Acousto-Optic Modulator Driver

Including: Basic Modulator Alignment

Instruction Manual

RFA2x1 / RFA4x1 Series

Models -

RFA2x1-z

x = 4 :	Fc = 40MHz
x = 5 :	Fc = 50MHz
x = 6 :	Fc = 60MHz
x = 7 :	Fc = 70MHz
x = 8 :	Fc = 80MHz

RFA4x1-z (higher power)

x = 4 :	Fc = 40MHz

Options -z:

- L	: active low gate (no connection = RF disabled)
- V	: 0-5V analog modulation range
- A	: analog modulation only. No gate signal
- D	: digital modulation only. No gate signal
- R	: coolant fittings on rear face

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1. GENERAL

The RFA2x1 is a 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. A summary of the driver specification is shown in the following table:

Model	Center Frequency	Output Power
RFA241	40MHz	> 70.0 Watt
RFA**4**41	40MHz	> 90.0 Watt
RFA251	50MHz	> 60.0 Watt
RFA261	60MHz	> 60.0 Watt
RFA281	80MHz	> 50.0 Watt

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 modulator is used to amplitude-modulate the RF carrier. The single turn potentiometer provides gain control for adjusting the maximum power.

A solid-state RF switch provides a high speed gate function. A TTL high level will gate the RF ON. The MMIC r-f pre-amplifier stage isolates the low level modulation and control circuitry from the power amplifier stage.

The rise and fall times for the amplifier from either modulation input is identical (approx 200nsec). See figure 3

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. The external power source 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)
NOTE : Maximum power = fully clockwise

1.1 ANALOG MODULATION

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 deflection 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 matched transducer.

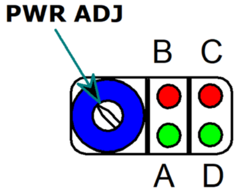
In effect, the acousto-optic interaction demodulates the RF carrier, transforming the modulation envelop (baseband signal) into intensity variation of the first order diffracted laser beam.

Figures 3 and 5 show the main AO modulator parameters

2 LED INDICATORS

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

The LEDs [C] and [D] illuminate when the DC power is applied, and the Interlocks are valid.



- [A] Shows GREEN when the RF output is live PROVIDED:
    a) the modulation duty cycle is more than 20% (approx).
    b) the RF CW power is > 20% (approx) of the driver maximum power

- [B] Not applicable – for future options

- [C] shows RED when the DC power is applied

- [D] shows GREEN when the (thermal) Interlocks are enabled

Caution, the RF output may be live even if these LED's are not illuminated.

LED Fault Conditions

The LEDs [C] and [D] 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).

The thermal interlocks will reset once the AO device and / or RF driver are cooled below the switching 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 AN1710 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.
Older versions may have a solder pin for +V and screw terminal for 0V. (See page 8).
DO NOT turn on DC supply until step 3.8.

3.3 Connect the RF output BNC jack to the acousto-optic modulator (or a 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 interlock inputs on the 9-pin D-type connector of the RFA. See page 8.
Connect pin 4 of ‘D’-type to INT+ and pin 5 to INT-

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.

3.5 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 makes 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 end plate.

3.7 With an insulated alignment tool or screwdriver rotate the PWR ADJ potentiometer fully anti-clockwise (CCW) , then clockwise (CW) approx 1/4 turn.

3.8 Apply DC to the amplifier.

3.9 Apply a 10.0V* constant modulation signal to the modulation inputs on the D-type connector of the RFA. Connect pin 8 of 'D' to the signal and pin 9 of 'D' to the signal return.
(Apply a constant TTL high level, if -D variant)

3.9.1 Apply a constant TTL high level to the digital gate input on the D-type connector.
Connect pin 6 of the 'D' to the signal and pin 7 of the 'D' to the signal return.
(Note required for -A or -D variants)

Input the laser beam toward the centre of either aperture of the AOM. Ensure the polarization is horizontal with respect to the base and the beam height does not exceed the active aperture height of the AOM. Refer to 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). See Figure 4 below for one possible configuration.

3.10 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.

3.11 After Bragg angle has been optimized, slowly increase the RF power (rotate PWR ADJ CW) until maximum first order intensity is obtained.

3.12 The driver is now ready for use for modulation using both the digital and the analog inputs.

* 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.

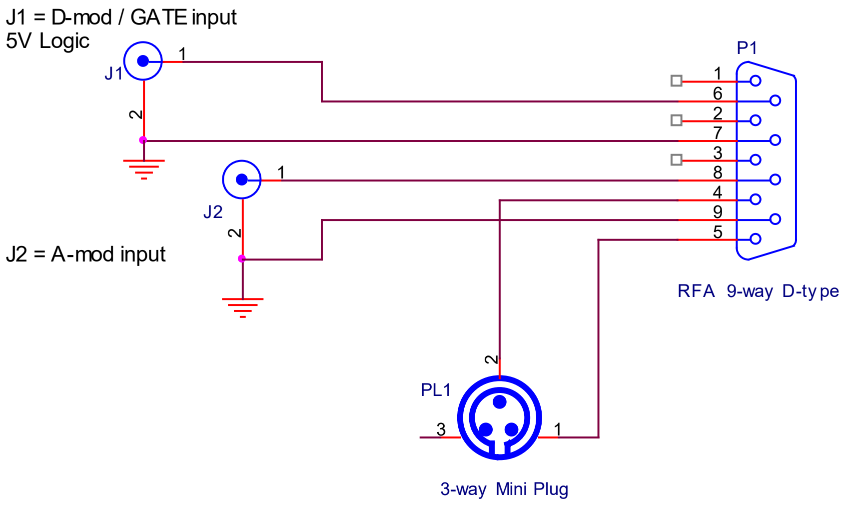
RFA 2x1 Standard Version

Connection Summary

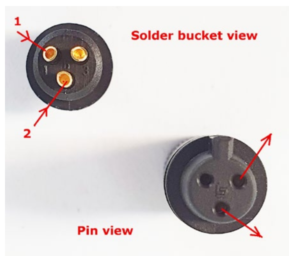
1.0 9 way 'D' Type Control Connections

Signal	**Type**	**Pin out connection**
GATE TTL high (>2.5V) = ON TTL low (<0.8V) or no connection = Off	Input	Signal pin 6, (Return pin 7)
Modulation	Input	Signal pin 8, (Return pin 9)
A-mod: Standard model or Option -A: **D-mod**: Option -D:	0.0V(off) to 10.0V(on) 5V logic high = ON	
Interlock Normally closed contact. (Connects to AO device 'INT')	Input	Signal pin 4, (Return pin 5)
Interlock Valid monitor (CMOS 15V logic, high = OK)	Output	Signal pin 1, (Return pin 2)

Minimum Connections shown below:



AO Thermal Interlock Cable
Connector, Pin View
(OK = connected contacts 1-2)



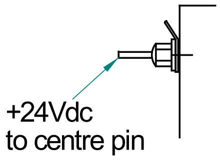
Binder 719 connector pin assignment
*Either pin is permitted

Cable Connector Binder719 – 3way		**Driver D-type 9way**
Pin1	to	Pin5 (or Pin4*)
Pin2	to	Pin4 (or Pin5*)

Binder 719 3-way cable connector (supplied)

Note:
Unless stated**, Both Digital GATE and Analog Modulation signals need to be applied.**
The interlock signal must be connected. Contacts closed for normal operation.

<u>Legacy design, DC supply connection</u>



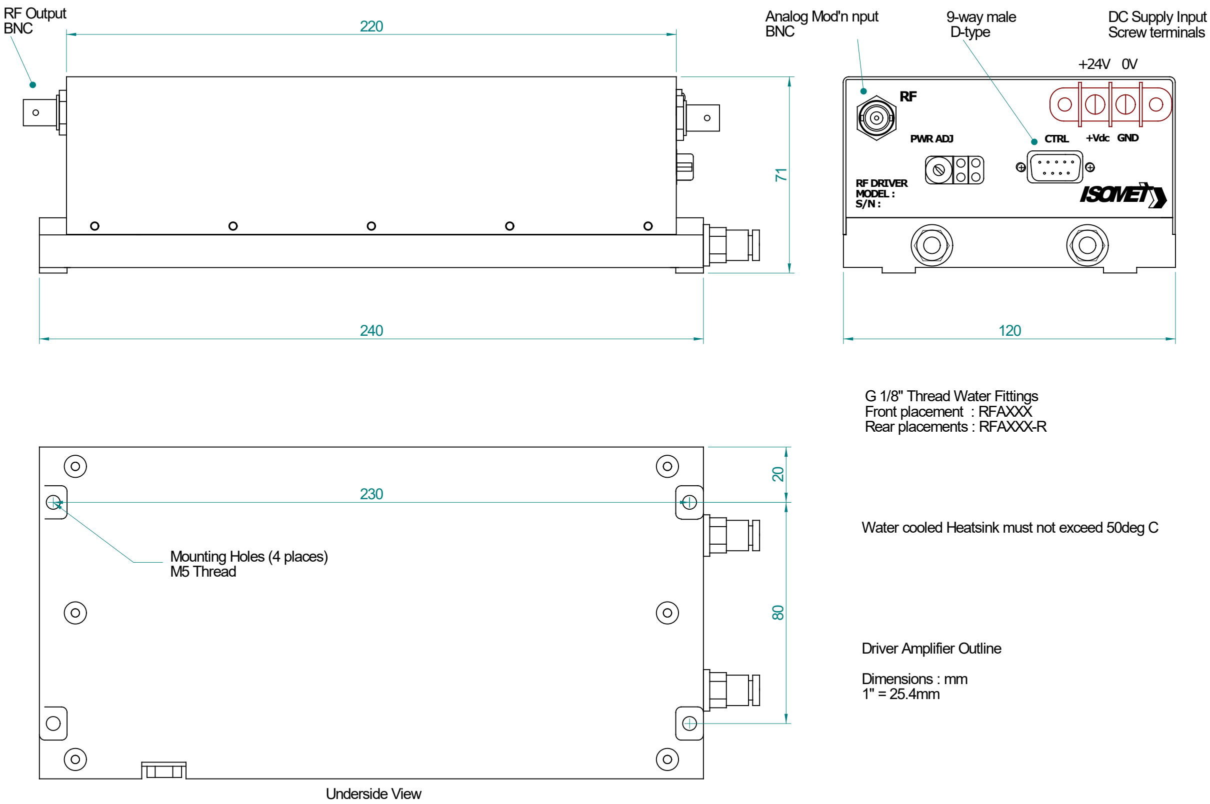


Figure 1:   Driver Installation, mounting holes: 4 x M5

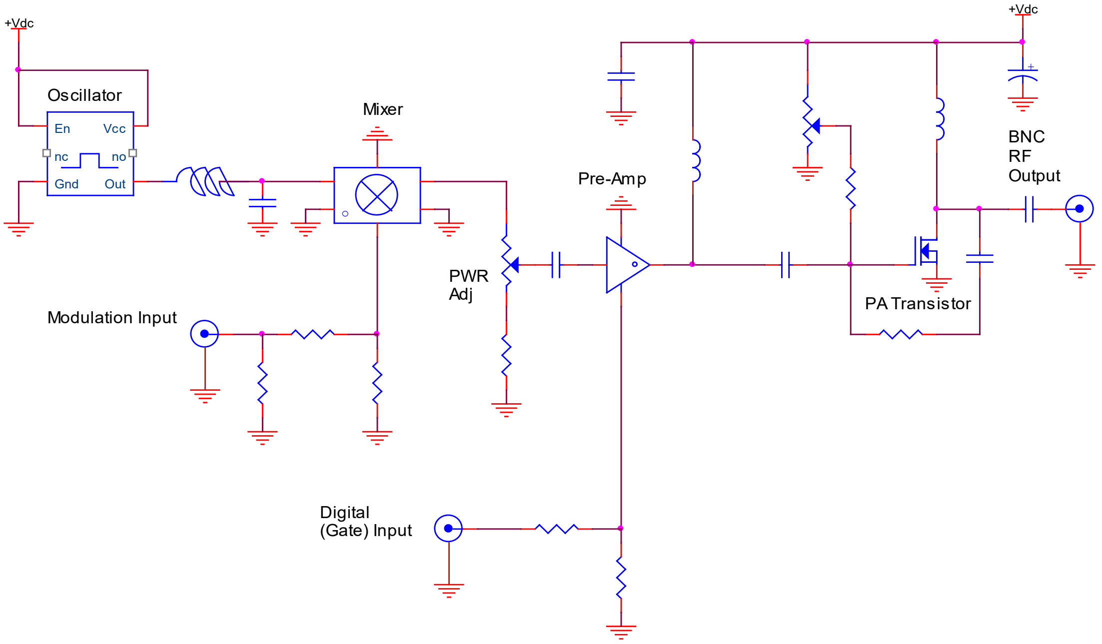
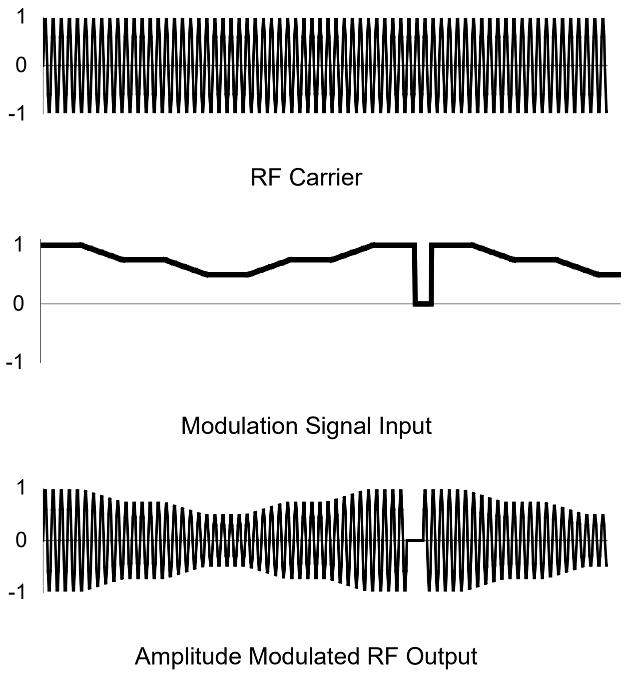


Figure 2: Driver Block Diagram



Typical analog modulation RF waveforms are shown above. D-Mod permanently ON

For the RFA2x1 and similar drivers, the modulation input is a combination of analog and digital controls as illustrated below.

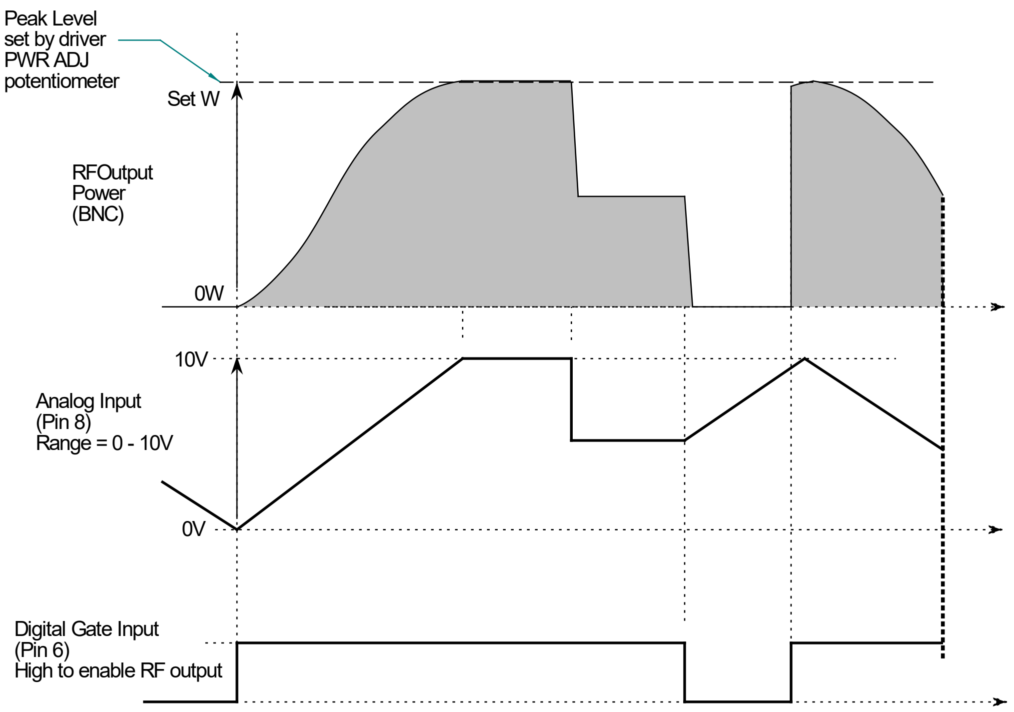


Figure 3: Typical Analog Modulation Waveforms

Timing spec's:

Ident	Description	Variant		
		Standard	**-A**	**-D**
t_R	RF rise time resulting from large signal modulation.	250 ns	250 ns	250 ns
t_F	RF fall time resulting from large signal modulation.	50 ns	50 ns	50 ns
t_{MD}	Latency delay between a change in modulation level (A-Mod or D-mod) and the RF output	60 ns	60 ns	60 ns
t_{GHD}	Latency delay between a Gate High input and RF output fully enabled	200 ns	NA	NA
t_{GLD}	Latency delay between a Gate Low input and RF output fully disabled	100 ns	NA	NA

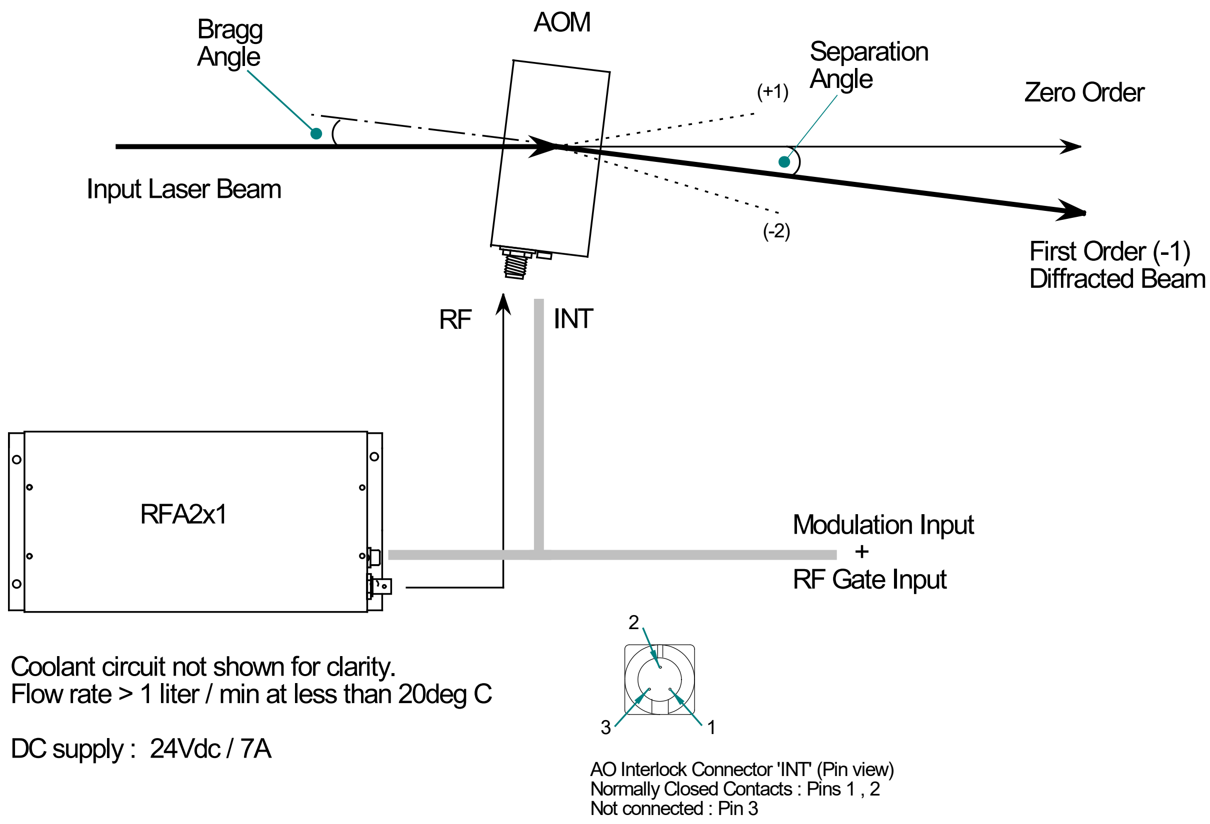
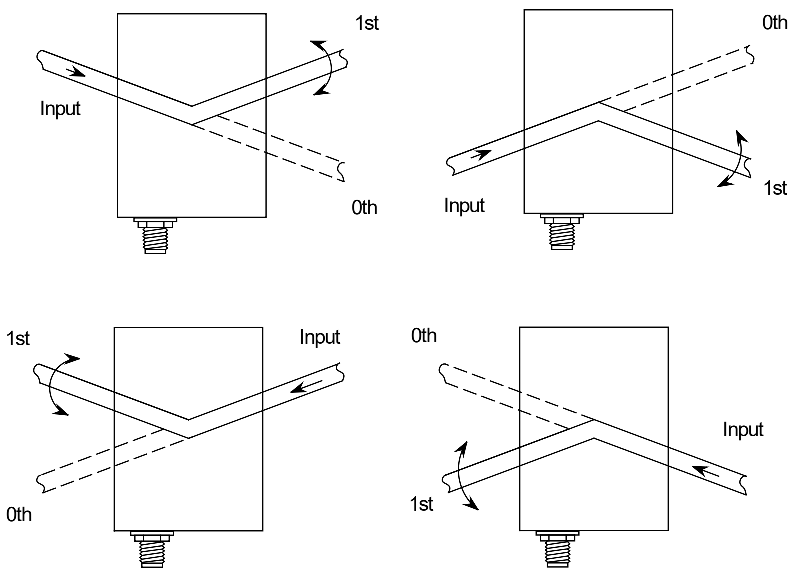


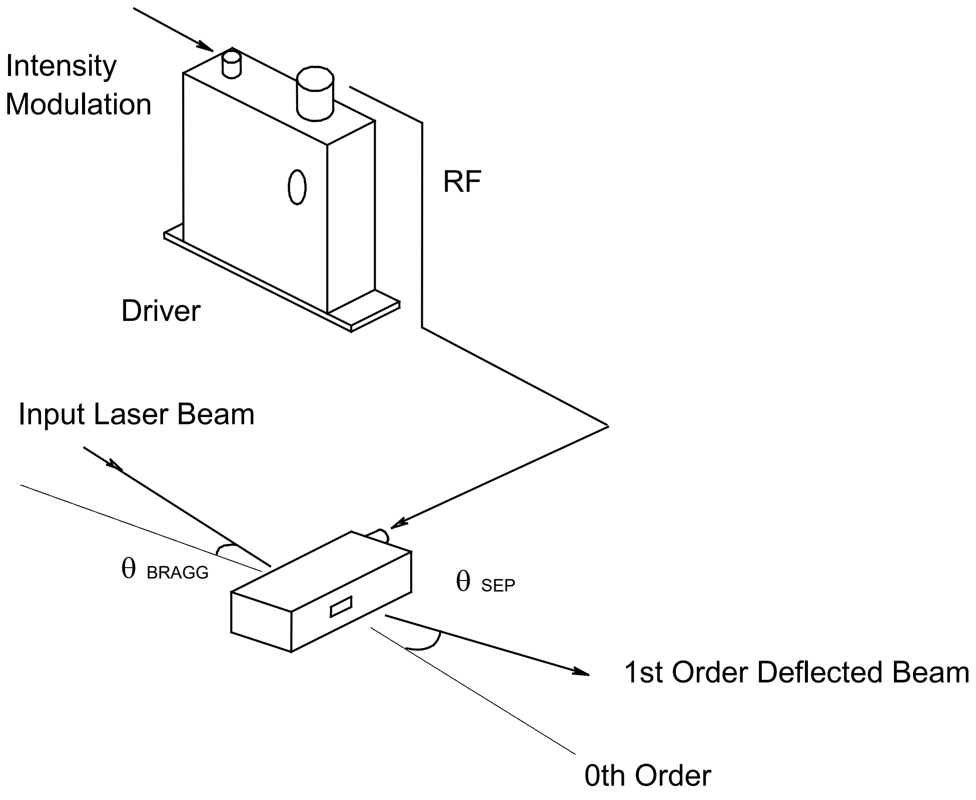
Figure 4: Typical Connection Configuration

Orientation options



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:

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

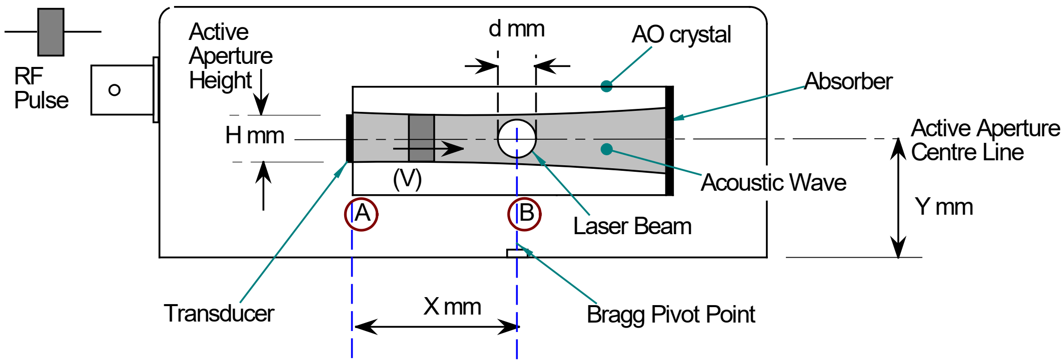
where: λ = wavelength
fc = centre frequency
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)
= 5.7mm/usec (Quartz)
d = $1/e^2$ beam diameter

Figure 5. Modulation System

Appendix A: Beam Position

Timing and delay considerations

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.



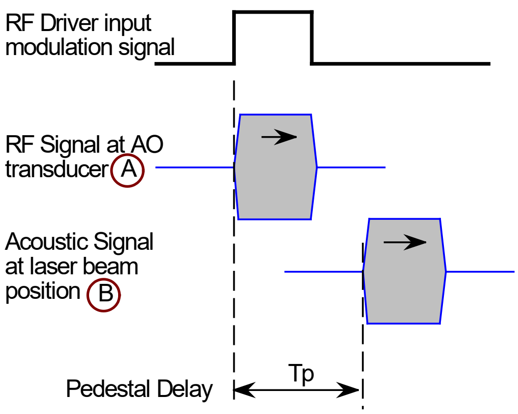
Input Beam Location

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

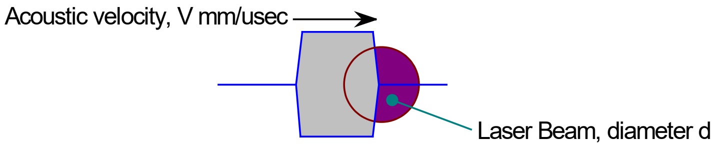
Timing considerations with respect to the RF modulation signal:

Acousto-optics are travelling wave devices. The acoustic wave is launched from the transducer and travels at velocity V across the laser beam and into the absorber.

1: Pedestal delay = time for the acoustic wavefront to reach the laser beam.
Tp = beam position from transducer (X) / acoustic velocity (V)



2: Transit time = time for the acoustic wavefront to cross the laser beam.
Tt = beam diameter (d) / acoustic velocity (V)
Optical switching time for a Gaussian beam is approximately 0.65 x Tt



Example:

For the 1209-7 series of CO_2 Germanium AO modulators/deflectors, the Bragg pivot point is located at X = 15mm from the transducer (+/- 1mm)

The acoustic velocity in Germanium is 5.5 mm/usec

Thus, for a laser beam placed above the Bragg Pivot point

Pedestal delay = 2.73 usec

The pedestal delay will depend on the AO model and the actual laser beam position.

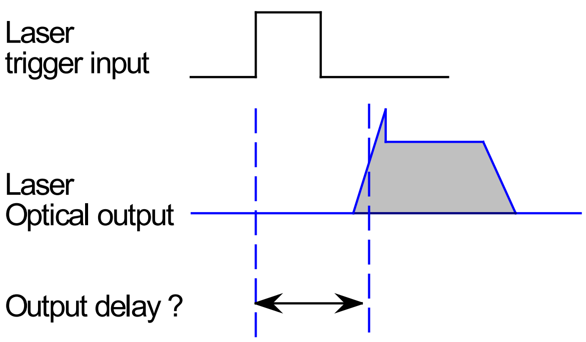
For an 6mm input beam diameter,

Transit time = 1.09 usec

(Note: The optical rise time for a Gaussian beam is approximated by 0.65 x transit time)

Laser synchronization

Please be aware, there may be a significant delay between the laser input trigger signal and the laser output pulse.



This delay should be considered when synchronizing the laser and pulsed RF (acoustic) waves.