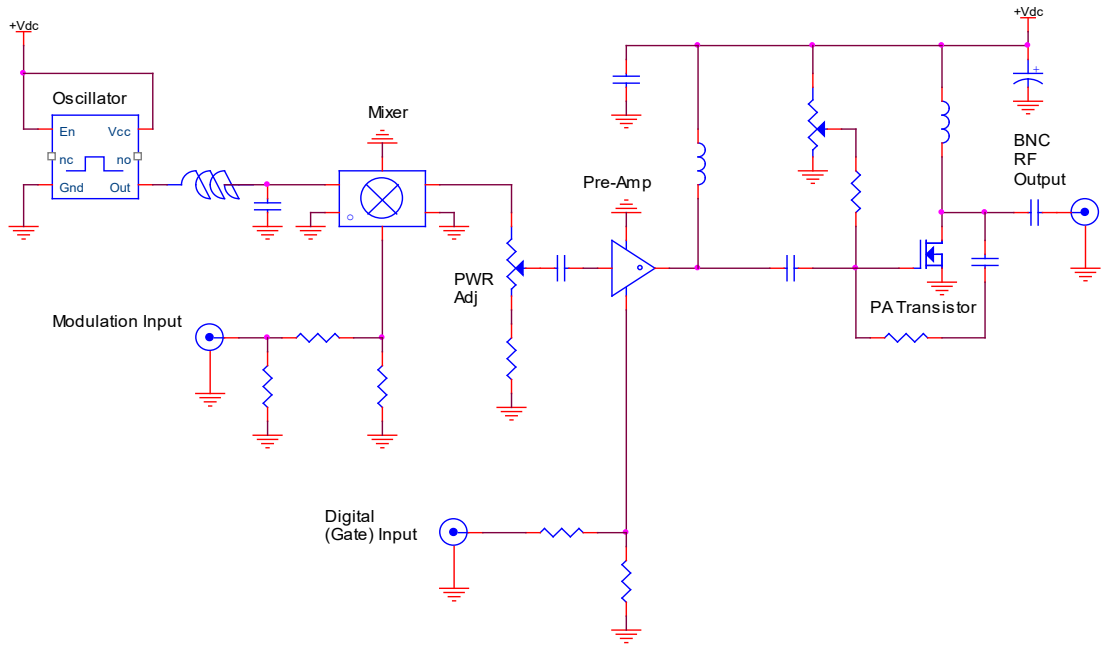


Figure 2: Driver Block Diagram

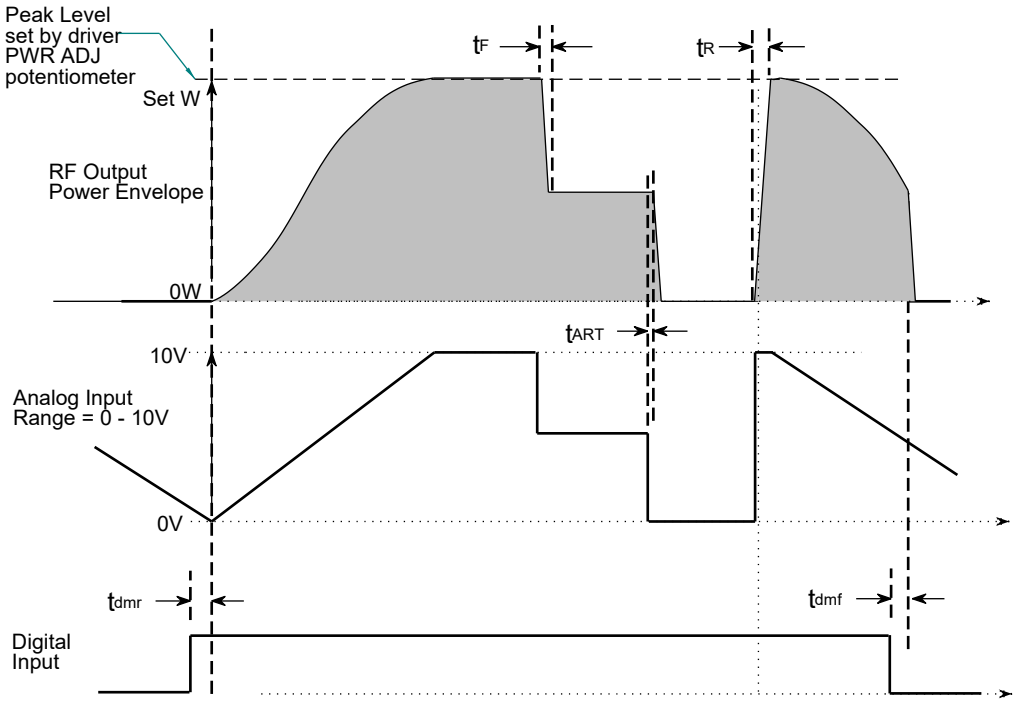


Figure 3: Typical RF Output Waveforms

For standard models, the RF output waveform is a combination of the Analog and Digital modulation inputs as illustrated above.

Description		Variant		
		Standard	-A	-D
t_R	RF rise time resulting from large signal modulation. (A-Mod or D-mod)	<250 ns	<250 ns	<250 ns
t_F	RF fall time resulting from large signal modulation. (A-Mod or D-mod)	<50 ns	<50 ns	<50 ns
t_{ART}	Latency delay between a change in modulation level (A-Mod) and RF output.	60 ns	60 ns	60 ns
t_{dmr}	Latency delay between a D-mod High input and RF output fully ON.	<50 ns	<50 ns	<50 ns
t_{dmf}	Latency delay between a D-mod Low input and RF output fully OFF.	<50 ns	<50 ns	<50 ns

Table 1: Timing spec's:

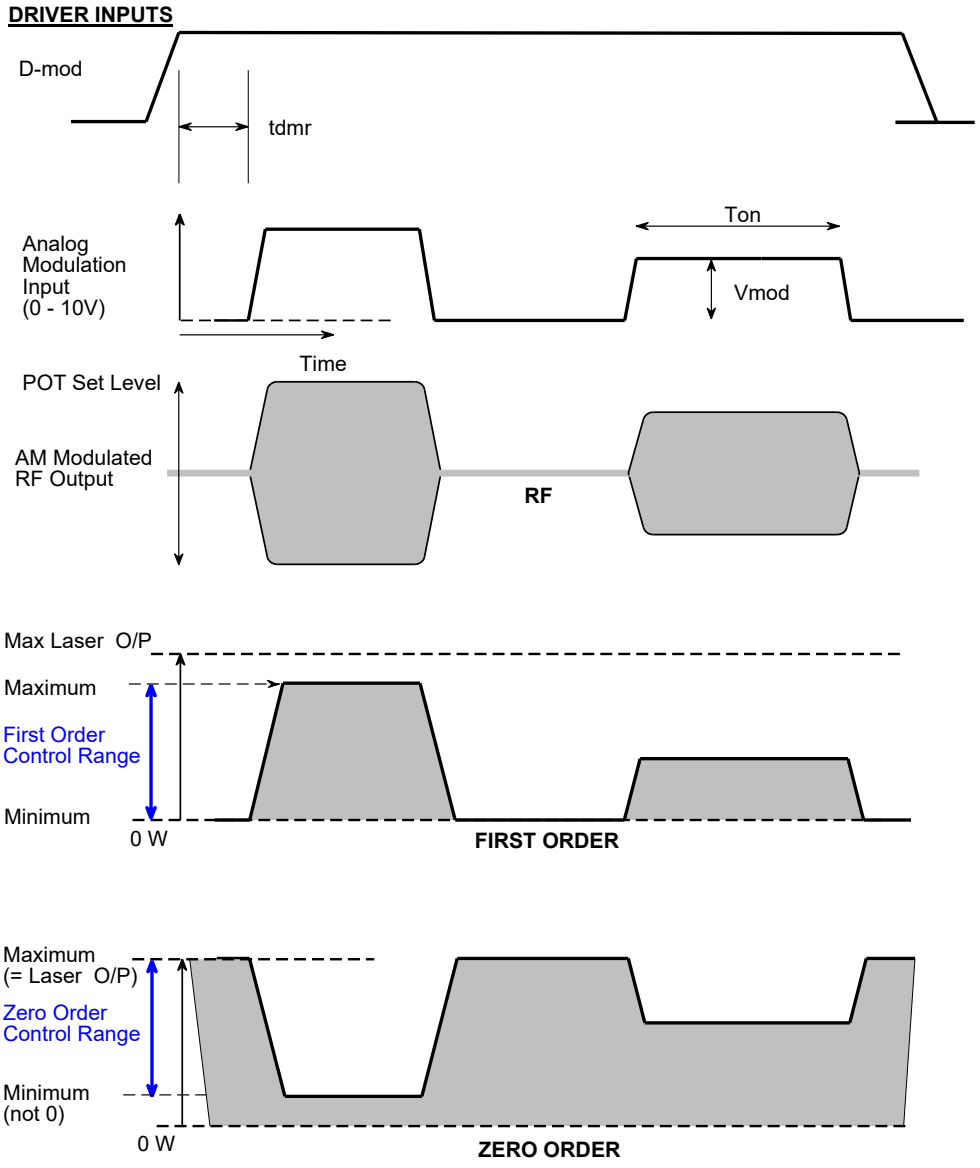


Figure 4: Illustration of Laser Beam Modulation and RF driver controls

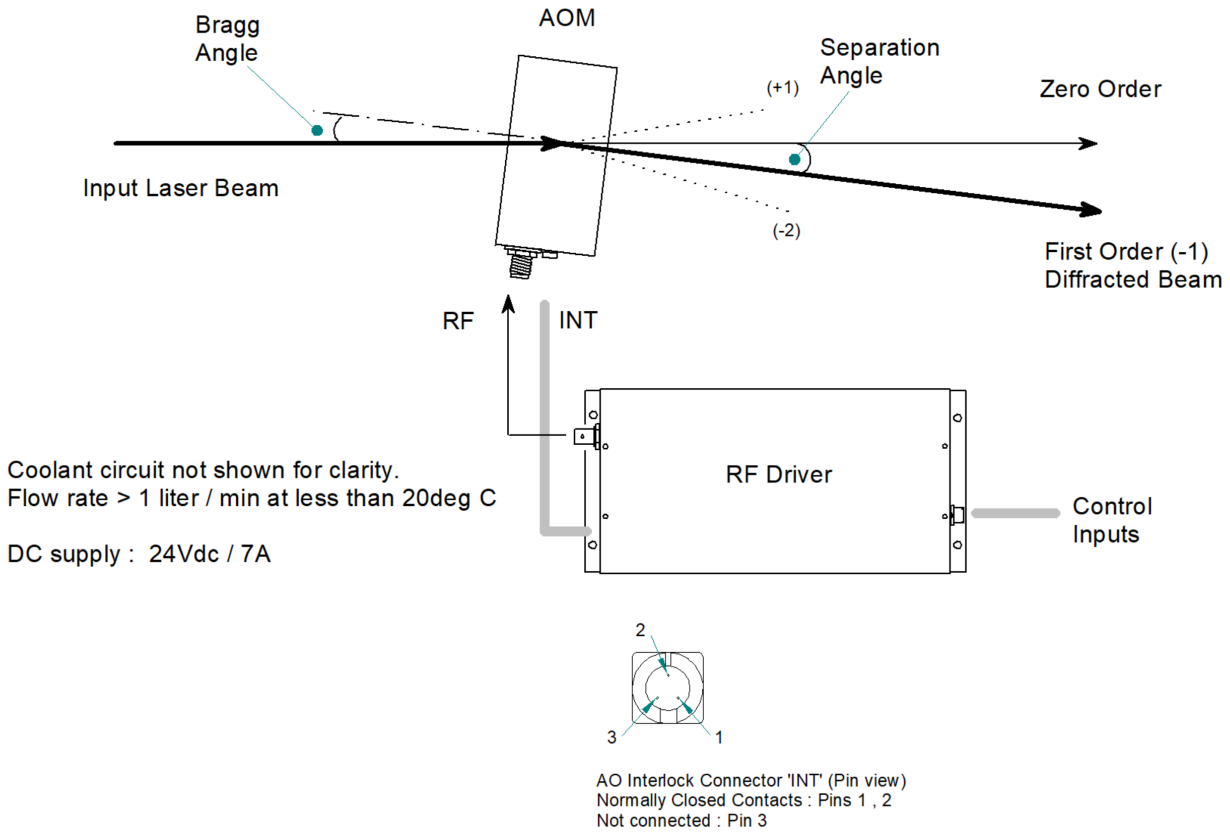


Figure 5: Typical Connection Configuration

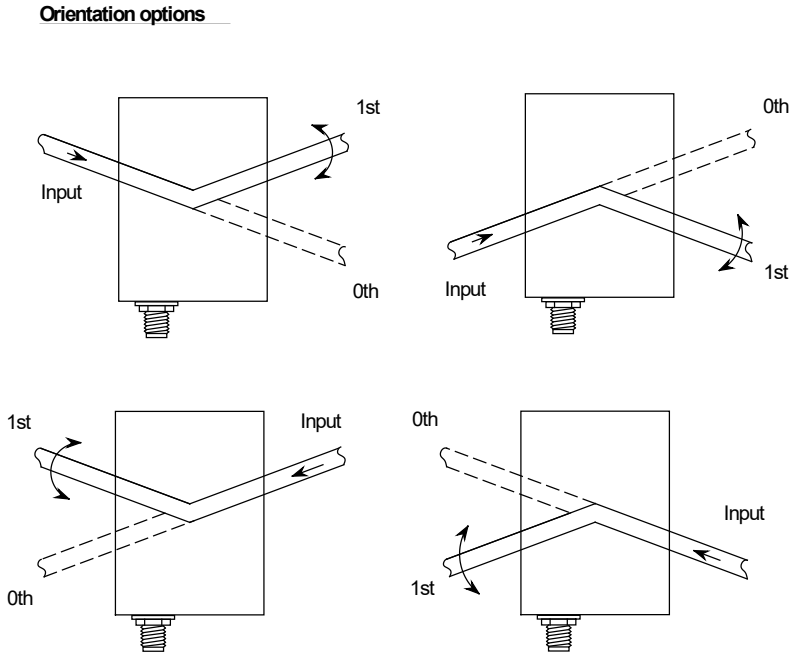
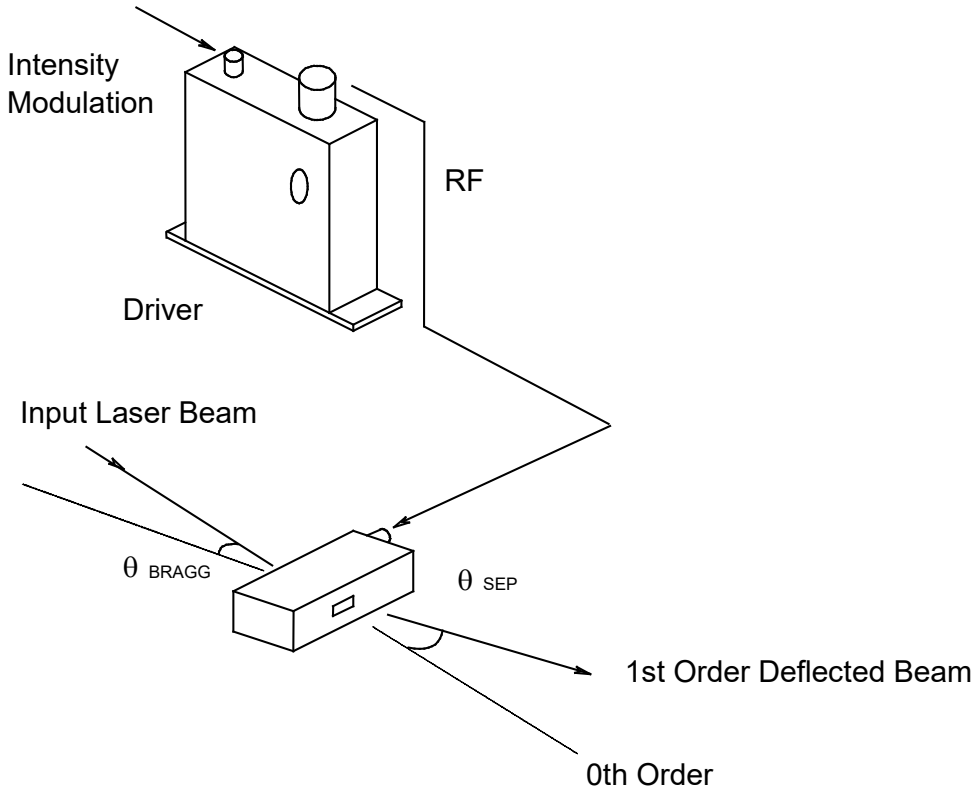


Figure 6: Possible Input Bragg Angle Orientations

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:

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

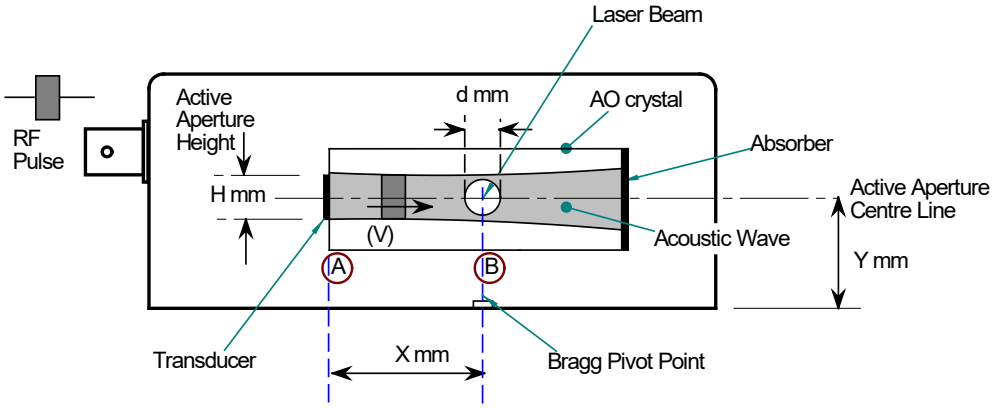
where: λ = wavelength
fc = centre frequency
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)
= 5.7mm/usec (Quartz)
= 5.96mm/usec (Fused Silica)
d = $1/e^2$ beam diameter

Figure 7. 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*.



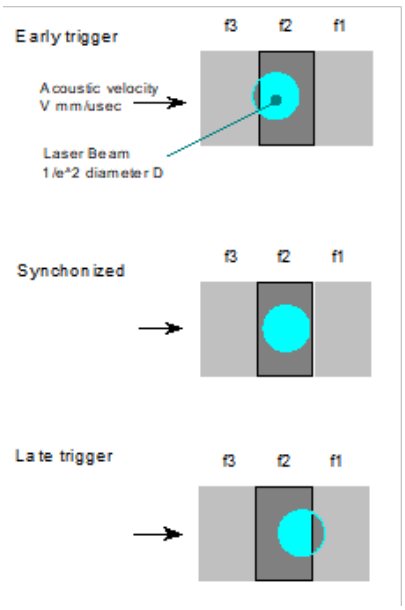
Input Beam Location

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.

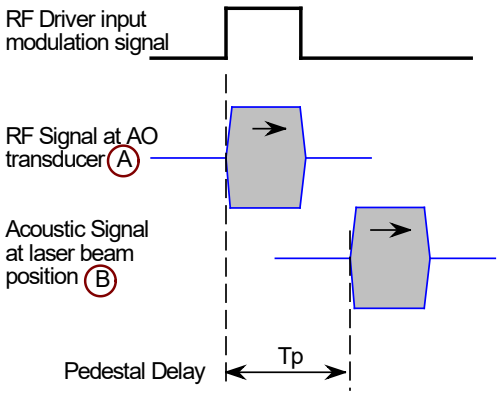
Early/later refers to the laser trigger timing relative to the RF driver modulation signal



Pedestal delay

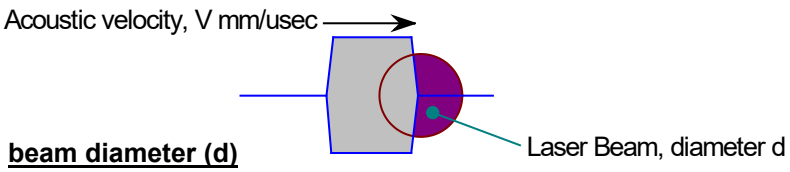
The time taken for the acoustic wavefront to reach the laser beam centre [2].

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



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.