Feb 17

Acousto-Optic Modulator Driver

Including: Basic Modulator Alignment

Instruction Manual

RFA2x1 Series

Models -

RFA2x1-z		:
	x = 5 :	Fc = 50MHz
	x = 6 :	Fc = 60MHz
	x = 7 :	Fc = 70MHz
	x = 8 :	Fc = 80MHz

Options -z:

- L	: active low digital modulation (gate) no connection RF disabled
- V	: 0-5V analog modulation range
- A	: analog modulation only. No RF gate
- D	: digital modulation only. No RF gate
- 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 1207B-6, 1208B-6 and 1209-7 series. The driver accepts two independent digital and analogue 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
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 switch provides digital modulation / RF 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).

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

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

<u>Water cooling is mandatory. The case temperature must not exceed 50°C.</u>

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 d-c power source is required. The operating voltage is +24V (+28Vdc MAX) at a current drain of approximately 5.0A. 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.

The output power level is set by the power adjust potentiometer (PWR ADJ)
NOTE : Maximum power = fully clockwise

1.1 <u>ANALOG MODULATION</u>

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 <u>envelop</u> voltage across the matched transducer.

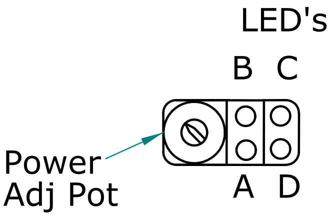
In effect, the acousto-optic interaction demodulates the RF carrier, transforming the modulation envelop (baseband signal) into intensity variation of the first order diffracted laser beam.

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.

LEDs Off

The LEDs [C] and [D] will not illuminate if :

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

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

The hysteresis of the thermal switches is 7-10deg C.

Once in a fault state the coolant temperature may need to be reduced to reset the thermal switches.

3. INSTALLATION AND ADJUSTMENT

3.1 Connect cooling water to the RFA2x1

Connect cooling water to the AO device (e.g. 1207, M1208, 1209).

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 mini 3pin connector) to the enable 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 of the modulator exceeds 32ºC or the internal driver temperature exceeds 50ºC. LED indicator illuminates when the Interlocks are 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 maximum output power is pre-set to approx.' 20W. (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.

3.9.1 Apply a constant TTL high level to the digital modulation inputs on the D-type connector. Connect pin 6 of the 'D' to the signal and pin 7 of the 'D' to the signal return.

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.

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.

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.

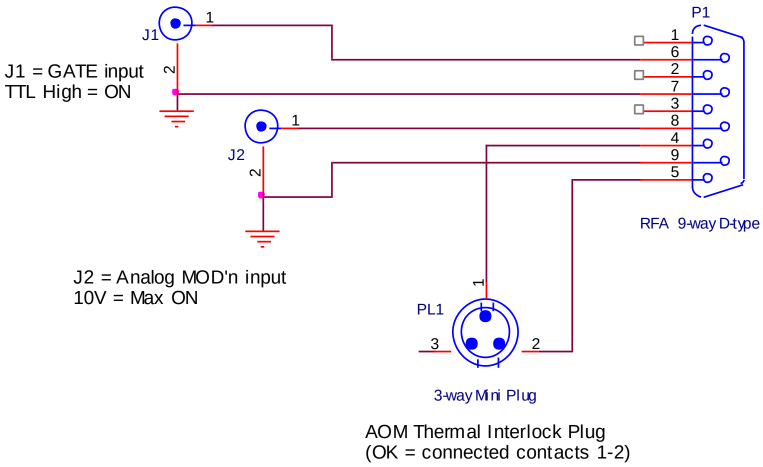
RFA 2x1 Standard Version

Connection Summary

1.0 ‘D’ Type Control Connection

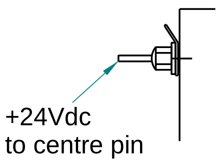
Signal	Type	Pin out connection
Digital Modulation / GATE TTL high (>2.5V) = ON TTL low (<0.8V) or no connection = Off	Input	Signal pin 6 Return pin 7
Analogue Modulation 0.0V(off) to 10.0V(on)	Input	Signal pin 8 Return pin 9
Interlock (connect to AO modulator ‘INT’)	Input	Signal pin 4 Return pin 5
‘Interlock Valid’ monitor (CMOS compatible ~15V = OK)	Output	Signal pin 1 Return pin 2

Minimum Connections shown below:



Notes:
Both Digital GATE and Analog Modulation signals need to be applied.
The interlock signal must be connected. Contacts closed for normal operation.

Older versions, DC supply connection



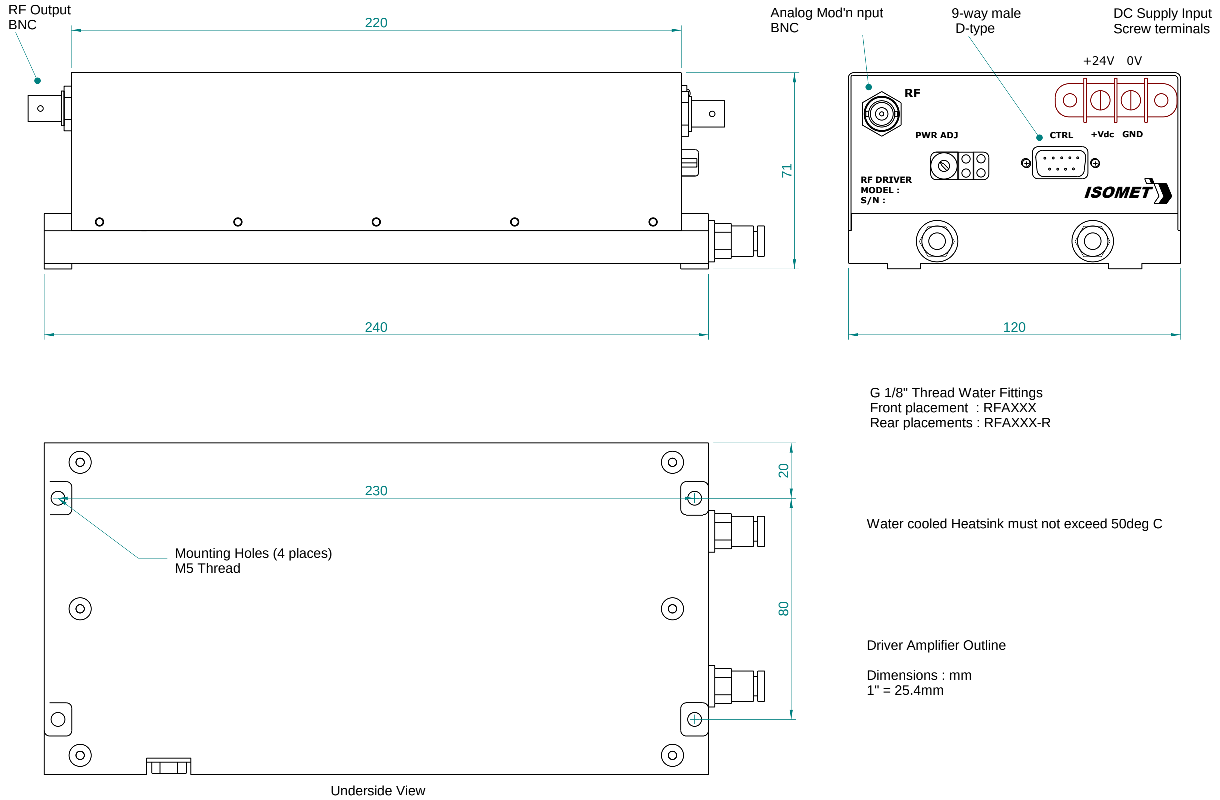


Figure 1: Driver Installation, Mounting Holes: 4 x M5

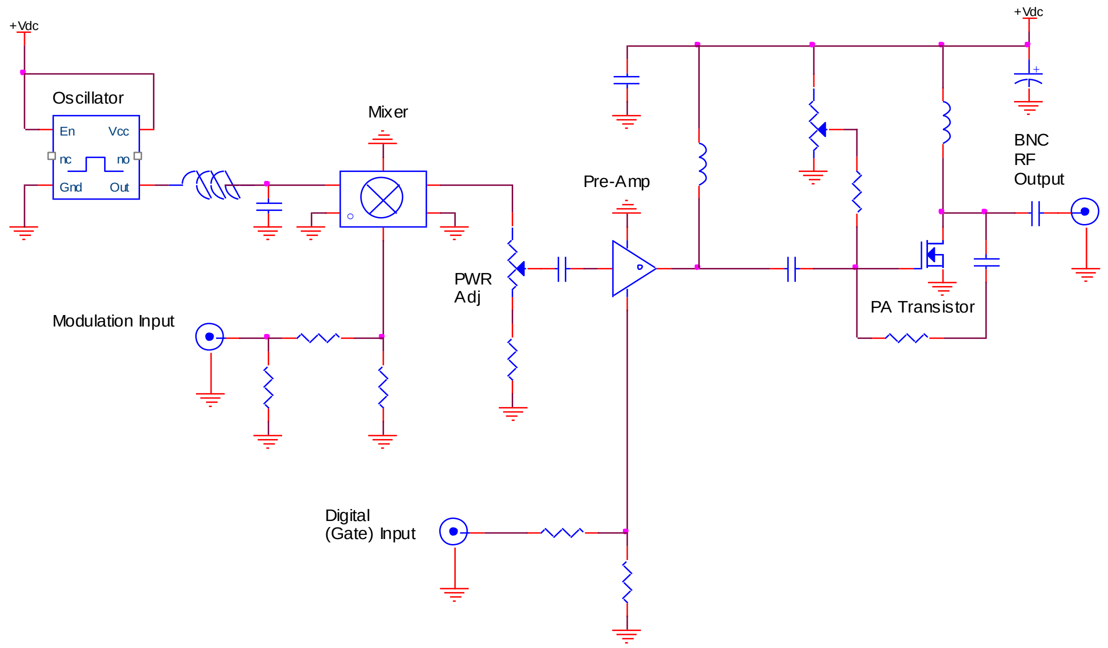
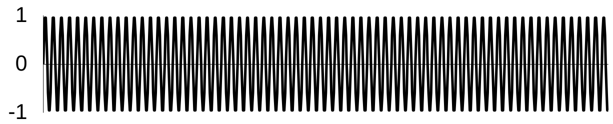
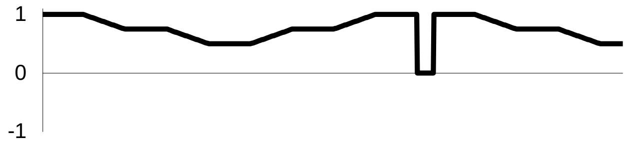


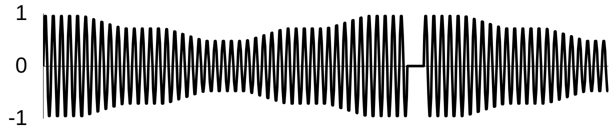
Figure 2: Driver Block Diagram



RF Carrier



Modulation Signal Input



Amplitude Modulated RF Output

Typical analog modulation RF waveforms are shown above.

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

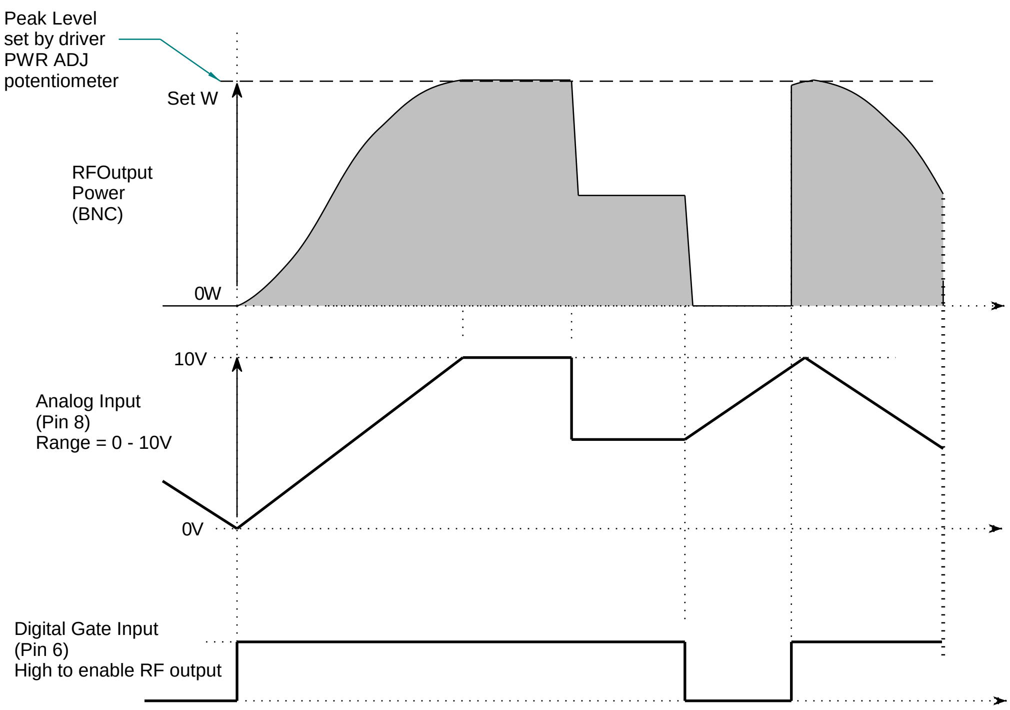


Figure 3: Typical Analog Modulation Waveforms

Timing spec's, refer Figure 3:

Ident	Description	Max
t_R	RF rise time resulting from 'large signal' modulation	500 ns
t_F	RF fall time resulting from 'large signal' modulation	100 ns
t_{ART}	Delay between a change in analog Modulation input and the resultant change in RF output	150 ns
t_{GRT}	Delay between a change in digital Gate input and RF output fully enabled	700 ns
t_{GFT}	Delay between a change in digital Gate input and RF output fully disabled	200 ns

Schematic of the Isomet 1209-7 Germanium Modulator and RFA241 RF Driver

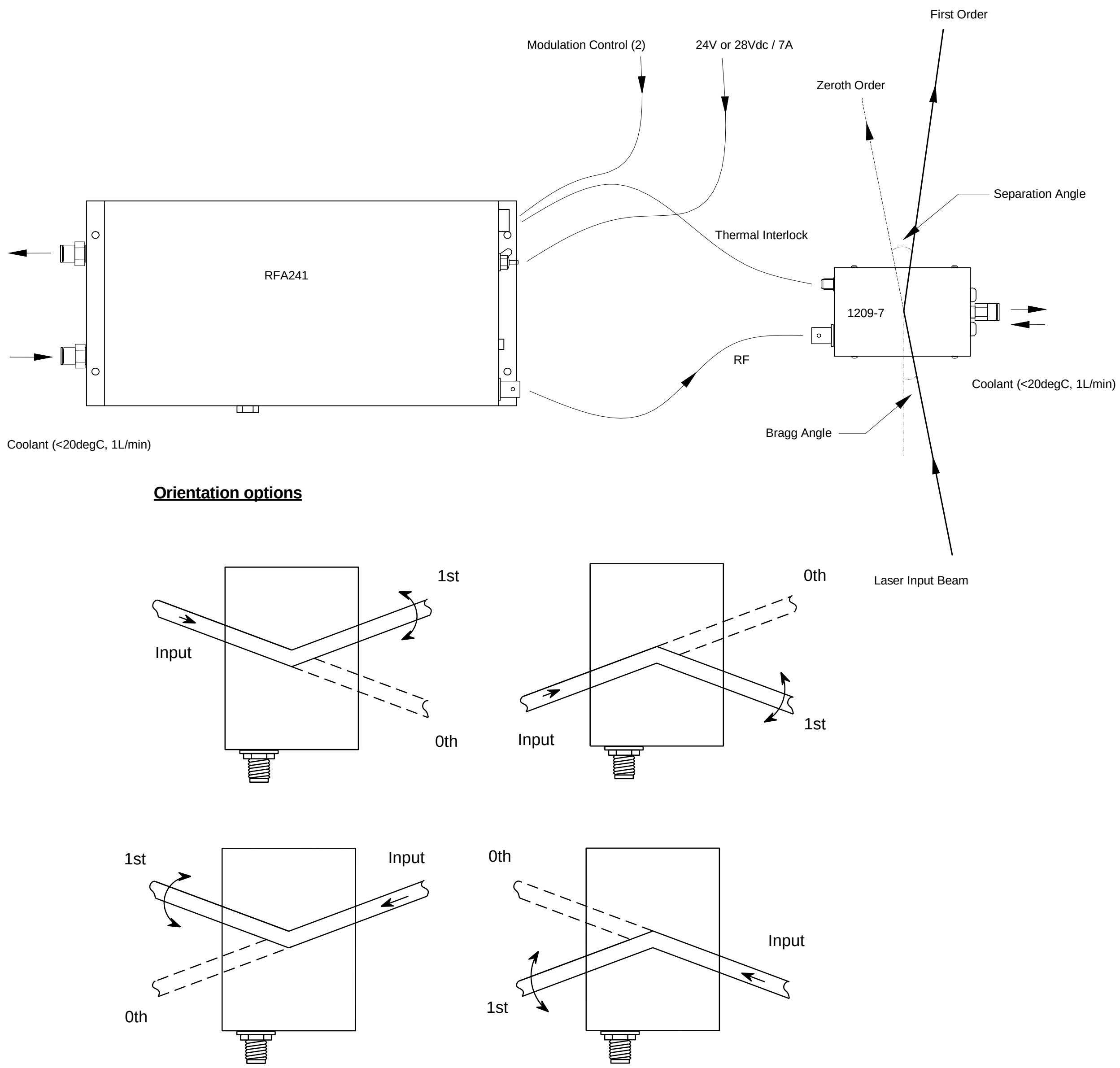
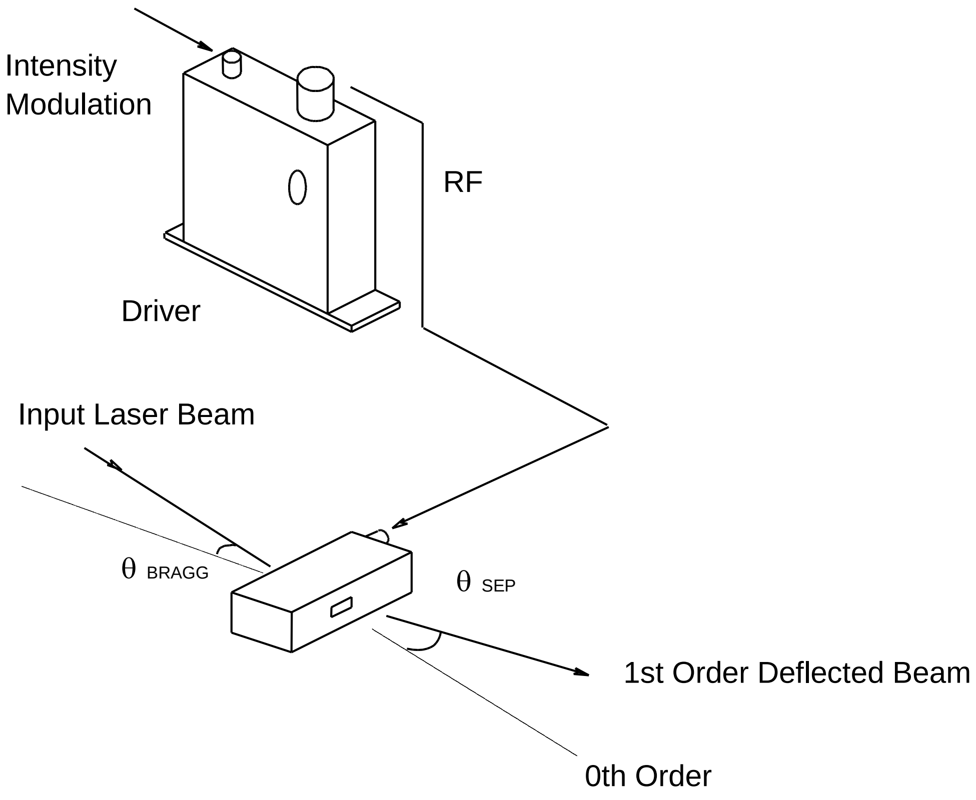


Figure 4: Typical Connection Configuration

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:

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

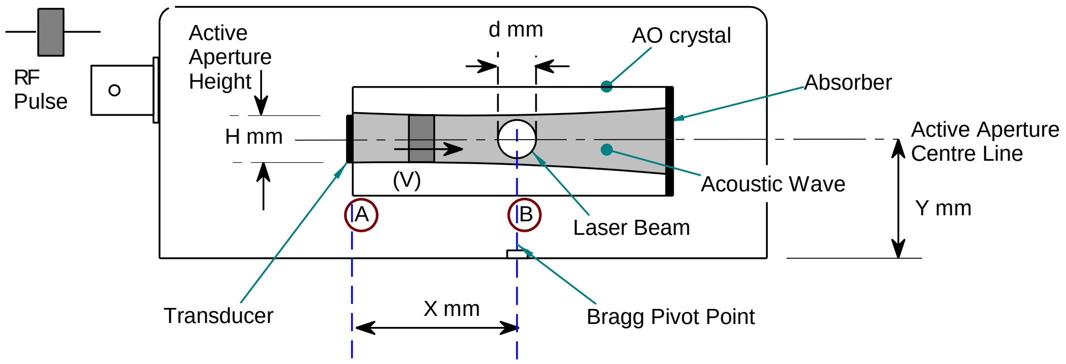
where:
- λ = wavelength
- fc = centre frequency
- v = acoustic velocity of interaction material = 5.5mm/usec (Ge) = 5.7mm/usec (Quartz)
- d = $1/e^2$ beam diameter

Figure 5. Modulation System

Appendix A: Beam Position

Timing and delay considerations

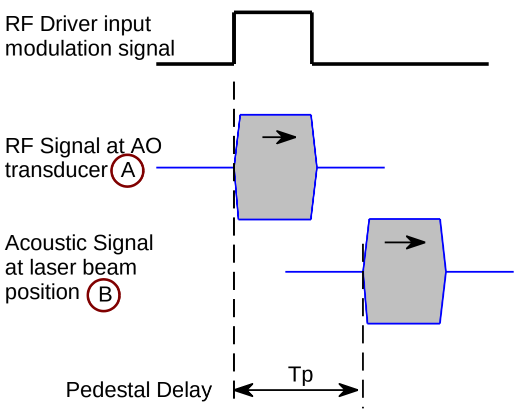
When attempting to synchronize a pulsed laser beam with a pulsed RF acoustic wave in an AO device, the designer must consider the transit time of the acoustic wave from the transducer to the laser beam position. This is called the Pedestal delay.



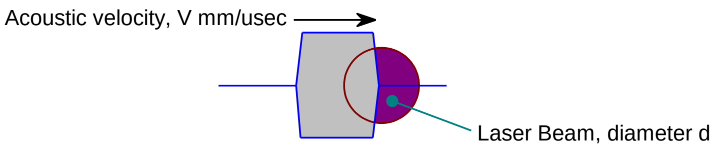
Input Beam Location
Vertical axis: Place the laser beam at the centre of the active aperture at Ymm above the base.
Horizontal (Diffraction) axis : Place beam above the Bragg pivot point.

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.

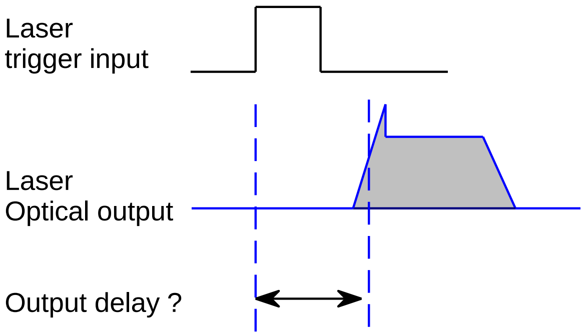
For an 6mm input beam diameter,

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, depending on the Laser type, there may be a significant delay between the laser input trigger signal and the actual laser optical output pulse.



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