IM4825

# Acousto-Optic Modulator / Deflector Driver

**Including: Basic M600 Alignment**

# Instruction Manual

## RNx-40-2-90

## RNxBR-40-2-90 with Brass Heatsink

Models –

**Digital Modulation**
**RN2**-40-2-90 : 40MHz, 100W output, digital modulation.
**RN2**BR-40-2-90

**Analog Modulation**
**RN3**-40-2-90 : 40MHz, 100W output, analog modulation
**RN3**BR-40-2-90

**Dual Modulation**
**RN5**-40-2-90 : 40MHz, 100W output, analog and digital modulation
**RN5**BR-40-2-90

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## 1. GENERAL

The RN5 series combined Driver and Power Amplifiers are fixed frequency RF power sources specifically designed to operate with Isomet high power Germanium acousto-optic modulators such as the M600 (aka AOM640). The driver is designed with two independent modulating signals and provides an amplitude modulated RF output to the acousto-optic modulator. Example driver specifications are shown in the following table:

| Model | Center Frequency | Output Power | Option |
|---|---|---|---|
| RN5BR-40-2-90 | 40MHz | > 180 Watt | (Dual mod'n) Brass Heatsink |
| RN3-40-2-90 | 40MHz | > 180 Watt | Analog mod'n only |
| RN2-40-2-90 | 40MHz | > 180 Watt | Digital mod'n only |

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

A high-frequency, diode ring mixer applies the analog amplitude modulation (A-mod).
A solid-state RF switch provides the 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 single turn potentiometer provides gain control for adjusting the peak RF power level when the modulation input(s) is at maximum.

The RF switching rise and fall time at full power is approx. 200nsec / 50nsec.

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.

A low impedance DC power supply is required. The operating voltage is +24V or +28Vdc at a current drain of approximately 16A. 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.

**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.**

## 2.0 MODULATION

The RF POWER ADJUST control sets the peak driver output for the fully ON condition.

**RN2**-40-2-, modulation full ON = logic High

**RN3**-40-2-, modulation full ON = 10V

**RN5-**40-2-, both, as above

NOTE : Maximum RF power = PWR ADJ fully clockwise

**The digital input levels must not exceed 7 volts**

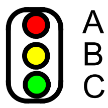
**The analog input levels must not exceed 15 volts**

Figure 3 illustrates modulation waveforms.

## 2.1 LED INDICATORS

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

The LEDs [A] illuminates when the DC power is applied, and the Interlocks are valid.




- [A] shows RED when the (thermal) Interlocks are enabled.
- [B] shows YELLOW when outputs are active.
- [C] shows GREEN when the RF power amplifiers are enabled.

Normal operating condition = all LEDS are ON

**LEDs Off**

The LED [A] will not illuminate if:

i. the internal driver thermal interlock switch is open (Over Temperature Fault)
ii. the AOM thermal interlock switch is open (Over Temperature Fault)
iii. the AOM thermal interlock is not connected to the driver interlock input.
iv. the DC supply is off.

The LED [B] may not illuminate or run dim if:

i. zero or no modulation signal.
ii. low modulation duty cycle.
iii. the DC supply is off.

The LED [C] may not illuminate if:

i. the optional Gate input is set logic high, disabling the amplifier.
ii. LED [A] is off.
iii. the DC supply is off.
iv. high reflected RF power (High Reflected Power fault).

## 2.2 Resetting over temperature fault (OTF)

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 trip point is 50°C +/- 5°C
- The AOM thermal switch over-temperature trip point is 32°C +/- 5°C

The trip-to-reset hysteresis of the thermal switches is 7-10deg C.
Once in the fault state, the heatsink temperature will need to be reduced to ~22deg C to reset the thermal switches.

See **AN1725** Resetting the AO Thermal Interlock (https://isomet.com/appnotes.html)

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### 2.3 Resetting high reflected power (HRP) fault.

Ensure the RF outputs are terminated correctly, and the RF cables are undamaged.

To reset the fault,

- cycle DC power to the RF driver.

  or
- momentarily connect pin 3 to pin 11.

If the fault persists then there may be a fault with the AO device.

## 3 INSTALLATION AND ADJUSTMENT

Connect cooling water to the driver. Minimum flow rate = 1 litre/minute at <25 degC.

Recommended flow rate and temperature = >2 litres/minute at <20 degC

Refer to Figure 1. 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.**

3.1 Connect +24V (or +28V) DC power to the screw terminals as marked. A 20A supply is recommended. DO NOT APPLY POWER.

3.2 Align the AOM to ensure that the incident light beam is centred in the active aperture of the device.

3.3 Connect the (2) RF output BNC jacks to the (2) SMA RF inputs of the acousto-optic deflector (or a 50-ohm RF load, if it is desired to measure the modulator RF output power). **The order of connection is not important. See Figure 4 for Bragg orientation options.**

The amplifier outputs must be terminated.

**The cable lengths from the amplifier to the AOM should be equal.**

3.4 Connect the Interlock of the acousto-optic device (Binder 719 3-pin snap connector) to the enable inputs on the Interlock connector on the RNx-40-2-90. Connect pin 1 to pin 1 and pin 2 to pin 2. (See Figure 5)

If the temperature of the modulator exceeds 32ºC or the internal driver temperature exceeds 50ºC, then the interlock connection becomes open circuit, disabling the RF output. LED indicators illuminate when the Interlocks are closed and the RF is enabled. In addition, a voltage free signals are provided on the D-type connector for remote monitoring purposes.

3.5 Adjustment of the RF output power is best done with driver connected to the acousto-optic device. The driver maximum output power is factory preset to approx 70W per output (140W total).

**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 relatively low RF power level.**

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

3.7 If uncertain of the RF power adjustment, start at a moderate power level.
Using an insulated alignment tool or screwdriver, rotate the PWR ADJ potentiometer fully anti-clockwise (CCW) i.e. OFF, then increase clockwise (CW) approx. 1/2 turn.

3.8 Apply DC to the driver.

3.9 **RN2- and RN5- models,** digital modulation:
Apply a TTL high (or 5V) constant modulation signal to the D-mod input.
Connect the modulation signal to pin 8 of ‘D’ type and signal return (0V) to pin 15.
Not required for RV3- models.

**RN3- and RN5 models,** analog modulation:
Apply 10V constant modulation signal to the A-mod input.
Connect the modulation signal to pin 7 of ‘D’ type and signal return (0V) to pin 14.
Not required for RV2- models.

3.10 Alignment (Also refer to Appendix A)

Input the laser beam toward the centre of either aperture of the AO device. Ensure the polarization is horizontal with respect to the base and the beam height does not exceed the active aperture height of the AO device.

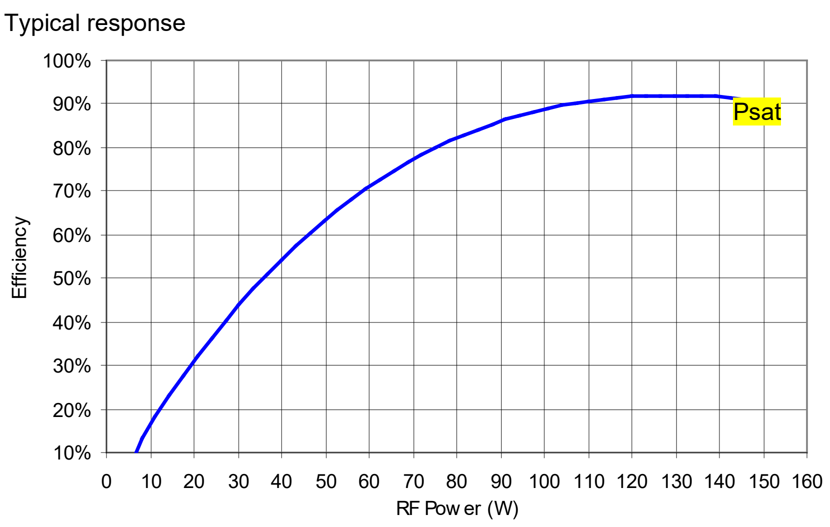
3.11 Start with the laser beam normal to the input optical face and very slowly rotate the AO device. Direction is related to the RF connection order. See Figures 4 & 5 for possible configurations.

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 for 40MHz, slowly increase the RF power. Rotate PWR ADJ CW until the maximum first order intensity is obtained.

3.14 Do not apply excessive RF power.

3.15 RF power considerations. Refer to the fundamental Efficiency vs. RF power characteristic below-




The optimum RF drive power for maximum diffraction efficiency is given by 'Psat' (e.g. at 120W). This scales with active aperture height and the wavelength^2

**Due to the sin^2 response, a ~20% reduction in RF power from the absolute maximum at Psat will result in a ~5% reduction in efficiency. This small sacrifice should be considered to reduce thermal dissipation and minimize undesirable thermal lensing effects.**

# 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 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 sensitivity 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.

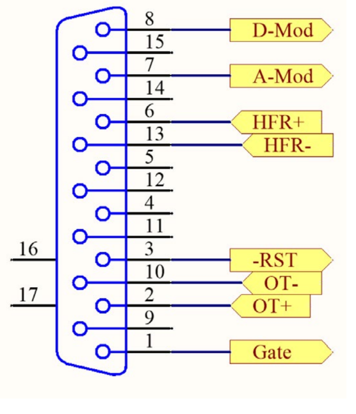
## 5.0 Connection Summary

### 5.1 15-way male 'D' Type Control Connection

| Signal | Type | Pin out connection |
|---|---|---|
| **Gate:** Frequency Select, TTL.<br>High = OFF, Low or nc = ON | Input | Signal pin 1<br>Return pin 9 |
| **RN2- and RN5-**<br>**Dmod**: Digital Modulation TTL *<br>< 0.8V(off), >2.7V(on) | Input | Signal pin 8<br>Return pin 15 |
| (or RN3 / and RN5) | | |
| **RN3- and RN5-**<br>**Amod:** Analog Modulation.<br>< 0.4V(off), 10.0V(full on) | Input | Signal pin 7<br>Return pin 14 |
| **-INT_OTF:** Over Temperature Fault monitor.<br>Open Drain logic, Low = OK<br>**Maximum applied voltage**<br>**(via external pull up resistor) = 5.5V**<br>**Maximum current = 10mA** | Output | Signal pin 2<br>Return pin 10 |
| **-HRP:** High reflected power fault monitor.<br>Open Drain logic, Low = OK<br>**Maximum applied voltage**<br>**(via external pull up resistor) = 5.5V**<br>**Maximum current = 10mA** | Output | Signal pin 6<br>Return pin 13 |
| **-RST:** Reset high reflected power fault.<br>Internal pull up to 5V via 22Kohm .<br>Momentarily contact to 0V-return to initiate a reset | Input | Signal pin 3<br>Return pin 11 |

**DO NOT** connect:
Pins 5,12

Spare 0V (Gnd)
Pin 4

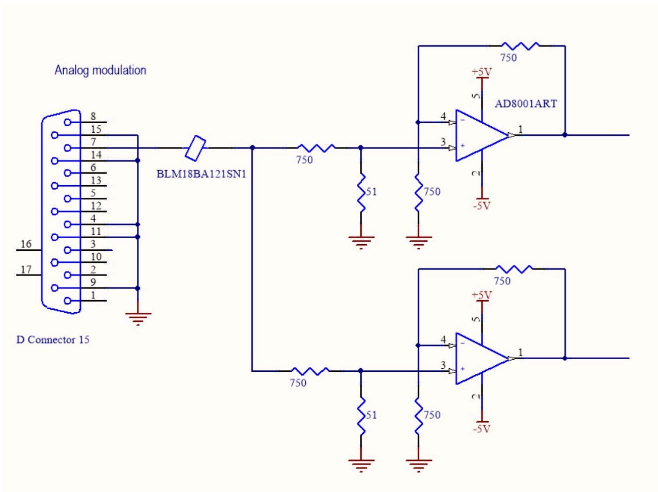


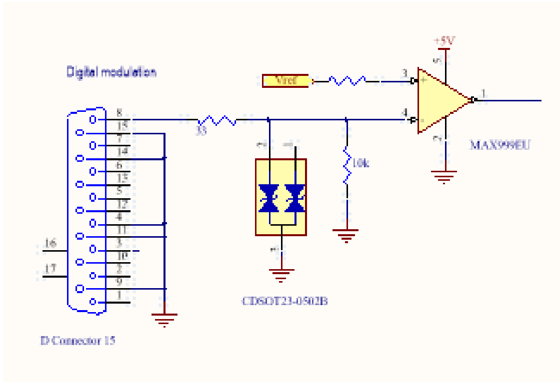

**Notes:**

**A modulation input signals need to be applied.**
**The interlock signal must be connected. See 5.3**

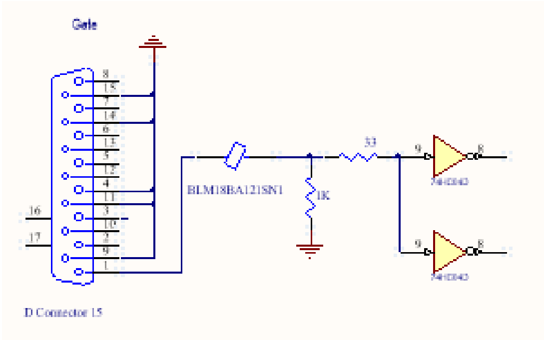
## 5.2 Interface details

**Analog Modulation** (Amod) **(and/or)** **Digital Modulation** (Dmod)



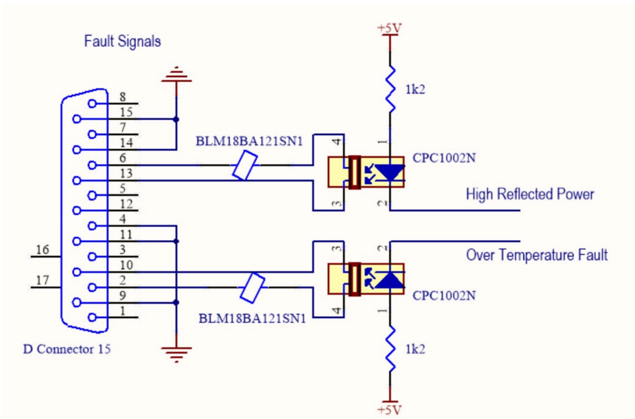



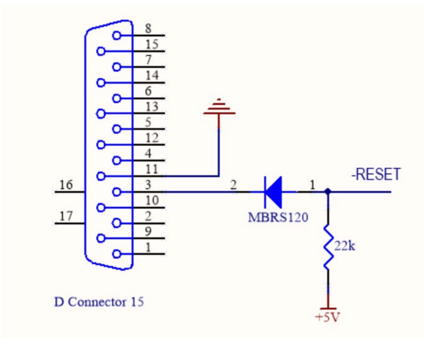

**Gate Input, TTL**
(Optional)




**Fault outputs**
Solid state relay

**HRP reset**

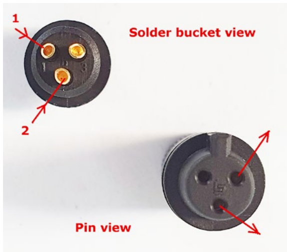


## 5.3 Interlock Connection (normally closed contact)

Binder 719 connector pin assignment
Isolated thermostatic switch in AO.

| Cable Connector Binder719 – 3way | | Driver Binder719 – 3way |
|---|---|---|
| Pin1 | to | Pin1 |
| Pin2 | to | Pin2 |




Binder 719 3-way cable connector (supplied)

## 5.4 DC Power Connection

Screw Terminals as illustrated below.

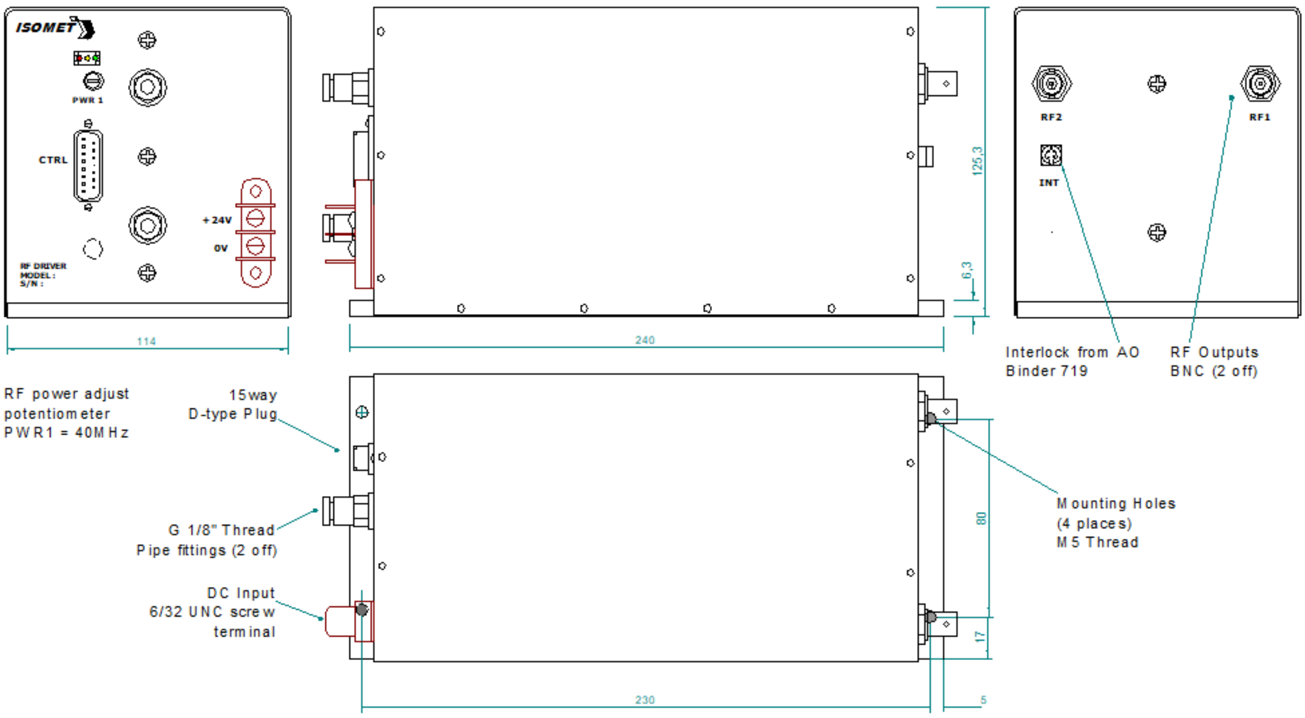



Figure 1: Driver Outline

**5.5 RF Power Adjustment:** Single turn potentiometer.

- PWR ADJ sets the 40MHz RF maximum power.

## 5.6 Mounting

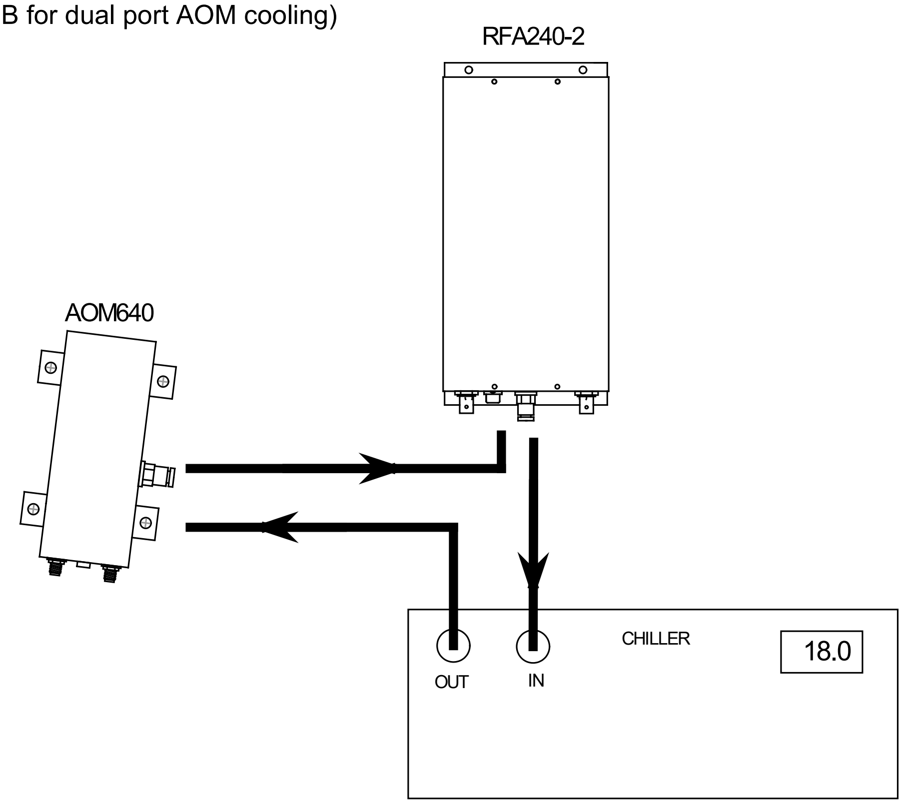
Mounting Holes: 4 x M5
Centres spacing: 220mm x 80mm

## 5.7 Coolant connection

Recommended coolant flow path.

*Chillier out > AO > Driver > return*

(see appendix B for dual port AOM cooling)



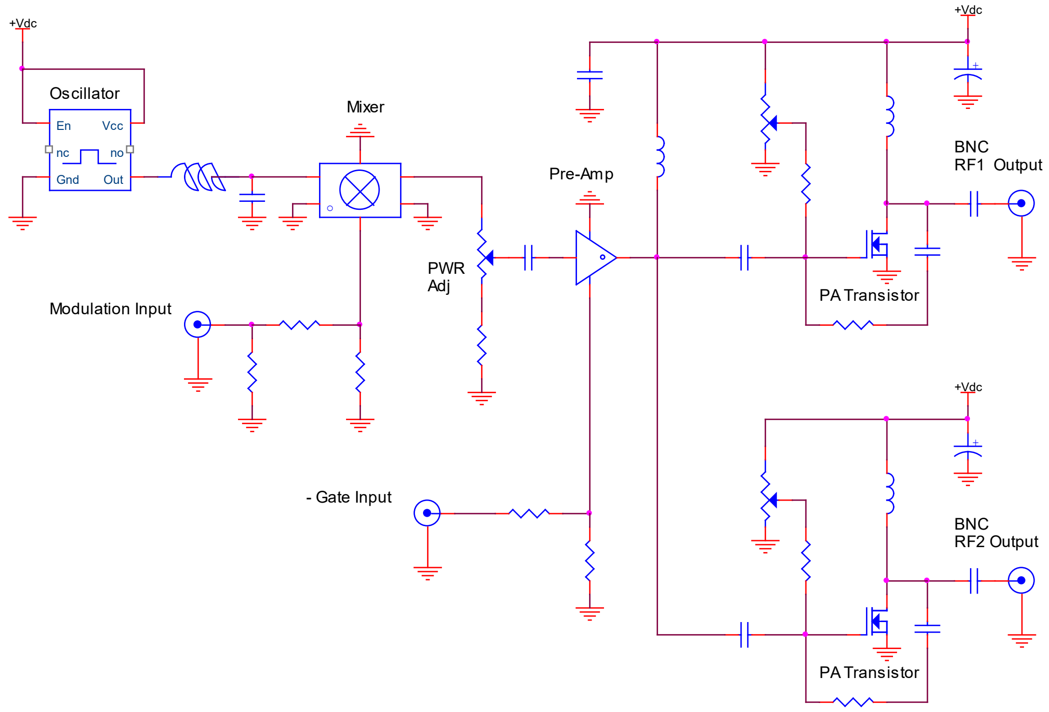
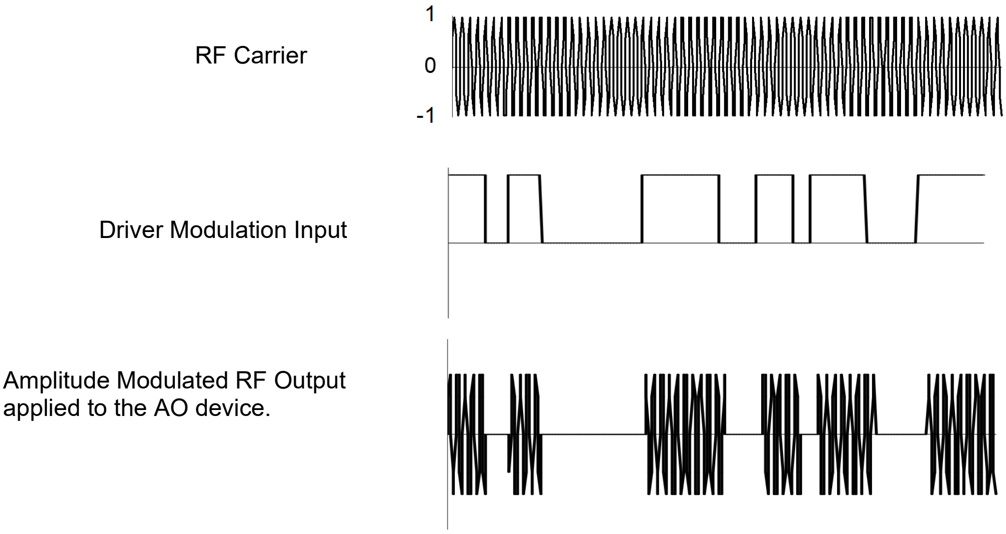
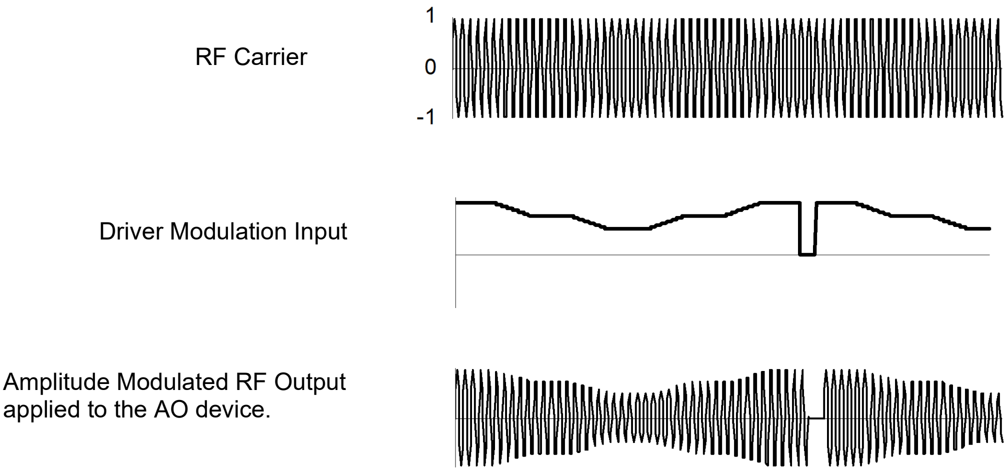



Figure 2: Conceptual Block Diagram

**RN2**-models: Typical digital modulation RF waveforms.

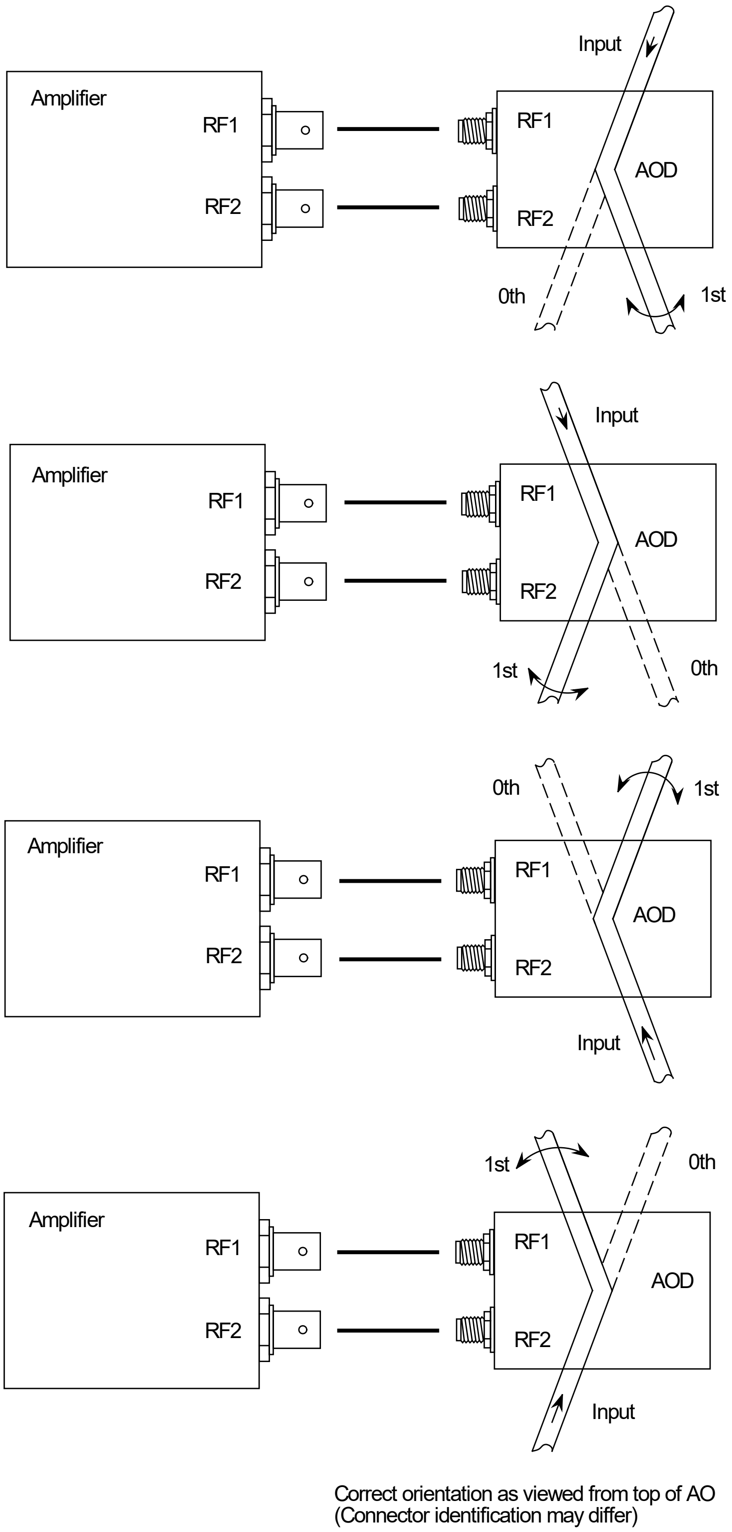



**RN3**-models: Typical analog modulation RF waveforms.



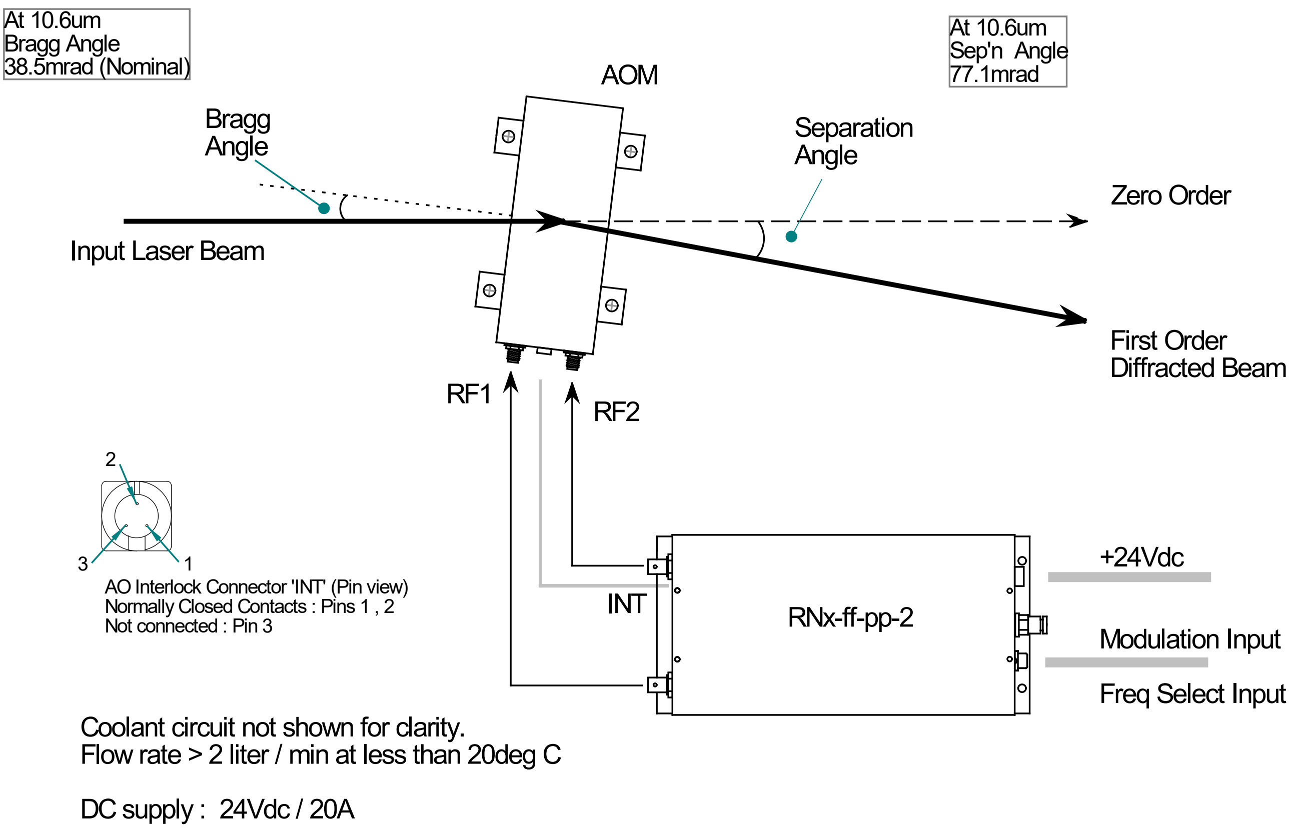

**RN5**-models:  Combination of above

Figure 3:  Typical Modulation Waveforms




Note: Connection order not important. Amp RF2 can connect the AOD RF1

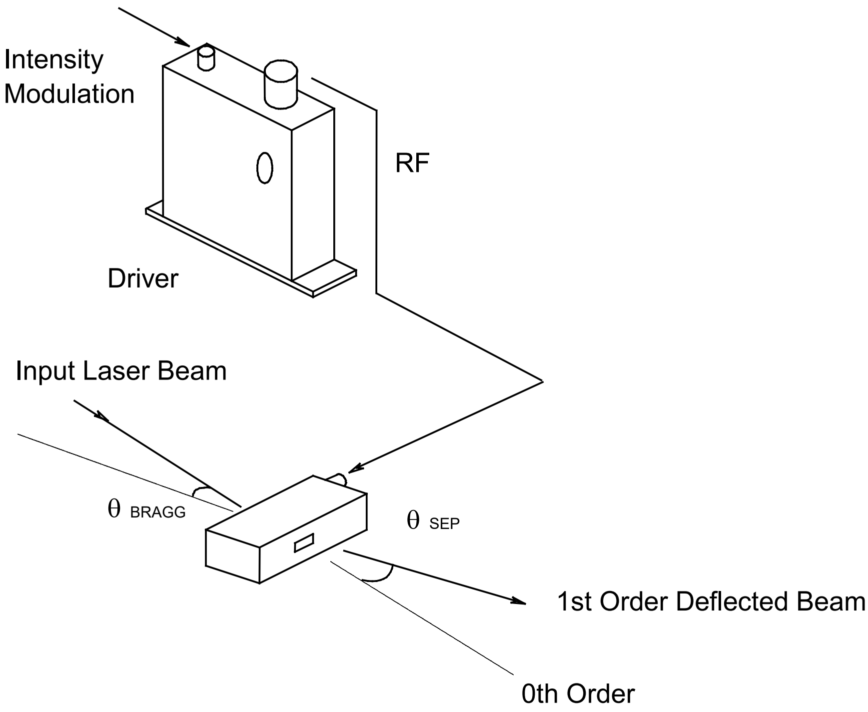
Figure 4: Connection orientations (J1 = RF1, J2 = RF2)




See Figure 4 for alternate beam orientations.

Figure 5: 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 or 50MHz
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)

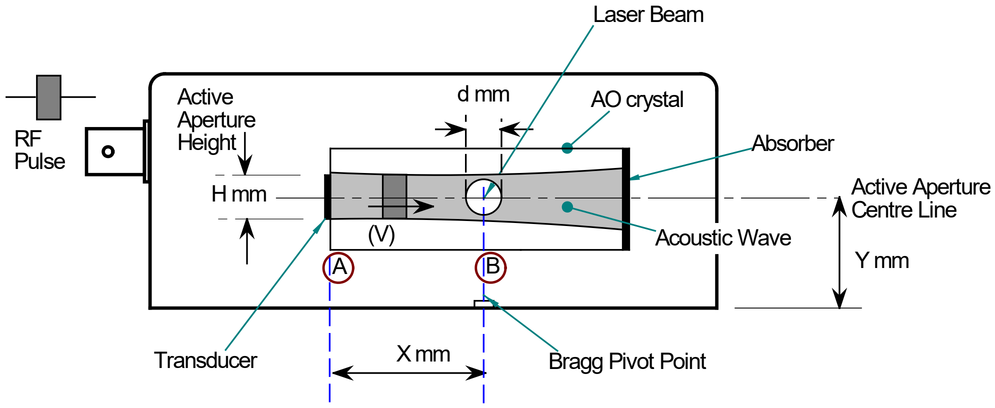
d = $1/e^2$ beam diameter

Figure 6. Modulation basic formulae

## 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*.



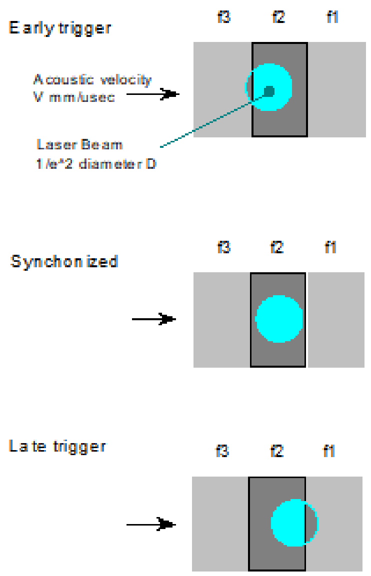

### Input Beam Location

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.

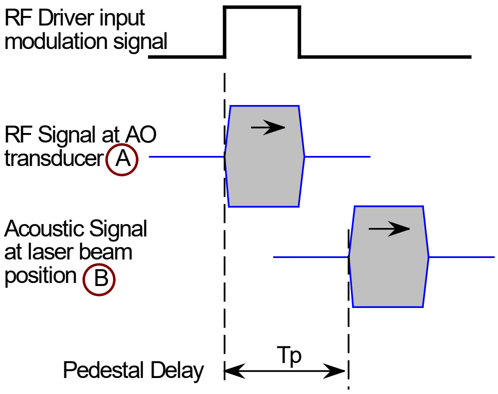
Early/later refers to the laser trigger timing relative to the RF driver modulation signal



## Pedestal delay

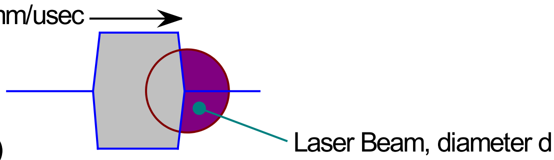
The time taken for the acoustic wavefront to reach the laser beam centre [2].

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




## 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.

## Appendix B

**<u>M600 / M1199  enhanced coolant flow</u>**

Flow rate enhancement using T-piece