IM3024

Acousto-Optic Modulator Driver

Including: Basic M1378 Alignment

Instruction Manual

RVx-40-1-200

RVxBR-40-1-200 with Brass Heatsink

Models –

Digital Modulation

RV2-40-1-200	: 40MHz, 200W output.
RV2BR-40-1-200	: with brass heatsink.

Analog Modulation

RV3-40-1-200	: 40MHz, 200W output.
RV3BR-40-1-200	: with brass heatsink.

Dual Modulation

RV5-40-1-200	: 40MHz, 200W output.
RV5BR-40-1-200	: with brass heatsink.

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1. GENERAL

The RV5 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 M1378. 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
RV5BR-40-1-200	40MHz	> 200 Watt	(Dual mod'n) Brass Heatsink
RV3-40-1-200	40MHz	> 200 Watt	Analog mod'n only
RA2-40-1-200	40MHz	> 200 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 oscillators are 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 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.

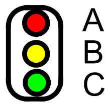
Water cooling is mandatory. The case temperature must not exceed 50°C.
SERIOUS DAMAGE TO THE AMPLIFIER MAY RESULT IF THE TEMPERATURE EXCEEDS 70°C.
SERIOUS DAMAGE TO THE AMPLIFIER MAY ALSO RESULT IF THE RF OUTPUT CONNECTOR IS OPERATED OPEN-CIRCUITED OR SHORT-CIRCUITED.

A low impedance DC supply is required. The operating voltage is +24V (+28Vdc MAX) at a current drain of approximately 16A. Please refer to the model data sheet. The external power supply 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.

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 50deg C
- The AOM thermal switch over-temperature trip point is 32deg 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 **AN1710** Resetting the AO Thermal Interlock (https://isomet.com/appnotes.html)

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 of 1 litre/minute at <25degC.
For optimum AO performance ensure the flow rate is more than 2 litres/minute at <20degC

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 16A supply is recommended. DO NOT APPLY POWER.

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

3.3 Connect the RF output BNC jack to the SMA RF input of the acousto-optic device (or a 50-ohm RF load, if it is desired to measure the modulator RF output power

3.4 Connect the Interlock of the acousto-optic device (Binder 719, 3-pin black snap connector) to the Interlock connector on the rear panel of the RVx-. 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' 100W.

The optimum RF power level required for the modulator to produce maximum first order intensity will be different at various laser wavelengths and/or frequencies. 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 end plate.

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 potentiometers fully anti-clockwise (CCW) i.e. OFF, then increase clockwise (CW) approx. 1/2 turn.

3.8 Apply DC to the driver.

3.9 **RV2- and RV5- models,** digital modulation:

Apply a TTL high (or 5V) constant modulation signal to the modulation input.

Connect the modulation signal to pin 8 of 'D' type and signal return (0V) to pin 15.

Not required for RV3- models.

RV3- and RV5 models, analog modulation:

Apply 10V constant modulation signal to the modulation input on the 15way D-type connector.

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

3.14 Change the selected Frequency to 48MHz (Freq Select signal = Low).

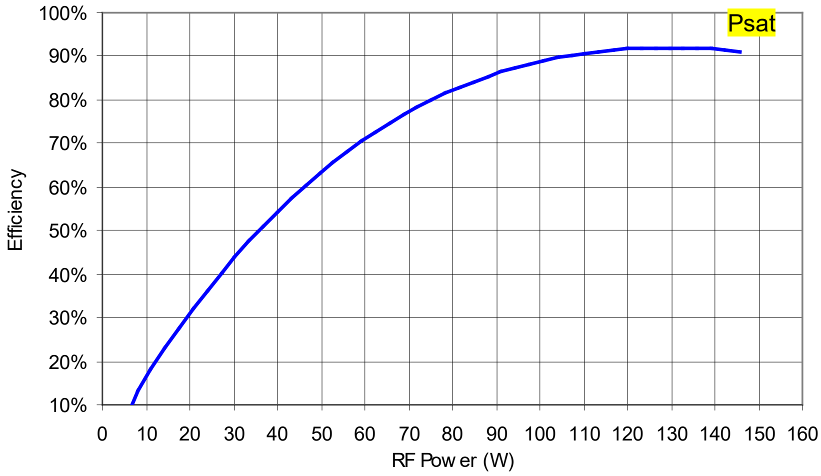
Increase the RF power for this frequency. Rotate PWR ADJ2 for 48MHz until the same dissipation is obtained at this spot.

To equalise dissipation, alternate between the two frequencies and carefully note the beam shape. Alternatively, compare using an inline RF power meter.

3.15 RF power considerations

Refer to the fundamental Efficiency vs. RF power characteristic below.

Typical response



The optimum RF drive power for maximum diffraction efficiency is given by 'Psat' (e.g. at 120W in this plot). 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, results 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 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.

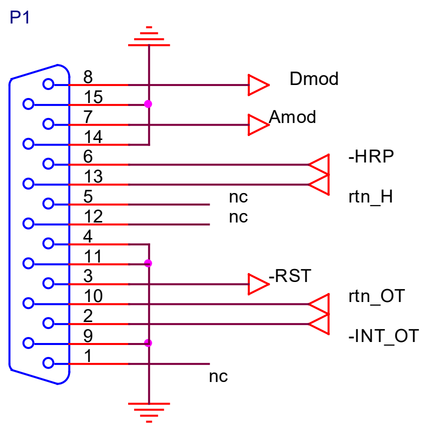
5.0 Connection Summary

15-way male 'D' Type Control Connection

Signal	Type	Pin out connection
RV2- and RV5- **Dmod**: Digital Modulation TTL * < 0.8V(off), >2.7V(on)	Input	Signal pin 8 Return pin 15
(or)		
RV3- and RV5- **Amod:** Analog Modulation. < 0.4V(off), 10.0V(full on)	Input	Signal pin 7 Return pin 14
-INT_OTF: Over Temperature Fault monitor. Open Drain logic, Low = OK **Maximum applied voltage** **(via external pull up resistor) = 5.5V** **Maximum current = 10mA**	Output	Signal pin 2 Return pin 10
-HRP: High reflected power fault monitor. Open Drain logic, Low = OK **Maximum applied voltage** **(via external pull up resistor) = 5.5V** **Maximum current = 10mA**	Output	Signal pin 6 Return pin 13
-RST: Reset high reflected power fault. Internal pull up to 5V via 22Kohm . Momentarily contact to 0V-return to initiate a reset.	Input	Signal pin 3 Return pin11

DO NOT connect:
Pins 1,5,12

Spare 0V (Gnd)
Pins 4,9

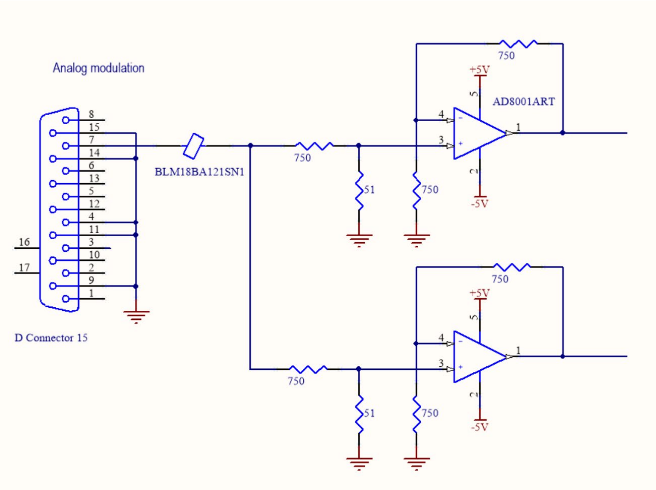


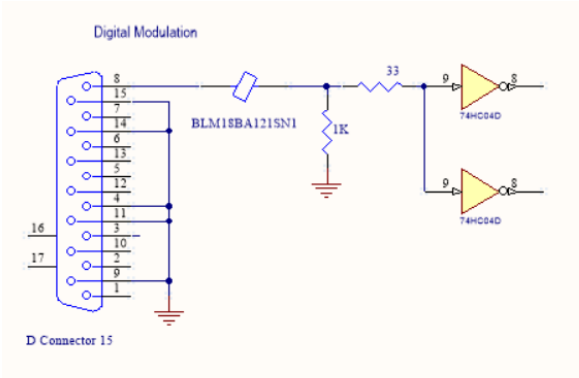
Notes:

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

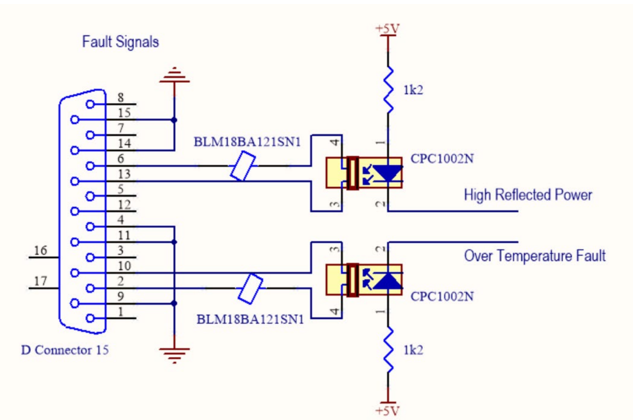
5.2 Internal interface details

Analog Modulation (Amod, RV3 and RV5) **and/or** **Digital Modulation** (Dmod, RV2 and RV5)

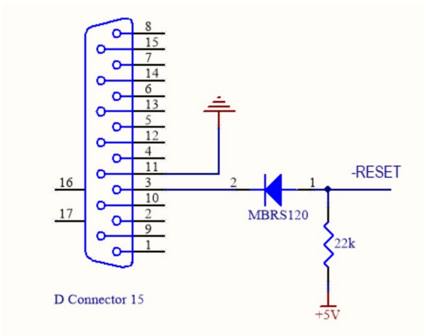




Fault outputs
Solid state relay



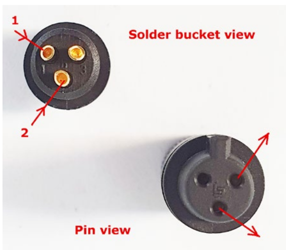
HRP reset



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.

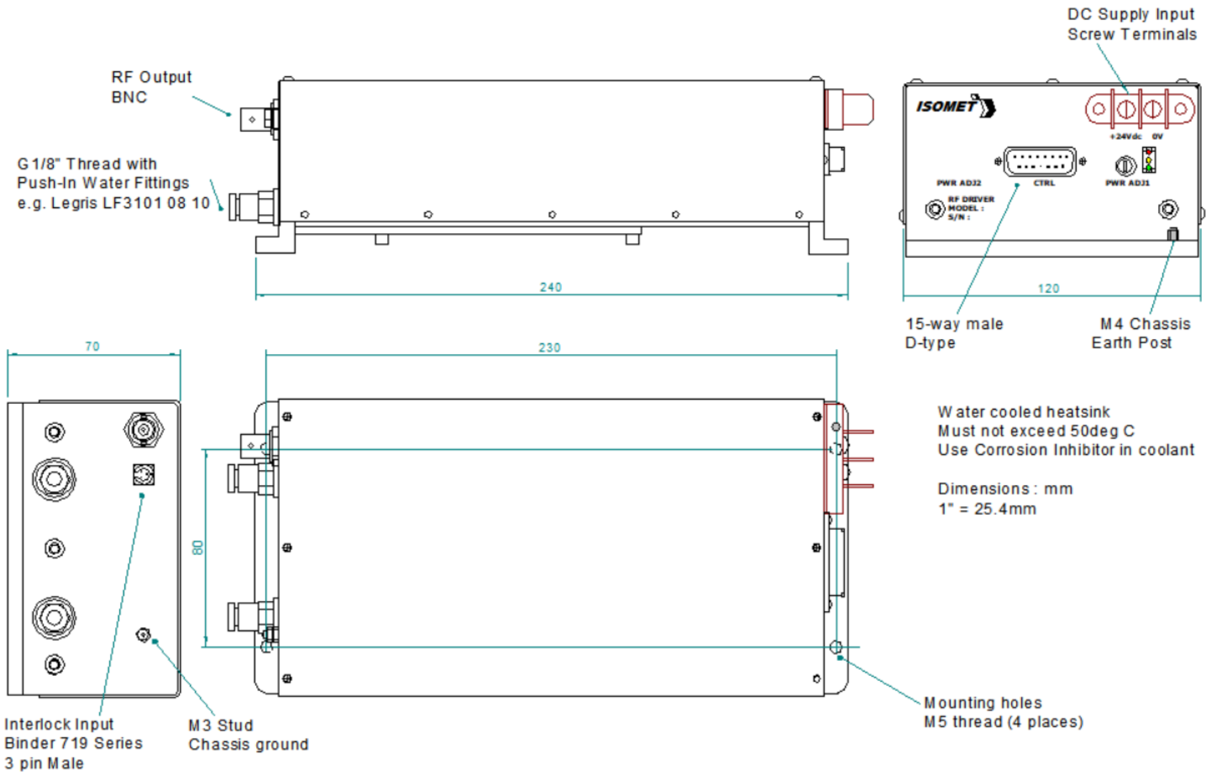


Figure 1: Driver Outline

5.5 RF Power Adjustment: Single turn potentiometer.

- PWR ADJ1 sets the 40MHz RF maximum power.

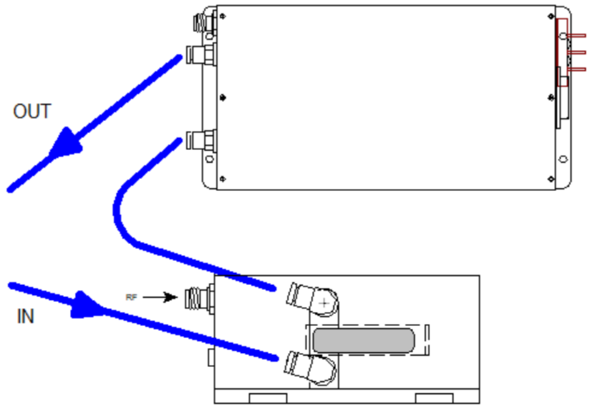
5.6 Mounting

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

5.7 Coolant connection

Recommended coolant flow path.

Chillier out > AO > Driver > return



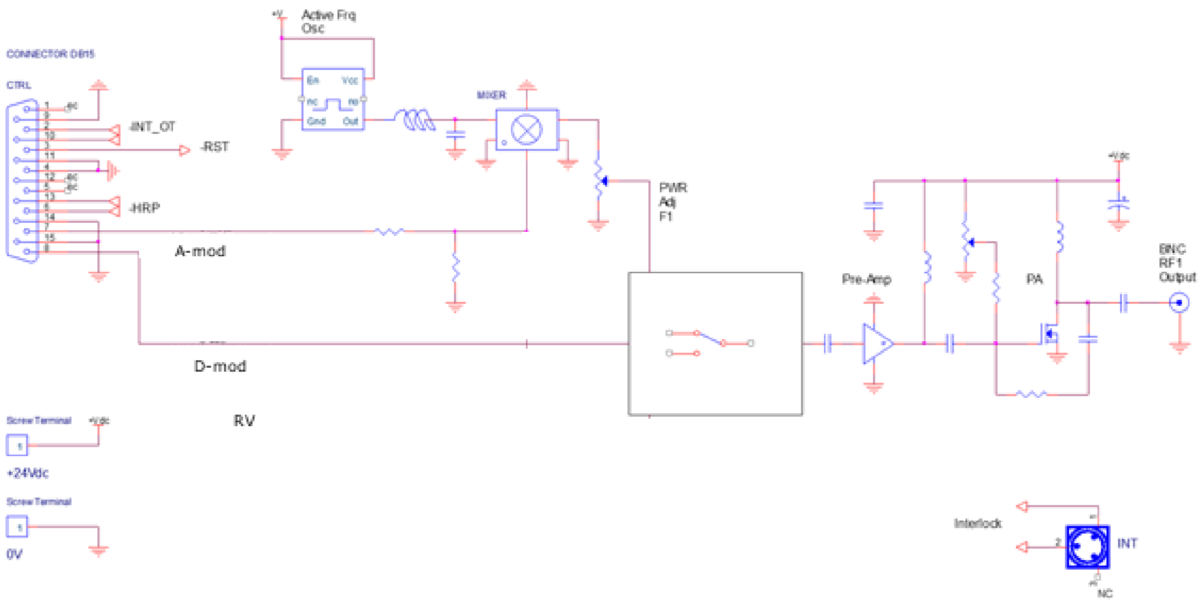
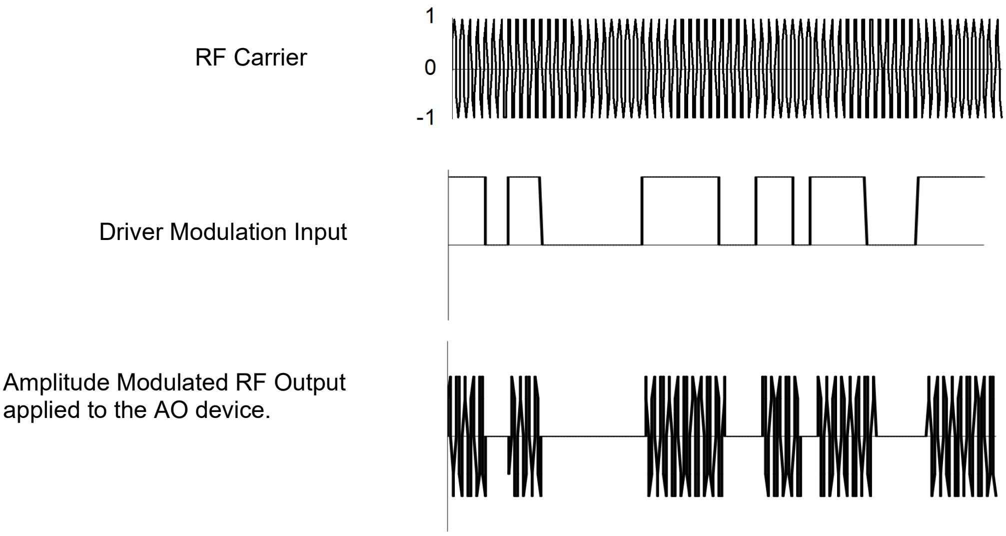


Figure 2: Conceptual Block Diagram

RV2-models: Typical digital modulation RF waveforms.



RV3-models: Typical analog modulation RF waveforms.

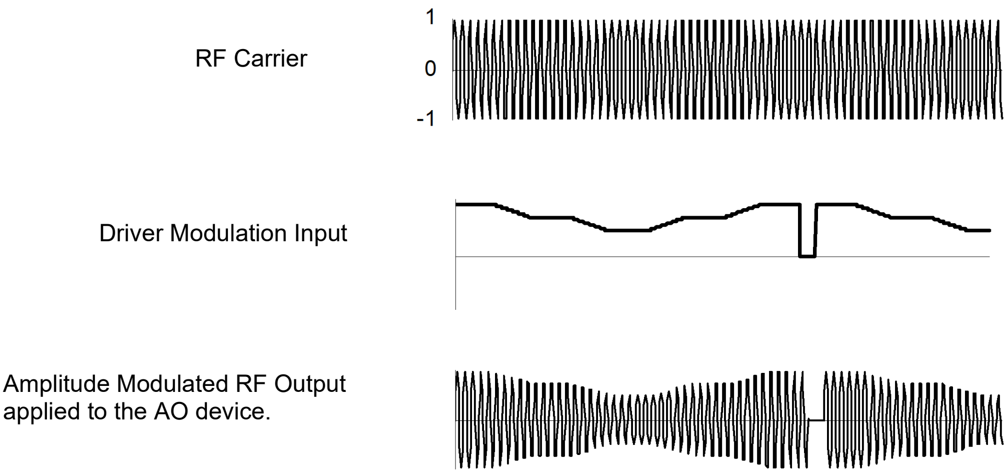


Figure 3: Typical Modulation Waveforms. Both apply for RV5 models.

Orientation options

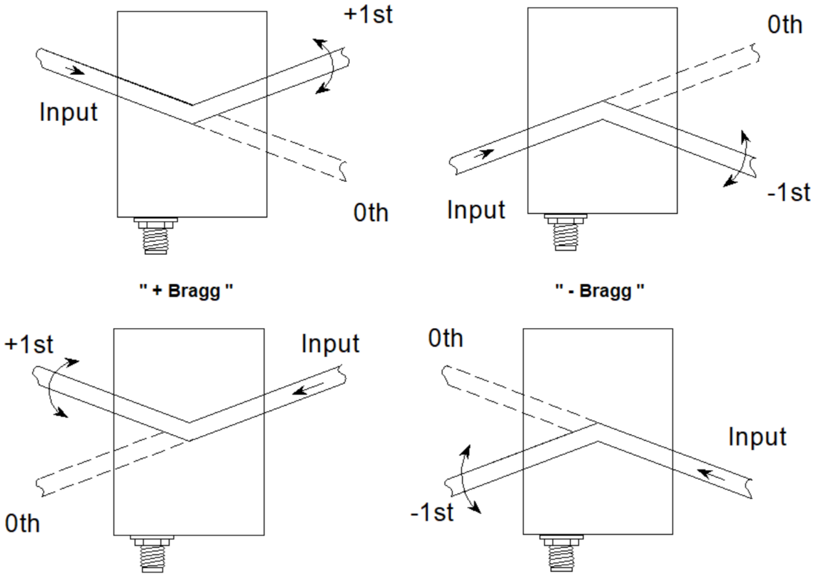


Figure 4: Connection orientations

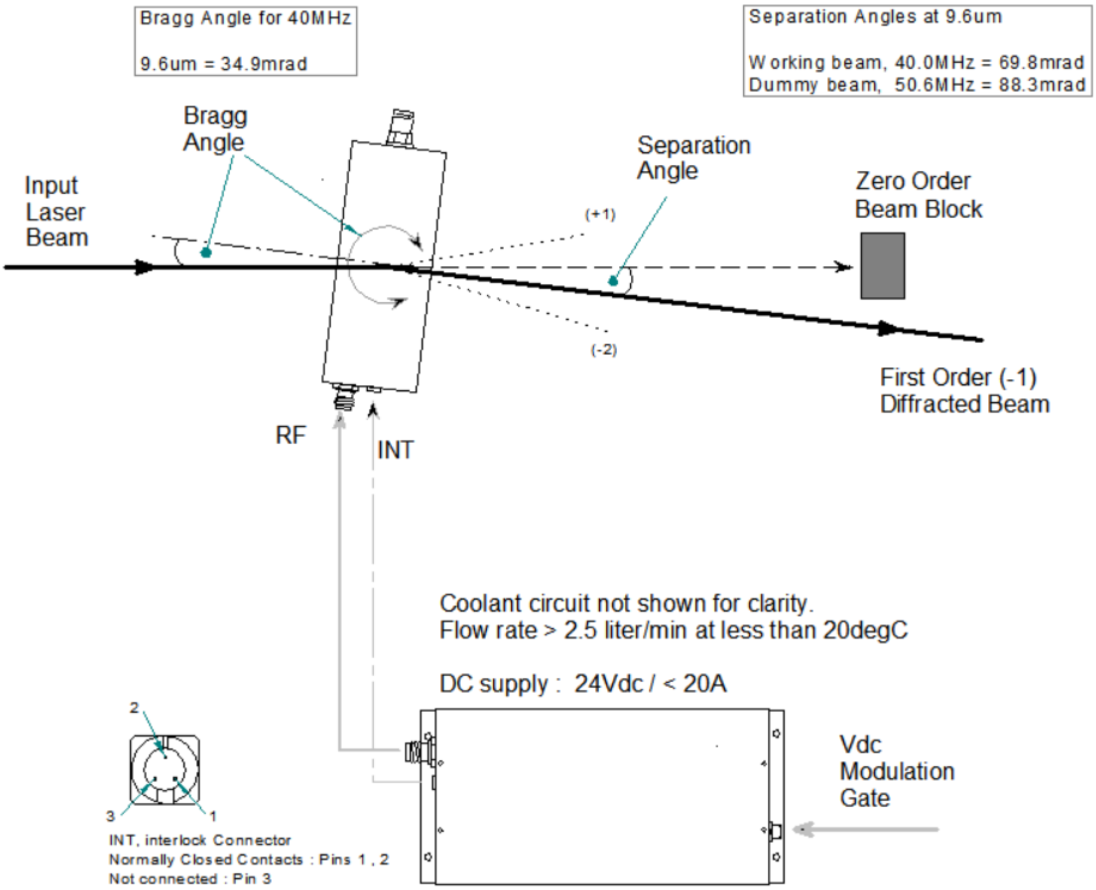
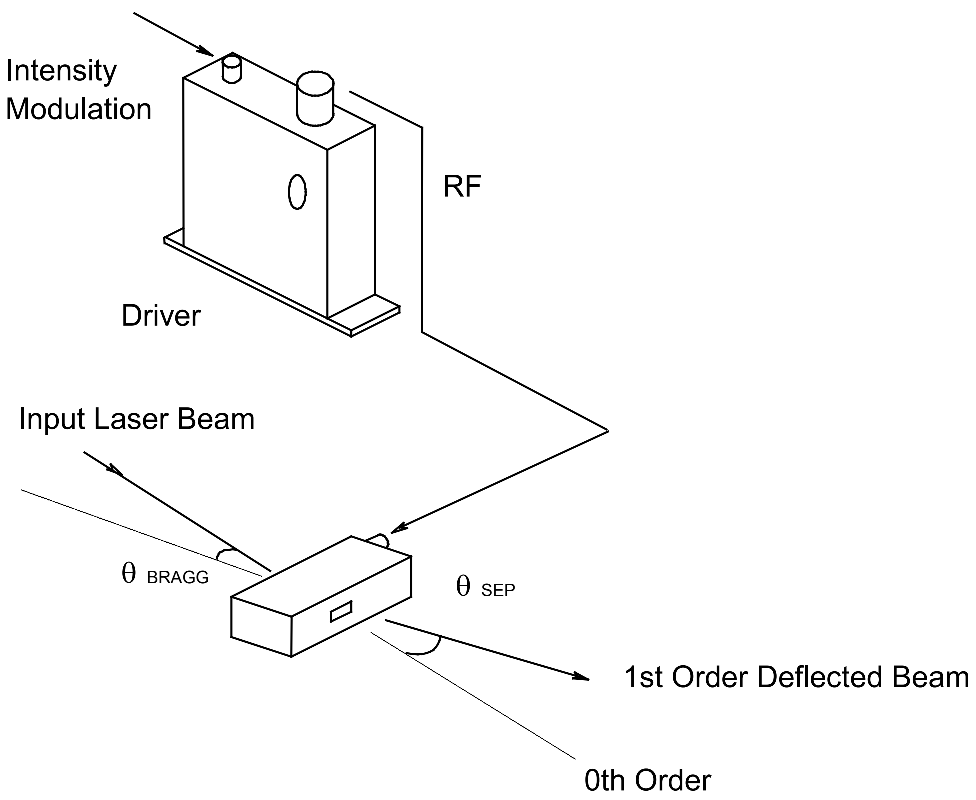


Figure 5: Typical Connection Configuration.

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 / 60MHz
v = acoustic velocity of interaction material = 5.5mm/usec (Ge)

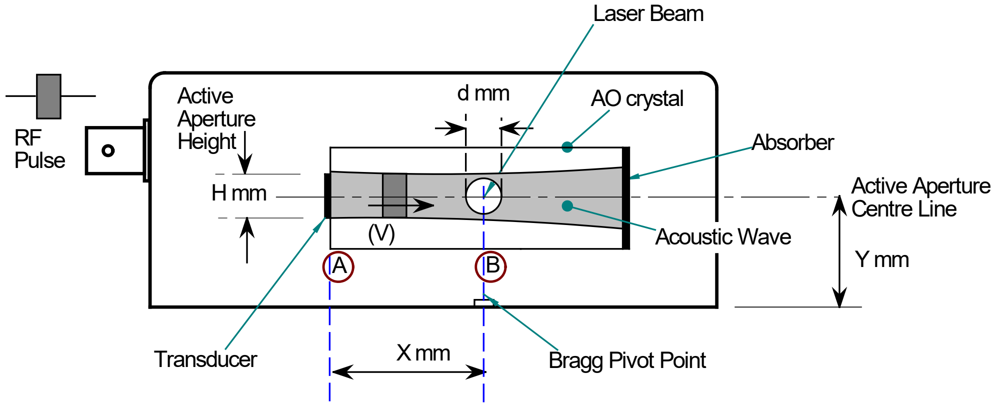
d = $1/e^2$ beam diameter

Figure 6. Modulation System

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*.



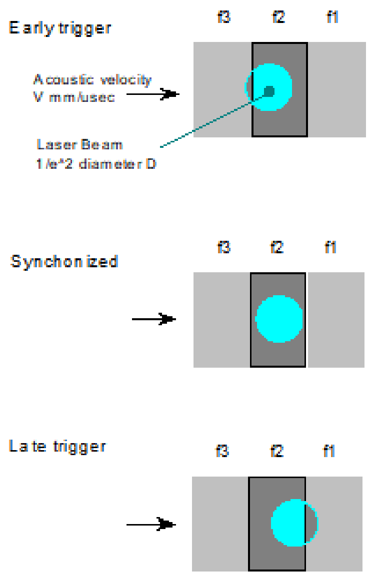
Input Beam Location

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.

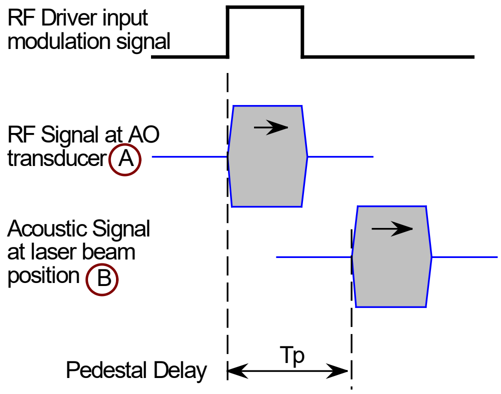
Early/later refers to the laser trigger timing relative to the RF driver modulation signal



Pedestal delay

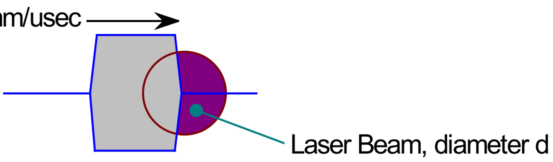
The time taken for the acoustic wavefront to reach the laser beam centre [2].

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



Transit time

The time taken for the acoustic wavefront to cross the entire laser beam diameter.



where: $$T_t = \frac{\text{beam diameter (d)}}{\text{acoustic velocity (V)}}$$

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.