Jul 13

Acousto-Optic Modulator Driver

Including: Modulator Alignment
AOM6x0-H series
M13xx-H series

Instruction Manual,

RFA240-2 / RFA250-2 Series

Analog and Digital Modulation

Models -

RFA240-2-x	: 40MHz, 160W output
RFA250-2-x	: 50MHz, 160W output
RFA260-2-x	: 60MHz, 140W output

Options **–x**, combinations possible:

- L	: active low RF enable (gate)
- D	: digital modulation and On-Off gate
- V	: 0-5V analog modulation range
- H	: High power option (+25%)
- Mxx	: power limited to xx Watts
- BR	: Brass water cooled heatsink

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1. GENERAL

The RFA2x0-2 Combined Analog Driver and Power Amplifier is a fixed frequency RF power source specifically designed to operate with the AOM600 series of acousto-optic high power modulators. The driver accepts independent Modulating and Gate inputs 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	Total Output Power
RFA240-2	AOM640 series	40MHz	> 160.0 Watt
RFA250-2	AOM650 series	50MHz	> 160.0 Watt
RFA260-2	AOM660 series	60MHz	> 140.0 Watt

Figure 3 is a block diagram of the driver. The center frequency is determined by a free-running quartz-crystal oscillator. The frequency is accurate to within ± 0.005% and the stability is better than ± 0.003%; the oscillator is not temperature stabilized.

A high-frequency, diode ring modulator is used to amplitude-modulate the RF carrier. A single turn potentiometer provides gain control for adjusting the maximum r-f power for both outputs of the Driver.

The amplitude-modulated r-f is divided and applied to two power amplifier stages.
MMIC r-f pre-amplifiers isolate this low level modulation 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, 1: Gate and 2: Modulation
The modulation input is configured at the factory to be either analog (see 2A) or digital (-D) option (see 2B).

1: The TTL Gate input disables the RF Output. Default condition is RF On.
A TTL high level will gate the RF **Off**.
If not connected or driven low (< 0.8V), the RF will be gated **ON.**
(See section 2.1)

2A: Applies to all drivers except -D

Analog modulation. This configuration gives variable amplitude control of the RF power (see section 2A). An input swing of 10 volt (positive with respect to ground) will result in 100% depth of modulation. An input voltage of less than 0.4V will drive the RF Off.

An input of 10V will result in maximum RF output as pre-set by the RF power adjustment potentiometer.

or

2B: Applies to drivers with –D option (see section 2B).

Digital modulation. This configuration gives bi-level On:Off amplitude control of the RF power. A TTL high level will turn the RF **ON** and will result in maximum RF output as pre-set by the RF power adjustment potentiometer.

The rise and fall times for the amplifier from either modulation or gate inputs is identical. (approx 200nsec).

The maximum RF output is set by the power adjust potentiometers PWR ADJ2

NOTE : Maximum RF power = fully clockwise

The video analog input level must not exceed 15 volts

The digital input levels must not exceed 7 volts

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

Corrosion inhibitor should be added to the cooling water

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 supply is required. The operating voltage is +24V or +28Vdc at a current drain of approximately 12A. 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.

2A. ANALOG MODULATION

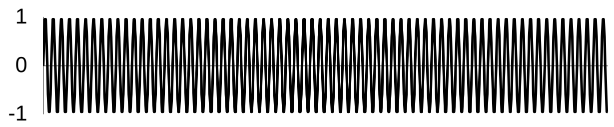
To intensity modulate a laser beam in an acousto-optic modulator requires that the amplitude of the applied RF carrier is varied according to the required baseband information. From the viewpoint of intensity modulation, the deflection efficiency equation is normalized as:

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

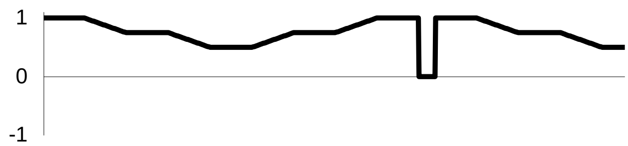
where i_1 is the instantaneous intensity in the first order diffracted beam and E_{RF} is the instantaneous RF envelop voltage across the AO matched transducer.

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.

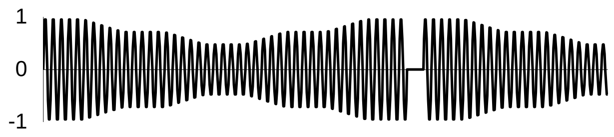
Typical analog modulation RF waveforms are shown above.



RF Carrier



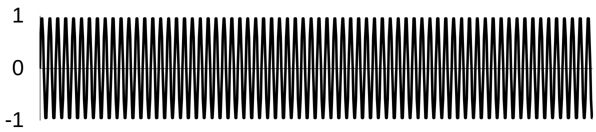
Modulation Input



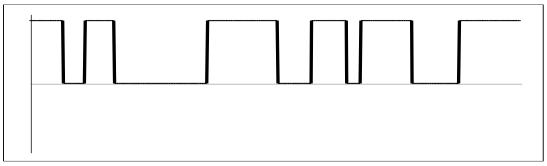
Amplitude Modulated RF Output applied to the AOM

2B. DIGITAL MODULATION

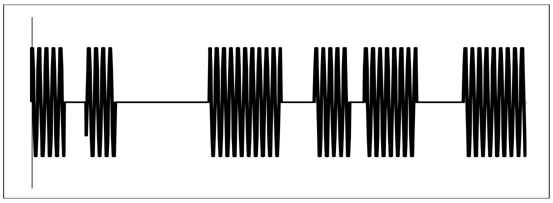
To On:Off modulate a laser beam in an acousto-optic modulator requires the amplitude of the applied RF carrier to be switched according to the required baseband digital information.
The equivalent waveforms for digital modulation are shown below



RF Carrier



Modulation Input



Modulated RF applied to the AOM

Basic AO calculations are given in Figure 5

2.1 GATE INPUT

In addition to the Modulation input, these drivers feature a RF Gate Input, that can be driven to disable/enable the RF output

For the RFA2x0-2 drivers, the RF modulation is a combination of modulation and digital gate inputs as illustrated below for analog modulation drivers.

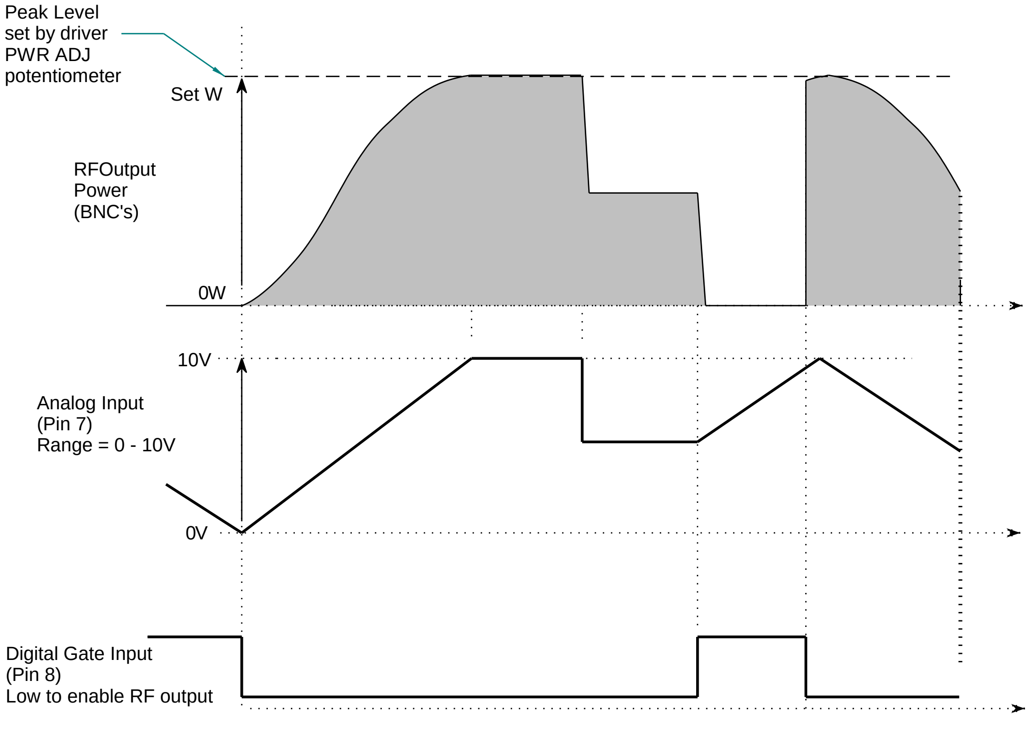


Figure 1: Typical Analog Modulation Waveforms

2.2 LED INDICATOR

The front panel LED indicator serves to indicate a number of possible operating states.

The LED will illuminate RED or GREEN when the DC power is applied and the Interlocks are valid.

The RF outputs may be “live” if the LED is illuminated RED or GREEN. The colour will depend on the average RF output level.

- Shows GREEN when the RF outputs are live and provided that :
  - a) the modulation duty cycle is more than 20% (approx).
  - b) the RF CW power is > 20% (approx) of the driver maximum power

- Shows RED when one or both RF outputs have low average power

  e.g. a) Modulation OFF

  b) RF power set to less than approximately 20% of the maximum driver RF power

  c) Modulation duty cycle is less than approximately 20%

LED Off

The LED 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 threshold is 50deg C

- The AOM600 series thermal switch over-temperature threshold is 32deg C

The hysterisis 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.

e.g. for the AOM, less than 22deg C

3. INSTALLATION AND ADJUSTMENT

Connect cooling water to the RFA2x0-2. Minimum flow rate of 1 litre/minute at < 25 deg.C. For optimum AO performance ensure the flow rate is more than 2 litres/minute at < 20 deg.C

Refer to Figure 2. 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.

3.2 With no d-c power applied, connect the + 24V (or +28V) DC in to the center terminal of the feed-thru terminal. DO NOT APPLY POWER.

3.1 Connect the BNC output RF1 to the acousto-optic modulator input J1 (or a 50Ω RF load, if it is desired to measure the RF1 output power).

Connect the BNC output RF2 to the acousto-optic modulator input J2 (or a 50Ω RF load, if it is desired to measure the RF2 output power).
(Connection order is not critical)

3.4 Connect the Interlock of the acousto-optic modulator (mini 3-pin snap connector) to the enable inputs on the 15-pin D-type connector of the RFA2x0-2. Connect pin 1 of ‘D’ to the centre pin 1 and pin 9 of ‘D’ to the outer pin 2. (See Figure 4)

If the temperature of the modulator exceeds 32ºC or the internal driver temperature exceeds 70ºC then the interlock connection becomes open circuit, disabling the RF output. An LED indicator illuminates when the Interlocks are closed and the RF is enabled. In addition, a open drain ‘interlock valid’ signal output is provided on pin 2 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 45W per output (90W total).

The optimum RF power level required for the modulator to produce maximum first order intensity will be differ depending in the laser wavelength. 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 2 access hole on the driver end plate.

3.7 With an insulated alignment tool or screwdriver rotate the PWR ADJ potentiometer fully anti-clockwise (CCW) i.e. OFF, then clockwise (CW) approx 1/2 turn.

3.8 Apply DC to the amplifier.

3.9 For analog modulation drivers e.g. RFA240-2 or RFA250-2 apply a 10.0V constant modulation signal to the modulation inputs on the D-type connector. Connect pin 7 of 'D' to the signal and pin 14 of 'D' to the signal return.

or

3.10 For digital modulation drivers e.g. RFA240-2D / RFA250-2D, apply a constant TTL **high** modulation signal to the modulation inputs on the D-type connector. Connect pin 7 of 'D' to the signal and pin 14 of 'D' to the signal return.

3.11 If the GATE input is to be used, apply a constant TTL **low** level (< 0.8V) to the digital Gate input on the D-type connector. Connect pin 8 of the 'D' to the signal and pin 15 of the 'D' to the signal return. Alternatively if the RF Gate control is not required, leave unconnected (except option "L" drivers).

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 for one possible configuration.

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 by turning PWR ADJ2 clockwise until maximum first order intensity is obtained.

3.14 The modulator and driver 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 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 2x0-2 **Connection Summary**

1.0 15 way 'D' Type Control Connection

Signal (see notes)	Type	Pin out connection
GATE		
Digital Gate **	Input	Signal pin 8
TTL high (2.7v<V<6.0v) = OFF		Return pin 15
TTL low (0.0v<V<0.8v) or nc = ON		
[Input current 4.8mA at 5V]		

MODULATION

Analogue Version e.g. RFA240-2 or RFA250-2

Signal	Type	Pin out connection
Modulation, proportional*	Input	Signal pin 7
< 0.4V(off) to 10.0V(on)		Return pin 14
[Input current 4.0mA at 10V]		

or –D option

Digital Version e.g. RFA240-2D or RFA250-2D

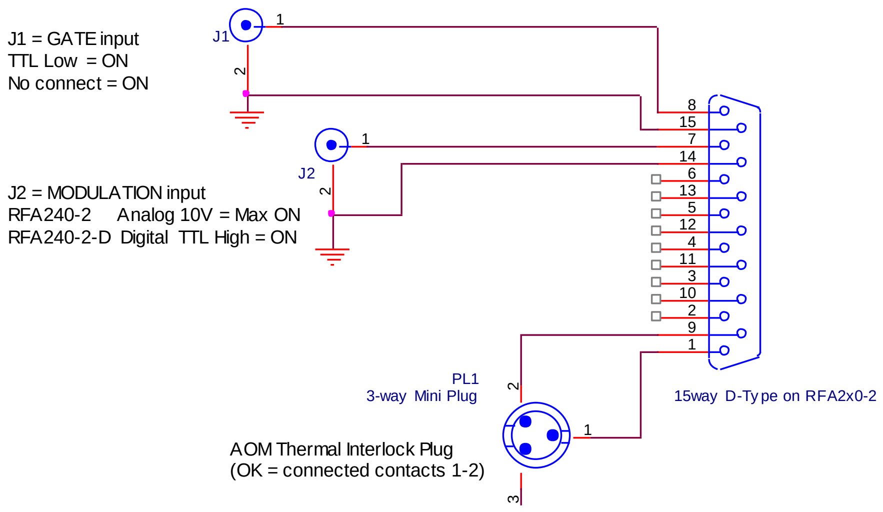
Signal	Type	Pin out connection
Modulation, ON/OFF *	Input	Signal pin 7
TTL high (2.7v<V<6.0v) = ON		Return pin 14
TTL low (0.0v<V<0.8v) = OFF		
[Input current 1.5mA at 5V]		

INTERLOCK

Signal	Type	Pin out connection
Interlock (NC contact) ***	Input	Signal pin 1
Connect to AO modulator 'INT'		Return pin 9
[Sink current 10mA]		
'Interlock Valid' monitor	Output	Signal pin 2
Open Drain logic, Low = OK		Return pin 10

Maximum applied voltage (via external pull up resistor) = 5.5V
[Maximum current = 10mA]

Input connections



Notes:

*   The modulation input signal (pin 7) needs to be applied,
This is always required even if the digital Gate signal (pin 8) only is used to modulate the RF power.

** Except Option "-L" drivers (e.g. RFA2x0-2L) with Inverted Digital Gate

"-L" Digital Gate: TTL Low (0.0v<V<0.8v) = ON
TTL High or unconnected = OFF

*** The interlock signal must be connected. Contacts closed for normal operation.

2.0 Mounting Holes

4off x M5

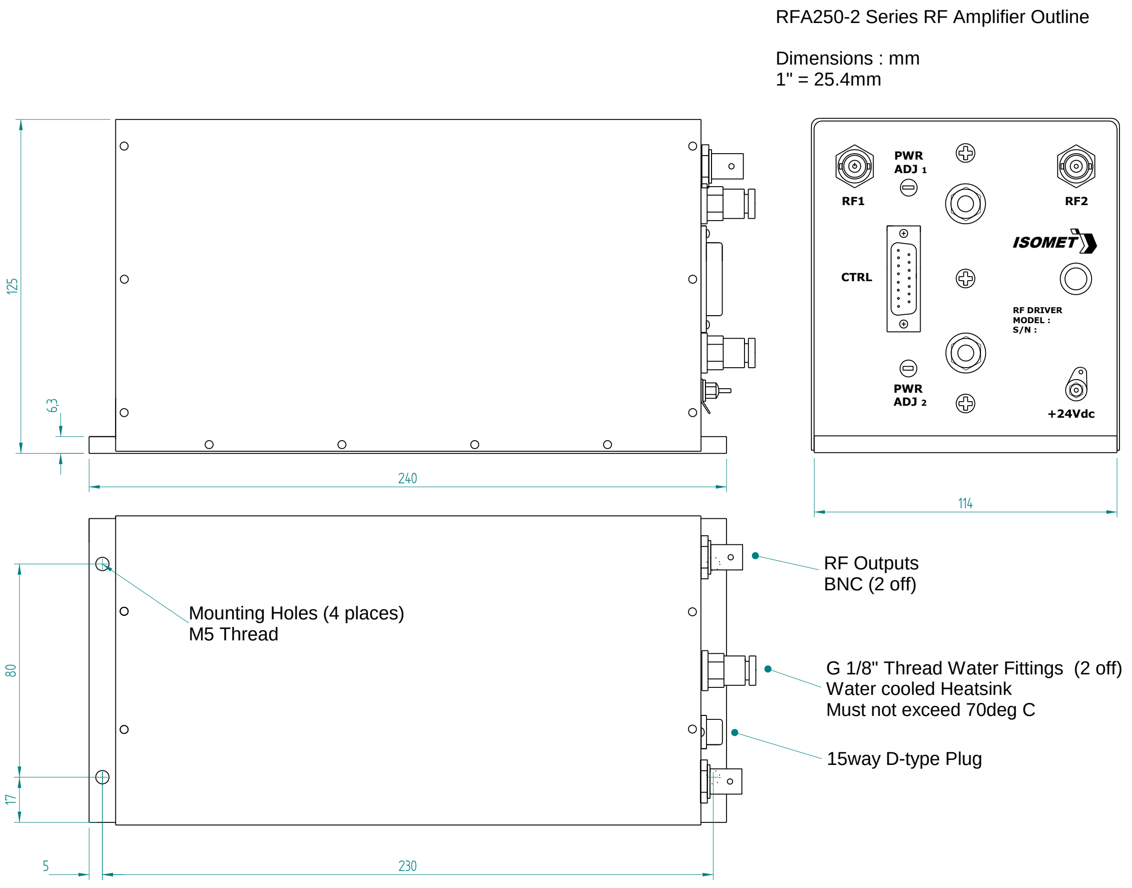


Figure 2:   Driver Installation

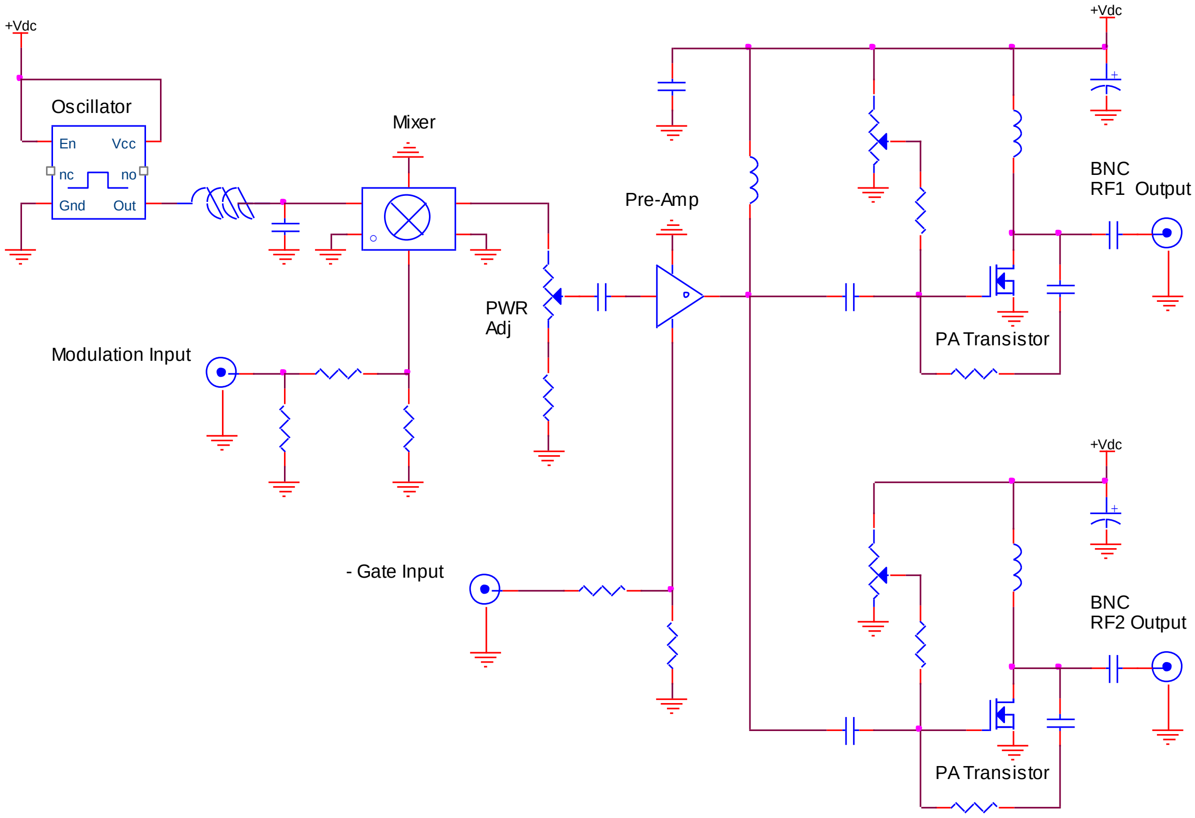
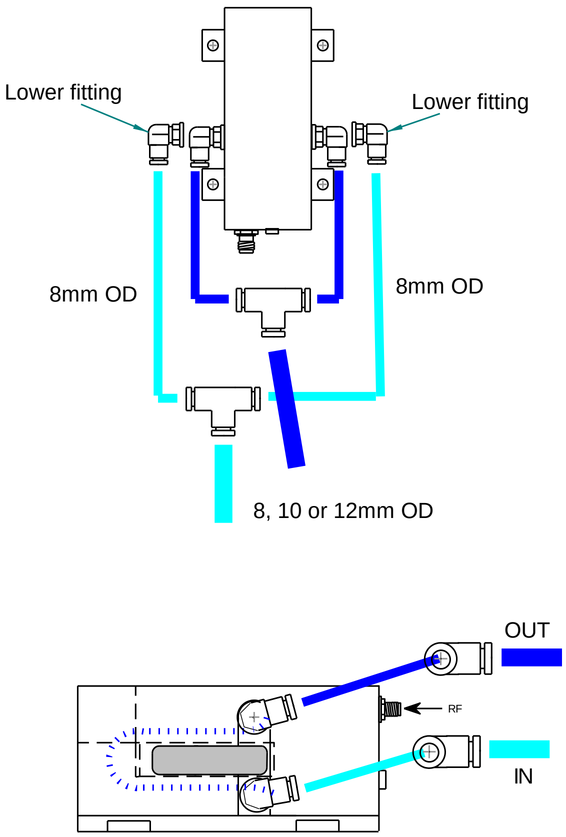


Figure 3: Driver Block Diagram

AOM600 / AOM700 / DBM coolant flow

Flow rate enhancement
using dual fittings and T-piece



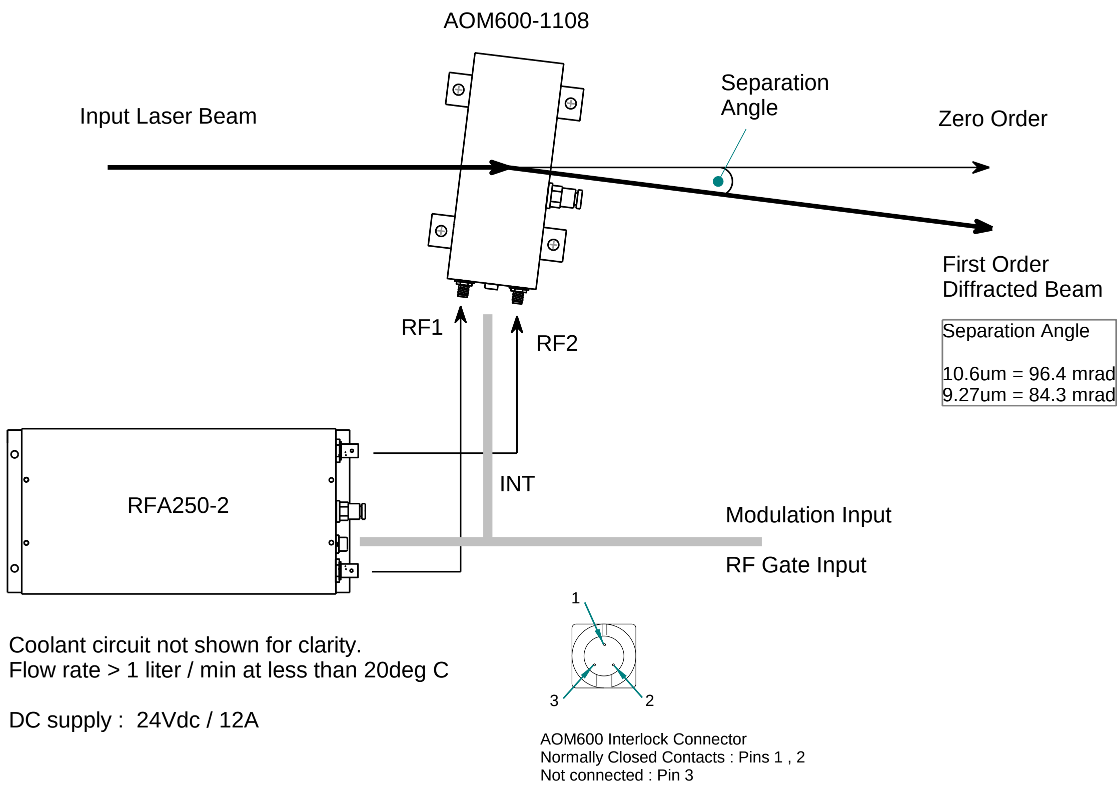
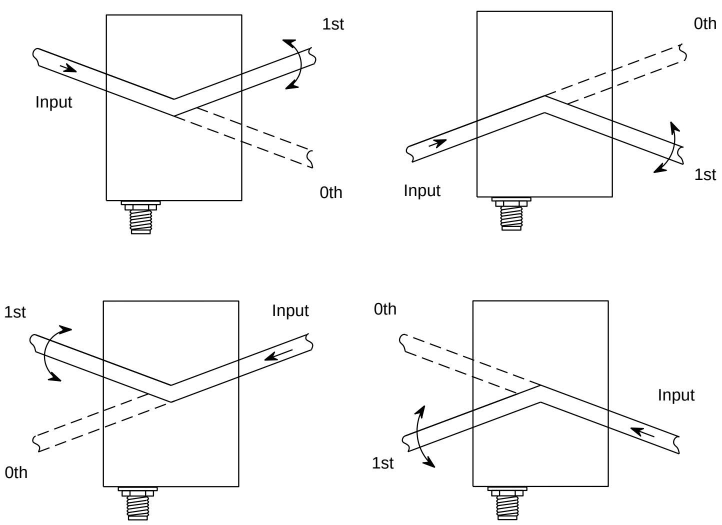


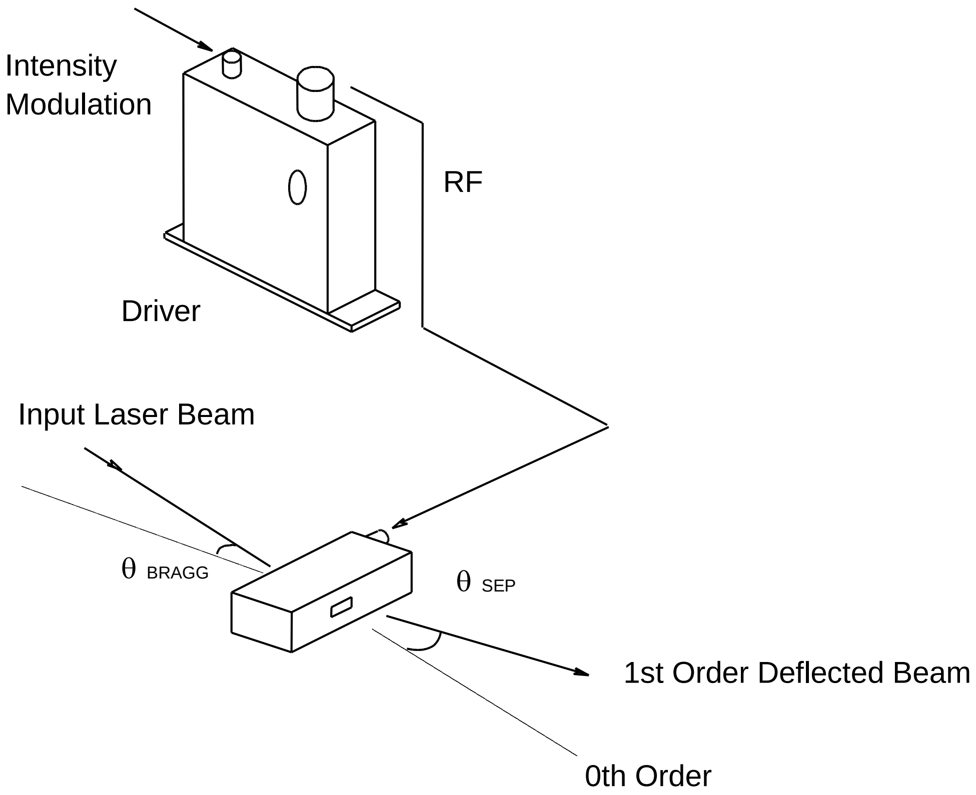
Figure 4: Typical Connection Configuration using RFA250 series.
Angles given are shown for <u>50MHz</u>

(Scale with frequency. At 40MHz multiply angles shown by a scale factor of 0.8)

<u>Orientation options</u>



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 / RFA240-2
50MHz / RFA250-2
60MHz / RFA260-2

v = acoustic velocity of interaction material = 5.5mm/usec (Ge)
d = $1/e^2$ beam diameter

Figure 5. Modulation System