Oct 14

Acousto-Optic Modulator Driver

Including: Basic Modulator Alignment

Instruction Manual

RFA141, RFA151, RFA181 Series

Models -

RFA141-x	: 40MHz, >30W output
RFA151-x	: 50MHz, >40W output
RFA181-x	: 80MHz, >30W output

Options -x:

- 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
- BR	: Brass heatsink, rear mounted water fittings only. (to suit brass or copper cased AO devices)

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1. GENERAL

The RFA1x1 combined Analog Driver and Power Amplifiers are fixed frequency RF power source specifically designed to operate with Isomet acousto-optic devices such as the 1202-4 and 1208-G series. The driver accepts 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	Use With	Center Frequency	Output Power
RFA141	1202-4 series	40MHz	> 30.0 Watt
RFA151	1208 series	50MHz	> 40.0 Watt
RFA181	1208 series	80MHz	> 30.0 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 at 40MHz, 50MHz or 80MHz. This frequency is accurate to within ± 25ppm and its stability is better than ± 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 r-f power at the Driver output.

A solid state switch provides the Digital Modulation or RF Gating 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 rise, 50nsec fall).

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.

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 d-c power source is required.   The operating voltage is +24V or +28Vdc at a current drain of approximately 4A.   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 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.

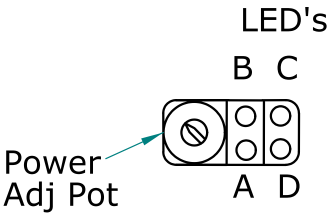
In effect, the acousto-optic interaction demodulates the RF carrier, transforming the modulation envelop (i.e. the baseband signal) into intensity variation of the first order diffracted laser beam.

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 switch 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

Refer figure 4, 5 and Appendix A

3.1 Connect cooling water to the RFA1x1 and to the AO device (1202, 1208 etc).

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.

For optimum AO performance ensure the flow rate is more than 1 litre/minute at < 20 deg.C

3.2 With no d-c power applied, connect the + 24V (or +28V) DC to the center pin of the solder feed-thru terminal or to the screw terminal as marked. DO NOT APPLY POWER. Connect the + 0V DC to the ground stud or screw terminal as marked.

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. Connect pin 4 of 'D' to the centre pin of the SMA/SMC and pin 5 of 'D' to the outer ground of the SMA.

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 15V logic '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 factory preset to approx' 20W.

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.

Please refer to the AOM and RF driver test data sheets for RF power settings

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 to the signal and pin 9 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 to the signal and pin 7 to the signal return.

Input the laser beam toward the centre of either aperture of the AOM. Ensure the laser polarization is correct for the AOM model 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.

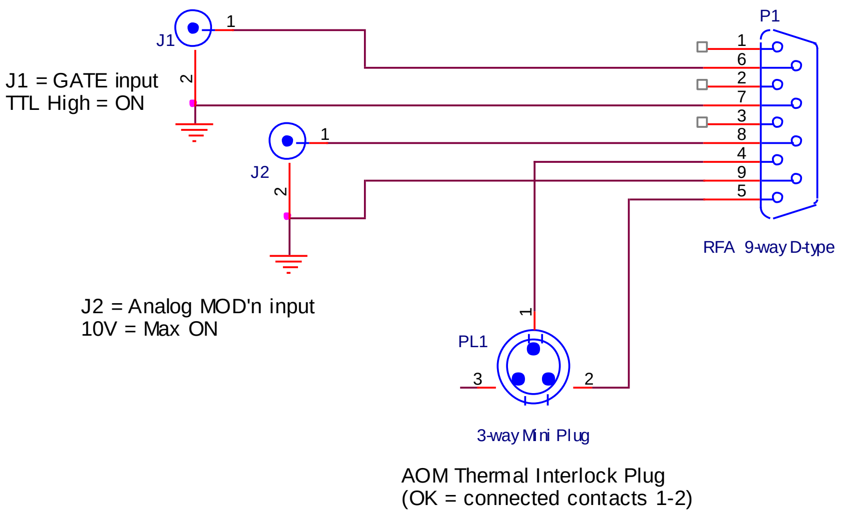
RFA 1x1 Standard Version

Connection Summary

5.0 ‘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:

<u>Both</u> Digital GATE and Analog Modulation signals need to be applied.
The interlock signal must be connected. Contacts closed for normal operation.

6.0 Mounting, Holes 4 x M5

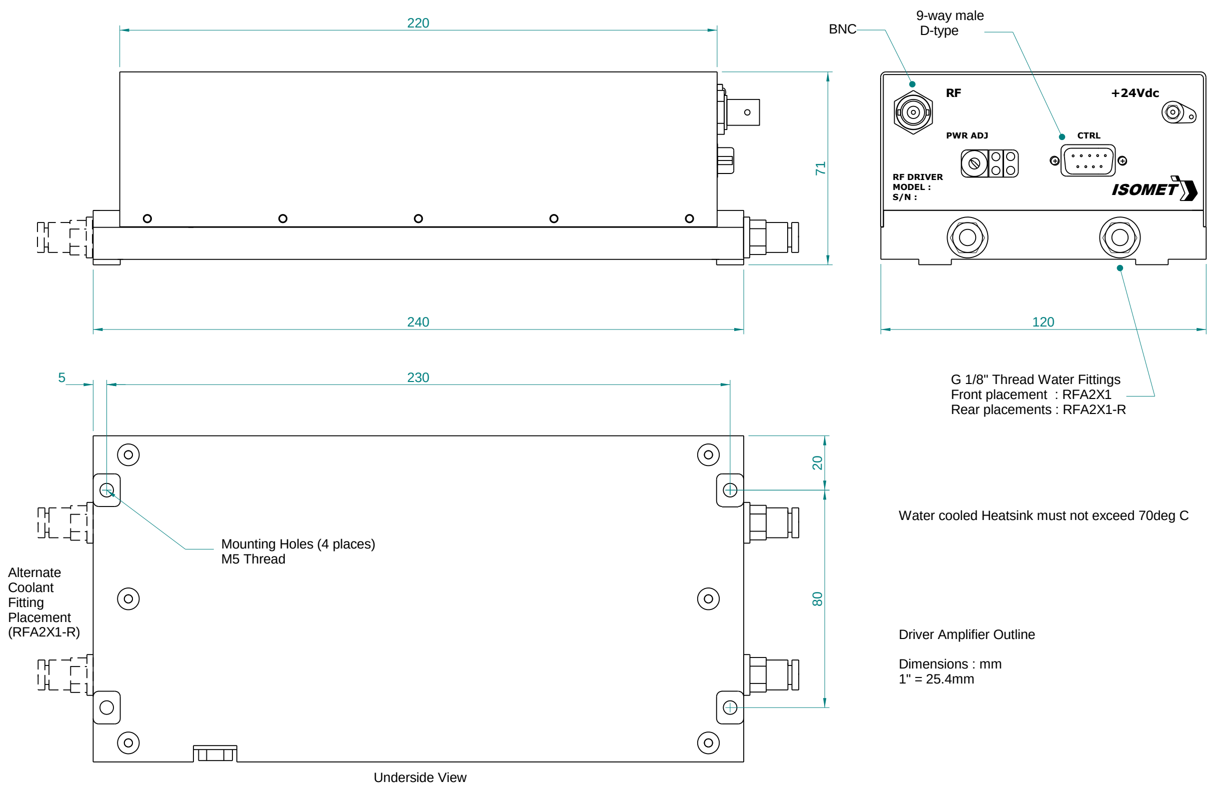


Figure 1: Driver Installation

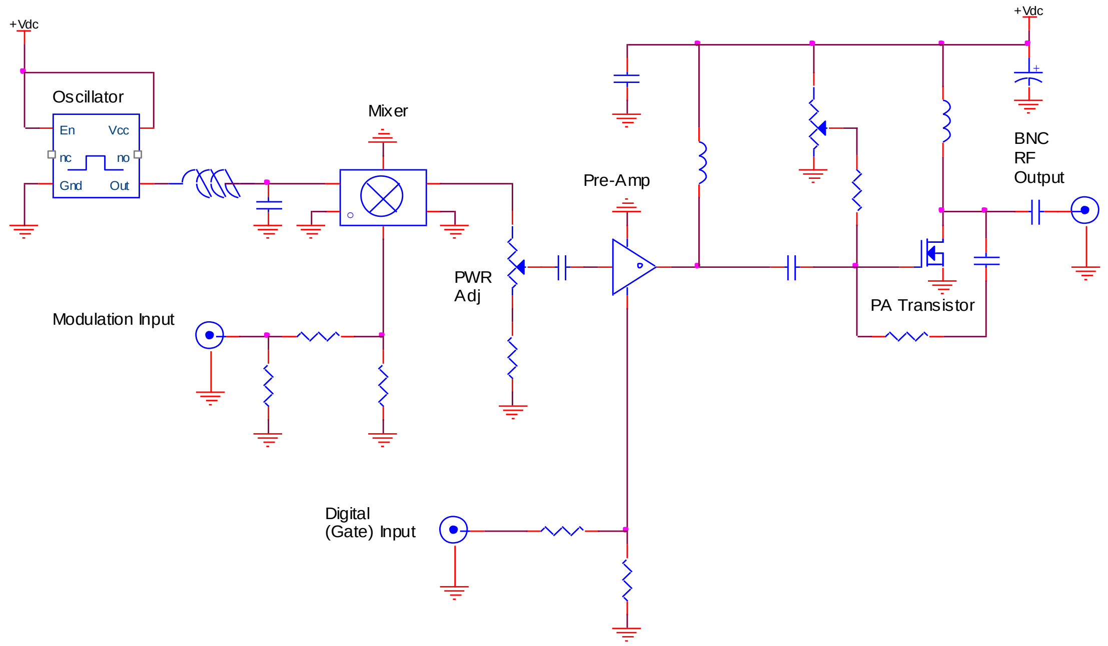
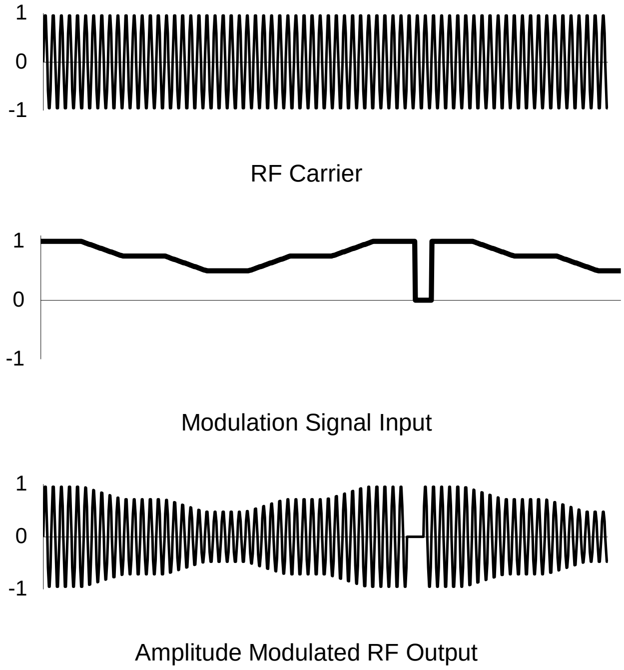


Figure 2: Driver Block Diagram

Analog modulation of an RF carrier.



RF amplitude modulation input is a combination of analog and digital control signals as illustrated below.

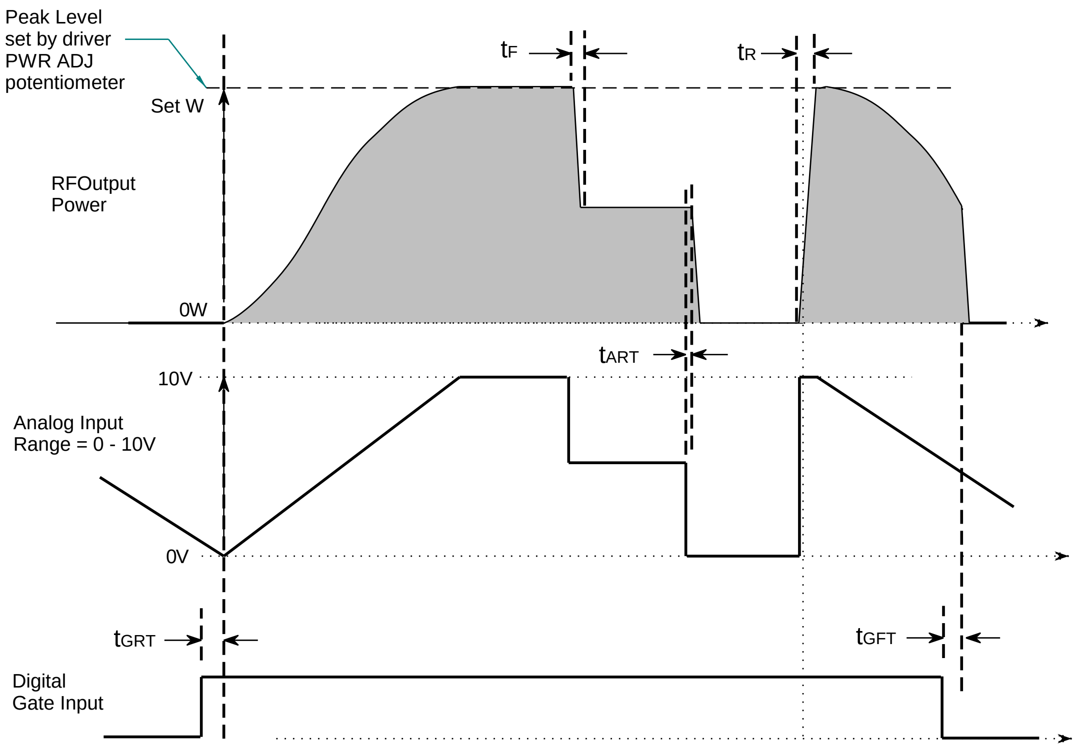


Figure 3: Typical Analog Modulation Waveforms

RF output timing spec's, refer Figure 3:

Ident	Description	Max
tR	RF rise time resulting from 'large signal' modulation	400 ns
tF	RF fall time resulting from 'large signal' modulation	100 ns
tART	Delay between a change in analog modulation input and change in RF output	150 ns
tGRT	Delay between a change in digital Gate input and RF output fully enabled	700 ns
tGFT	Delay between a change in digital Gate input and RF output fully disabled	200 ns

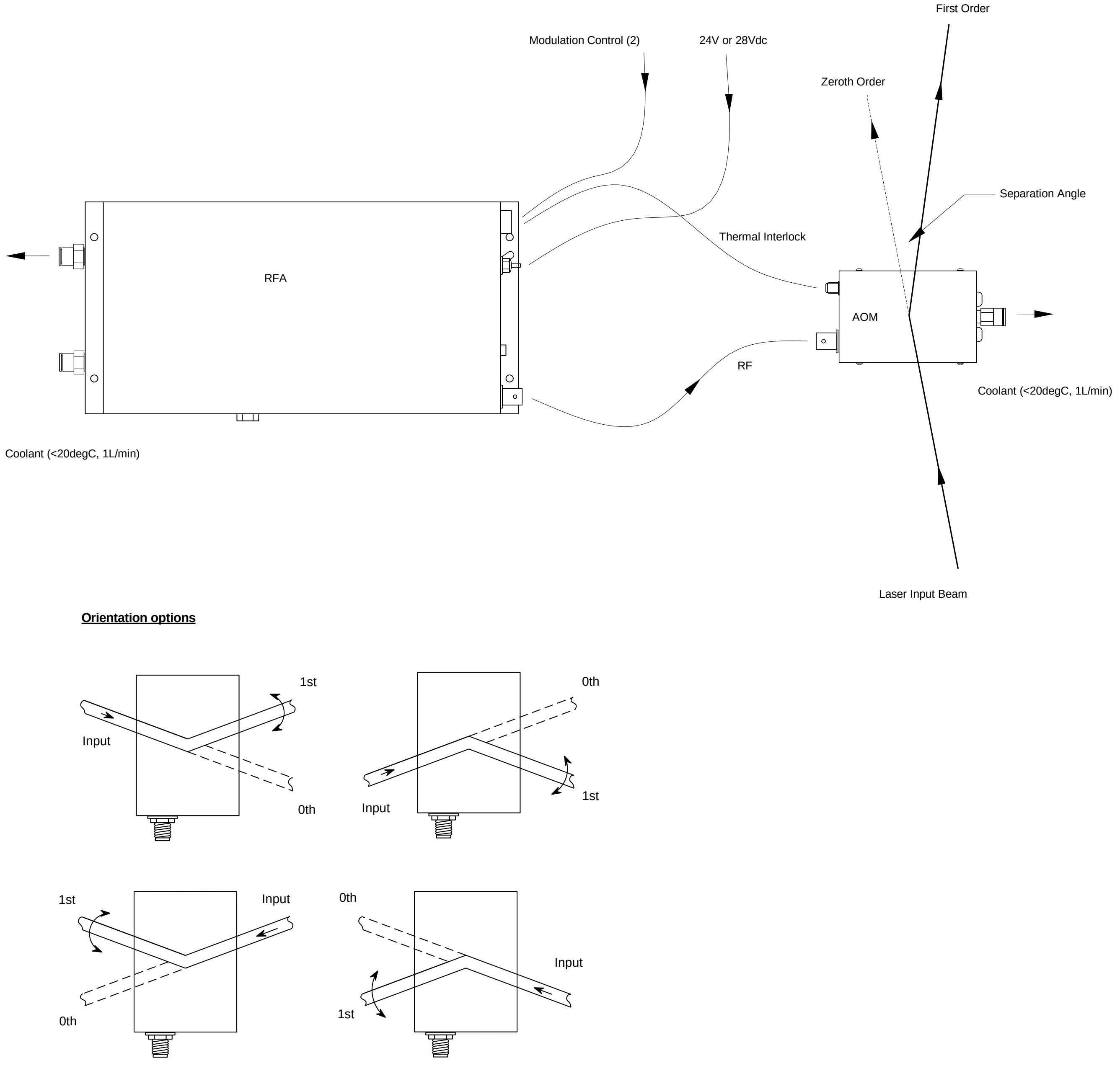
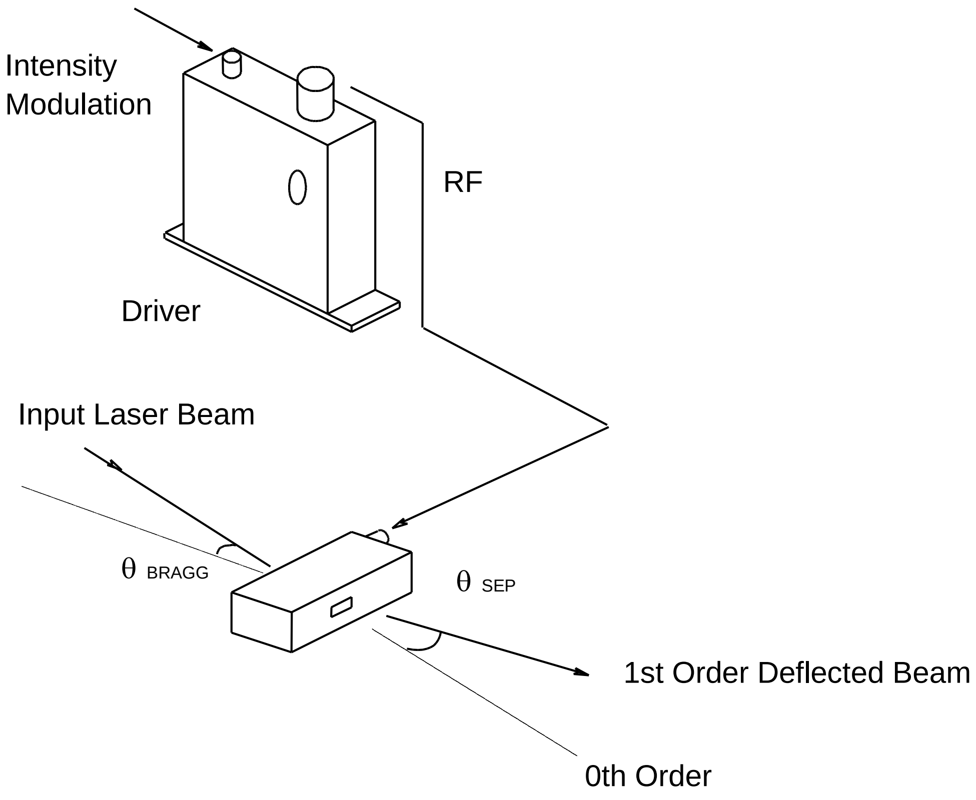


Figure 4: Typical Connection Configuration

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 = 40MHz / 50MHz / 80MHz
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)
= 3.6mm/usec (Dense Flint Glass)

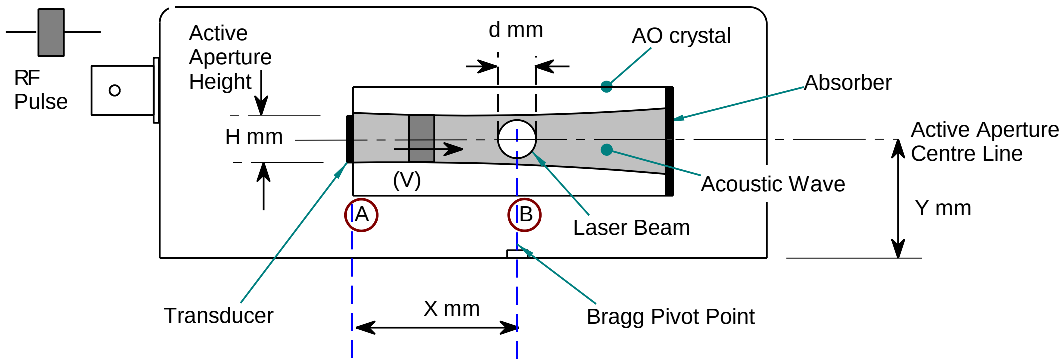
d = $1/e^2$ beam diameter

Figure 5. Modulation Parameters

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.



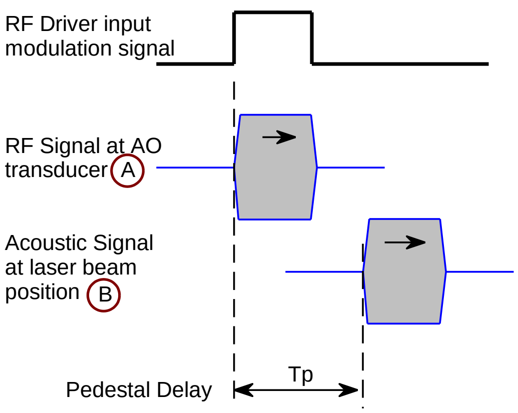
Input Beam Location

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.

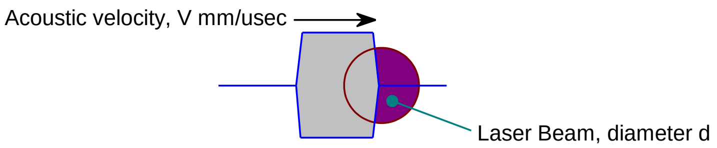
Timing considerations with respect to the RF modulation signal:

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 1208-G 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.

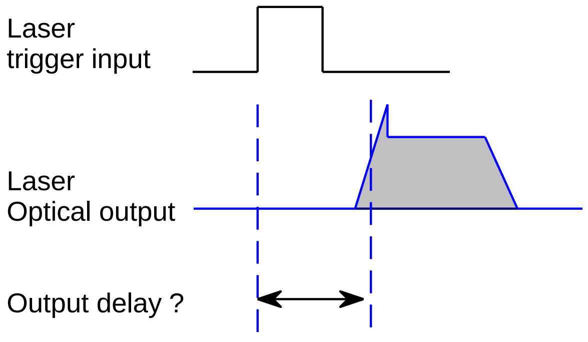
For an 3mm input beam diameter,

Transit time = 0.54 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.